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FLORIDA DEPARTMENT OF TRANSPORTATION

STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION FY 2024-25

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These Florida Department of Transportation Standard Specifications for Road and Bridge Construction, FY 2024-25, are hereby approved for application on highway and related construction contracts as referenced in the plans or specifications, and they shall apply as noted and amended by those documents.

Michael A. Shepard, P.E.
Director, Office of Design

DocuSigned by:
Michael A. Shepard
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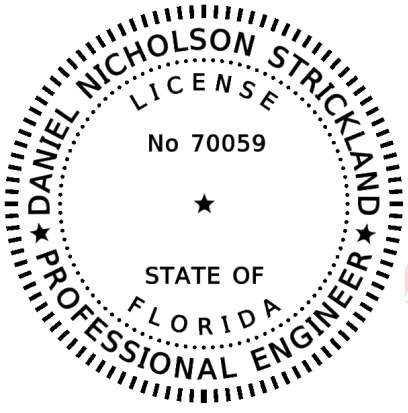
I hereby certify that these Standard Specifications were prepared by me or under my responsible charge, compiled from specifications prepared, examined, adopted and implemented by the Florida Department of Transportation in accordance with established procedures, and as approved by the Federal Highway Administration.

This item has been digitally signed and sealed by Daniel Strickland on the date adjacent to the seal. Printed copies of this document are not considered signed and sealed and the signature must be verified on any electronic copies.

Daniel Strickland, P.E.
State Specifications Engineer



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DIVISION I

General Requirements and Covenants

SECTION 1
DEFINITIONS AND TERMS

1-1 General.

These Specifications are written to the bidder, prior to award of the Contract, and to the Contractor. Within Divisions I and II of the specifications, sentences that direct the Contractor to perform work are written in the active voice-imperative mood. These directions to the Contractor are written as commands. In the imperative mood, the subject "the bidder" or "the Contractor" is understood.

All other requirements to be performed by others, with the exception of the Method of Measurement and the Basis of Payment Articles, have been written in the active voice, but not in the imperative mood. Sentences written in the active voice identify the party responsible for performing the action. For example, "The Engineer will determine the density of the compacted material." Certain requirements of the Contractor may also be written in the active voice, rather than active voice-imperative mood.

Division III of the Specifications (Materials) is written in the passive voice writing style.

1-2 Abbreviations.

The following abbreviations, when used in the Contract Documents, represent the full text shown.

AAN	American Association of Nurserymen, Inc.
AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
AGC	The Associated General Contractors of America, Inc.
AGMA	American Gear Manufacturers Association
AIA	American Institute of Architects
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute, Inc.
AREA	American Railway Engineering Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWG	American Wire Gauge
AWPA	American Wood Preservers Association
AWS	American Welding Society
AWWA	American Water Works Association
CRSI	Concrete Reinforcing Steel Institute
EASA	Electrical Apparatus Service Association
EPA	Environmental Protection Agency of the United States Government
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration

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FSS	Federal Specifications and Standards
IEEE	Institute of Electrical and Electronics Engineers
IES	Illuminating Engineering Society
IPCEA	Insulated Power Cable Engineers Association
ISO	International Organization for Standards
MASH	AASHTO Manual for Assessing Safety Hardware
MUTCD	Manual on Uniform Traffic Control Devices
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NIST	National Institute for Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
OSHA	Occupational Safety and Health Administration
SAE	Society of Automotive Engineers
SI	International System of Units
SSPC	Society of Protective Coatings
UL	Underwriters' Laboratories

Each of the above abbreviations, when followed by a number or letter designation, or combination of numbers and letters, designates a specification, test method, or other code or recommendation of the particular authority or organization shown.

Use standards, specifications, test methods, or other codes as specified in the current edition at the time of the bid opening.

1-3 Definitions.

The following terms, when used in the Contract Documents, have the meaning described.

Advertisement.

The public announcement, as required by law, inviting bids for work to be performed or materials to be furnished, usually issued as “Notice to Contractors,” or “Notice to Bidders.”

Article.

The numbered prime subdivision of a Section of these Specifications.

Bidder.

An individual, firm, or corporation submitting a proposal for the proposed work.

Bridge.

A structure, including supports, erected over a depression or over an obstruction such as water, highway or railway, or for elevated roadway, for carrying traffic or other moving loads, and having a length, measured along the center of the roadway, of more than 20 feet between the inside faces of end supports. A multiple-span box culvert is considered a bridge, where the length between the extreme ends of the openings exceeds 20 feet.

Calendar day.

Every day shown on the calendar, ending and beginning at midnight.

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Contract.

The term "Contract" means the entire and integrated agreement between the parties thereunder and supersedes all prior negotiations, representations, or agreements, either written or oral. The Contract Documents form the Contract between the Department and the Contractor setting forth the obligations of the parties thereunder, including, but not limited to, the performance of the Work and the basis of payment.

Contract Bond.

The security furnished by the Contractor and the surety as a guaranty that the Contractor shall fulfill the terms of the Contract and pay all legal debts pertaining to the construction of the project.

Contract Claim (Claim).

A written demand submitted to the Department by the Contractor in compliance with 5-12.3 seeking additional monetary compensation, time, or other adjustments to the Contract, the entitlement or impact of which is disputed by the Department.

Contract Documents.

The term "Contract Documents" includes: Advertisement for Proposal, Proposal, Certification as to Publication and Notice of Advertisement for Proposal, Appointment of Agent by Nonresident Contractors, Noncollusion Affidavit, Warranty Concerning Solicitation of the Contract by Others, Resolution of Award of Contract, Executed Form of Contract, Performance Bond and Payment Bond, Specifications, Plans (including revisions thereto issued during construction), Estimated Quantities Report, Standard Plans, Addenda, or other information mailed or otherwise transmitted to the prospective bidders prior to the receipt of bids, work orders and supplemental agreements, all of which are to be treated as one instrument whether or not set forth at length in the form of contract.

Note: As used in Sections 2 and 3 only, Contract Documents do not include work orders, and supplementary agreements. As used in Section 2 only, Contract Documents also do not include Resolution of Award of Contract, Executed Form of Contract, and Performance and Payment Bond.

Contract Letting.

The date that the Department opened the bid proposals.

Contract Time.

The number of calendar days allowed for completion of the Contract work, including authorized time extensions.

Contractor.

The individual, firm, joint venture, or company contracting with the Department to perform the work.

Contractor's Engineer of Record.

A Professional Engineer registered in the State of Florida, other than the Engineer of Record or his subcontracted consultant, who undertakes the design and drawing of components of the permanent structure as part of a redesign or Cost Savings Initiative Proposal, or for repair

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designs and details of the permanent work. The Contractor's Engineer of Record may also serve as the Specialty Engineer.

The Contractor's Engineer of Record must be an employee of a pre-qualified firm. The firm shall be pre-qualified in accordance with the Rules of the Department of Transportation, Chapter 14-75. Any Corporation or Partnership offering engineering services must hold a Certificate of Authorization from the Florida Department of Business and Professional Regulation.

As an alternate to being an employee of a pre-qualified firm, the Contractor's Engineer of Record may be a Department-approved Specialty Engineer. For items of the permanent work declared by the State Construction Office to be "major" or "structural", the work performed by a Department-approved Specialty Engineer must be checked by another Department-approved Specialty Engineer. An individual Engineer may become a Department-approved Specialty Engineer if the individual meets the Professional Engineer experience requirements set forth within the individual work groups in Chapter 14-75, Rules of the Department of Transportation, Florida Administrative Code. Department-approved Specialty Engineers are listed on the State Construction Website. Department-approved Specialty Engineers will not be authorized to perform redesigns or Cost Savings Initiative Proposal designs of items fully detailed in the Plans.

Controlling Work Items.

The activity or work item on the critical path having the least amount of total float. The controlling item of work will also be referred to as a Critical Activity.

Culverts.

Any structure not classified as a bridge that provides an opening under the roadway.

Delay.

Any unanticipated event, action, force or factor which extends the Contractor's time of performance of any controlling work item under the Contract. The term "delay" is intended to cover all such events, actions, forces or factors, whether styled "delay", "disruption", "interference", "impedance", "hindrance", or otherwise, which are beyond the control of and not caused by the Contractor, or the Contractor's subcontractors, materialmen, suppliers or other agents. This term does not include "extra work".

Department.

State of Florida Department of Transportation.

Developmental Specification.

See definition for Specifications.

Engineer.

The Director, Office of Construction, acting directly or through duly authorized representatives; such representatives acting within the scope of the duties and authority assigned to them.

Note: In order to avoid cumbersome and confusing repetition of expressions in these Specifications, it is provided that whenever anything is, or is to be done, if, as, or, when, or where "acceptable, accepted, approval, approved, authorized, condemned, considered necessary, contemplated, deemed necessary, designated, determined, directed, disapproved, established,

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given, indicated, insufficient, ordered, permitted, rejected, required, reserved, satisfactory, specified, sufficient, suitable, suspended, unacceptable, or unsatisfactory," it shall be understood as if the expression were followed by the words "by the Engineer," "to the Engineer," or "of the Engineer."

Engineer of Record.

The Professional Engineer or Engineering Firm registered in the State of Florida that develops the criteria and concept for the project, performs the analysis, and is responsible for the preparation of the Plans and Specifications. The Engineer of Record may be Departmental in-house staff or a consultant retained by the Department.

The Contractor shall not employ the Engineer of Record as the Contractor's Engineer of Record or as a Specialty Engineer.

Equipment.

The machinery and equipment, together with the necessary supplies for upkeep and maintenance thereof, and all other tools and apparatus necessary for the construction and acceptable completion of the work.

Estimated Quantities Report.

The Estimated Quantities Report contains pay item and quantity information for the project. When the Plans do not adequately describe quantity related information, refer to the Estimated Quantities Report.

Extra Work.

Any "work" which is required by the Engineer to be performed and which is not otherwise covered or included in the project by the existing Contract Documents, whether it be in the nature of additional work, altered work, deleted work, work due to differing site conditions, or otherwise. This term does not include a "delay".

Federal, State, and Local Rules and Regulations.

The term "Federal, State and Local Rules and Regulations" includes: any and all Federal, State, and Local laws, bylaws, ordinances, rules, regulations, orders, permits, or decrees including environmental laws, rules, regulations, and permits.

Highway, Street, or Road.

A general term denoting a public way for purposes of vehicular travel, including the entire area within the right-of-way.

Holidays.

Days designated by the State Legislature or Cabinet as holidays, which include, but are not limited to, New Year's Day, Martin Luther King's Birthday, Memorial Day, Independence Day, Labor Day, Veterans' Day, Thanksgiving Day and the following Friday, and Christmas Day.

Inspector.

An authorized representative of the Engineer, assigned to make official inspections of the materials furnished and of the work performed by the Contractor.

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Laboratory.
The official testing laboratory used by the Department.

Major Item of Work.
Any item of work having an original Contract value in excess of 5% of the original Contract amount.

Materials.
Any substances to be incorporated in the work under the Contract.

Median.
The portion of a divided highway or street separating the traveled ways for traffic moving in opposite directions.

Plans.
The plans sheets and digital models (2D and 3D) provided as contract documents, including reproductions thereof, showing the location, character, dimensions, and details of the work.

Proposal (Bid, Bid Proposal).
The offer of a bidder, on the prescribed form, to perform the work and to furnish the labor and materials at the prices quoted.

Proposal Form.
The official form or the electronically generated bid item sheets on which the Department requires formal bids to be prepared and submitted for the work.

Proposal Guaranty.
The security furnished by the bidder as guaranty that the bidder will enter into the Contract for the work if the Department accepts the proposal.

Request for Correction.
A document initiated by the Contractor proposing a method for correction of work that is not in compliance with the Contract Documents. The Request for Correction is submitted to the Engineer for review and disposition.

Request for Information.
A document initiated by the Contractor that is submitted to the Engineer for interpretation of a Contract Document provision, the meaning of which is not clear to the Contractor. The Request for Information is submitted to the Engineer for review and disposition.

Request for Modification.
A document initiated by the Contractor requesting to modify the Contract Documents, that is submitted to the Engineer for review and disposition.

Right-of-Way.
The land that the Department has title to, or right of use, for the road and its structures and appurtenances, and for material pits furnished by the Department.

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Roadbed.
The portion of the roadway occupied by the subgrade and shoulders.

Roadway.
The portion of a highway within the limits of construction.

Secretary.
Secretary of Transportation, State of Florida Department of Transportation, acting directly or through an assistant or other representative authorized by him; the chief officer of the Department of Transportation.

Section.
A numbered prime division of these Specifications.

Special Event.
Any event, including but not limited to, a festival, fair, run or race, motorcade, parade, civic activity, cultural activity, charity or fund drive, sporting event, or similar activity designated in the Contract Documents.

Special Provisions.
See definition for Specifications.

Specialty Engineer.
A Professional Engineer registered in the State of Florida, other than the Engineer of Record or his subcontracted consultant, who undertakes the design and drawing preparation of components, systems, or installation methods and equipment for specific temporary portions of the project work or for special items of the permanent works not fully detailed in the Plans and required to be furnished by the Contractor. The Specialty Engineer may also provide designs and details, repair designs and details, or perform Engineering Analyses for items of the permanent work declared by the State Construction Office to be "minor" or "non-structural".

For items of work not specifically covered by the Rules of the Department of Transportation, a Specialty Engineer is qualified if he has the following qualifications:

1. Registration as a Professional Engineer in the State of Florida.
2. The education and experience necessary to perform the submitted design as required by the Florida Department of Business and Professional Regulation.

Specifications.
The directions, provisions, and requirements contained herein, together with all stipulations contained in the Contract Documents, setting out or relating to the method and manner of performing the work, or to the quantities and qualities of materials and labor to be furnished under the Contract.

Standard Specifications: "Standard Specifications for Road and Bridge Construction" an electronic book, applicable to all Department Contracts containing adopted requirements, setting out or relating to the method or manner of performing work, or to the quantities and qualities of materials and labor.

Supplemental Specifications: Approved additions and revisions to the Standard Specifications, applicable to all Department Contracts.

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Special Provisions: Specific clauses adopted by the Department that add to or revise the Standard Specifications or supplemental specifications, setting forth conditions varying from or additional to the Standard Specifications applicable to a specific project.

Technical Special Provisions: Specifications, of a technical nature, prepared, signed, and sealed by an Engineer registered in the State of Florida other than the State Specifications Engineer or his designee, that are made part of the Contract as an attachment to the Contract Documents.

Developmental Specification: A specification developed around a new process, procedure, or material.

Standard Plans.

"Standard Plans for Road and Bridge Construction", an electronic book describing and detailing aspects of the Work. Where the term Design Standards appears in the Contract Documents, it will be synonymous with Standard Plans.

Standard Specifications.

See definition for Specifications.

State.

State of Florida.

Subarticle.

A headed and numbered subdivision of an Article of a Section of these Specifications.

Subgrade.

The portion of the roadbed immediately below the base course or pavement, including below the curb and gutter, valley gutter, shoulder and driveway pavement. The subgrade limits ordinarily include those portions of the roadbed shown in the Plans to be constructed to a design bearing value or to be otherwise specially treated. Where no limits are shown in the Plans, the subgrade section extends to a depth of 12 inches below the bottom of the base or pavement and outward to 6 inches beyond the base, pavement, or curb and gutter.

Substructure.

All of that part of a bridge structure below the bridge seats, including the parapets, backwalls, and wingwalls of abutments.

Superintendent.

The Contractor's authorized representative in responsible charge of the work.

Superstructure.

The entire bridge structure above the substructure, including anchorage and anchor bolts, but excluding the parapets, backwalls, and wingwalls of abutments.

Supplemental Agreement.

A written agreement between the Contractor and the Department, and signed by the surety, modifying the Contract within the limitations set forth in these Specifications.

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Supplemental Specifications.
See definition for Specifications.

Surety.
The corporate body that is bound by the Contract Bond with and for the Contractor and responsible for the performance of the Contract and for payment of all legal debts pertaining thereto.

Technical Special Provisions.
See definition for Specifications.

Traveled Way.
The portion of the roadway for the movement of vehicles, exclusive of shoulders and bicycle lanes.

Unilateral Payment.
A payment of money made to the Contractor by the Department pursuant to Section 337.11(12), Florida Statutes (2009), for sums the Department determines to be due to the Contractor for work performed on the project, and whereby the Contractor by acceptance of such payment does not waive any rights the Contractor may otherwise have against the Department for payment of any additional sums the Contractor claims are due for the work.

Work.
All labor, materials and incidentals required to execute and complete the requirements of the Contract including superintendence, use of equipment and tools, and all services and responsibilities prescribed or implied.

Work Order.
A written agreement between the Contractor and the Department modifying the Contract within the limitations set forth in these Specifications. Funds for this agreement are drawn against the Initial Contingency Pay Item or a Contingency Supplemental Agreement.

Working Day.
Any calendar day on which the Contractor works or is expected to work in accordance with the approved work progress schedule.

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SECTION 2
PROPOSAL REQUIREMENTS AND CONDITIONS

2-1 Prequalification of Bidders.

Except as noted below, prequalify with the Department to be eligible to bid. The Department publishes regulations covering prequalification of Bidders under separate cover.

The Department does not require the Bidder to be a prequalified Contractor if bidding construction contracts of $250,000 or less, or if constructing buildings. In addition, at its sole discretion, the Department may waive prequalification requirements on contracts of $500,000 or less.

For construction contracts requiring prequalification, file an application for qualification using the Department's online prequalification application system, giving detailed information with respect to financial resources, equipment, past record, personnel, and experience. For qualified applicants, the Department will issue a certificate fixing the types of work and the aggregate amount of work that the Department allows the prequalified Bidder to have under contract at any one time.

A person or affiliate who has been placed on the convicted vendor list following a conviction for a public entity crime may not submit the following:

1. A bid on a Contract to provide any goods or services to a public entity.
2. A bid on a Contract with a public entity for the construction or repair of a public building or public work.
3. Bids on leases of real property to a public entity.

A person or affiliate who has been placed on the convicted vendor list following a conviction for a public entity crime may not be awarded or perform work as a contractor, supplier, subcontractor, or consultant under a contract with any public entity, and may not transact business with any public entity in excess of the threshold amount provided in Section 287.017 F.S., for Category Two. All restrictions apply for a period of 36 months from the date of placement on the convicted vendor list.

All prequalified Contractors bidding on any Contract must certify their total dollar amount of Work Underway and submit Form 375-020-39 or a spreadsheet in a similar format prior to submitting a bid. This information must be submitted at least once during the month the bid is due via the "Work Underway" link in the Contractor Pre-Qualification System.

2-2 Proposals.

2-2.1 Obtaining Proposal Forms: Obtain Proposal Forms under the conditions stipulated in the Advertisement. The Advertisement states the location and description of the work to be performed; the estimate of the various quantities (if applicable); the pay items of work to be performed (if applicable); the Contract Time; the amount of Proposal Guaranty; and the date, time, and place of the opening of Proposals.

The Plans, Specifications and other documents designated in the Advertisement are part of the Proposal, whether attached or not.

Upon advertising, the Department will make the Proposal Forms available for download as an electronic file from the Online Ordering System or provide the Proposal Forms on portable electronic media as stipulated in the Advertisement. This file contains the information to be used by the Bidder, who has ordered and obtained the Proposal Forms, to submit the Proposal.

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The Department is not responsible for loss of or damage to the portable electronic media after it has been received by or delivered to the Bidder. If loss or damage occurs, the Bidder may order replacement Proposal Forms.

If the Bidder requests replacement Proposal Forms, the Department will attempt to provide the replacement by overnight delivery or by electronic transmittal of the files. The Department will not be held responsible if the Bidder cannot complete and submit a bid due to failure or incomplete delivery of the files.

Unless otherwise indicated in the Advertisement, the Bidder has the option to submit a bid either as an Internet Bid Submittal in accordance with 2-2.3 or as a Hard Copy Bid Submittal in accordance with 2-2.4. When an Internet bid submittal is used, the hard copy will not be considered.

2-2.2 Department Modifications to Contract Documents: Notification of modifications to any Contract Documents will be posted on the Department's website at the following URL address: https://www.fdot.gov/contracts/Lettings/Letting_Project_Info.shtm and will also be transmitted to the Bidder. The email address provided by the Bidder at the time of registration for Online Ordering will be used to transmit notification of modifications. Follow the instructions provided in the notification of modifications to access the amendment files.

The Bidder shall take responsibility for downloading the revised information per the instructions included in the notification of modifications.

2-2.3 Internet Bid Submittals: Unless otherwise indicated in the Advertisement, the Bidder shall use the Department's bid software to prepare a bid for Internet submittal. The Department will accept, as the official bid, the set of Proposal Forms generated from the Department's bid software along with a complete Proposal package, submitted via the Internet in accordance with 2-5 and 2-8. A Digital ID is required to submit a bid via the Internet. Digital IDs may be obtained as outlined in the Advertisement.

The Department will not be responsible for any communications or machine breakdowns, transmission interruptions, delays, or any other problems that interfere with the receipt of Proposals as required above either at the Bidder's transmitting location, at the Department's receiving location, or anywhere between these locations. Receipt or non-receipt of Proposals will not be considered grounds for a bid protest. The Department will not be held responsible if the Bidder cannot complete or submit a bid due to failure or incomplete delivery of the files submitted via the Internet.

2-2.4 Hard Copy Bid Submittals: Unless otherwise indicated in the Advertisement, the Bidder shall use the Department's bid software to prepare a bid for hard copy submittal.

The Department will accept, as the official bid, this set of Proposal Forms generated from the Department's bid software along with a complete Proposal package, delivered to the Department in hard copy in accordance with the instructions listed below and the requirements of 2-5 and 2-8.

Print and submit bid item sheets generated from the Department's bid software on letter size paper. Ensure that all computer generated sheets are legible. Do not submit computer generated sheets using a font size smaller than 9 point.

Return the Department's bid software generated Proposal as the official bid, with the Proposal labeled with the Bidder's Name, Vendor Number, Letting Date, Revision Date (if applicable) and the Proposal ID.

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2-3 Interpretation of Estimated Quantities.

2-3.1 Lump Sum Contracts: The Bidder is responsible for the determination of the quantities for those items constructed within the authorized plan limits or dimensions.

The Department does not assume any responsibility for any incidental information in bid documents that may be construed as a quantity of work and/or materials.

2-3.2 Contracts other than Lump Sum: For those items constructed within authorized plan limits or dimensions, use the quantities shown in the Plans and in the Proposal Form as the basis of the bid. The Department will also use these quantities for final payment as limited by the provisions for the individual items. For those items having variable final pay quantities that are dependent on actual field conditions, use and measurement, the quantities shown in the Plans and in the Proposal Form are approximate and provide only a basis for calculating the bid upon which the Department will award the Contract. Where items are listed for payment as lump sum units and the Plans show estimates of component quantities, the Department is responsible for the accuracy of those quantities limited to the provisions of 9-3.3. Where items are listed for payment as lump sum units and the Plans do not show estimates of component quantities, the Bidder is solely responsible for their own estimates of such quantities.

The Department may increase, decrease, or omit the estimated quantities of work to be done or materials to be furnished.

2-4 Examination of Plans, Specifications, Special Provisions, and Site of Work.

Examine the Contract Documents and the site of the proposed work carefully before submitting a Proposal for the work contemplated. Investigate the conditions to be encountered, as to the character, quality, and quantities of work to be performed and materials to be furnished and as to the requirements of all Contract Documents.

The Department does not guarantee the details pertaining to borings, and pavement cores as shown in the Contract Documents, to be more than a general indication of the materials likely to be found adjacent to holes bored at the site of the work, approximately at the locations indicated. The Bidder shall examine boring and pavement core data, where available, and make their own interpretation of the subsoil investigations and other preliminary data and shall base their bid solely on their own opinion of the conditions likely to be encountered.

The Bidder's submission of a Proposal is prima facie evidence that the Bidder has made an examination as described in this Article.

2-5 Preparation of Proposals.

2-5.1 General: Submit Proposals on the Proposal Form described in 2-2. Any pay item that will be provided free or at no cost to the Department shall be indicated as "free" or "$.00". If the pay item is left blank or n/a is used, the bid may be declared irregular. Show the total of the bid on the face of the Proposal.

2-5.2 Internet Bid Submittals: The Bidder shall execute the Proposal under the Bidder's Digital ID and enter the firm's bidding office street address on the Bidders Information Tab in the Department's bid software. This Digital ID represents the firm as an individual, partnership, corporation, limited liability company, or joint venture. By entering and submitting the Digital ID the authorized parties obligate the firm to the bid. Internet Bid Submittals must acknowledge, on behalf of, the person, firm, association, or corporation submitting the bid certifying that such person, firm, association, or corporation has not, either directly or indirectly, entered into any agreement, participated in any collusion, or otherwise taken any action in restraint of free

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competitive bidding in connection with the submitted bid, by indicating such in the Proposal. The Department will not consider any bid unless such acknowledgment is included.

2-5.3 Hard Copy Bid Submittals: If the Proposal is made by an individual, either in the Bidder's own proper person or under a trade or firm name, the Bidder shall execute the Proposal under the Bidder's signature and enter the firm's bidding office street address. If the Proposal is made by a partnership, execute the Proposal by setting out in full the names of the partners, the firm name of the partnership, if any, have two or more of the general partners or authorized person sign the Proposal and enter the firm's bidding office street address. If the Proposal is made by a corporation, execute the Proposal by setting out in full the corporate name and have the president or other legally authorized corporate officer or agent sign the Proposal, affix the corporate seal and enter the corporation's bidding office street address. If the Proposal is made by a limited liability company, execute the Proposal by setting out the company name, have the manager or authorized member sign the Proposal and enter the company's bidding office address. If the Proposal is made by a joint venture, execute the Proposal by setting out the joint venture name, have the authorized parties sign the Proposal and enter the bidding office's street address. File with the Department Form 375-020-08, contained in the Proposal, which includes an unsworn statement executed by, or on behalf of, the person, firm, association, or corporation submitting the bid certifying that such person, firm, association, or corporation has not, either directly or indirectly, entered into any agreement, participated in any collusion, or otherwise taken any action in restraint of free competitive bidding in connection with the submitted bid. The Department will not consider any bid unless such form is properly completed in accordance with the requirements shown thereon.

2-6 Rejection of Irregular Proposals.

A Proposal is irregular and the Department may reject such Proposal if the Proposal shows omissions, alterations of form, additions not specified or required, conditional or unauthorized alternate bids, or irregularities of any kind; or if the unit prices are obviously unbalanced, or if the cost is in excess of or below the reasonable cost analysis values, or if the Bidder submits a Proposal which was not generated using the Department's bid software.

When the Department provides for alternate bids in the Proposal Form, make only one entry for each alternate. A Proposal that provides for alternative bids is irregular and the Department may reject such Proposal if the Bidder makes entries for more than one alternate.

2-7 Guaranty to Accompany Proposals.

The Department will not consider any Proposal unless accompanied by a Proposal Guaranty of the character and amount indicated in the Advertisement, and unless made payable to the Florida Department of Transportation. Submit the Proposal with the understanding that the successful Bidder shall furnish a Contract Bond pursuant to the requirements of 3-5.

The Bidder's Proposal Guaranty is binding for all projects included in the Contract awarded to the Contractor pursuant to the provisions of this Subarticle.

2-8 Delivery of Proposals.

2-8.1 Internet Bid Submittals: Unless otherwise indicated in the Advertisement, the Proposal may be submitted via the Internet. The Department will not accept responsibility for Internet bids not meeting the time requirement stipulated in the Advertisement.

2-8.2 Hard Copy Bid Submittals: Unless otherwise indicated in the Advertisement, the Proposal may be submitted via hard copy. Submit the Proposal in a sealed envelope, bearing on

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the outside the name of the Bidder, the Bidder's address, and the Proposal ID of the project for which the Bidder submitted the bid. For Proposals that are submitted by mail, enclose the Proposal in a sealed envelope, marked as directed above. Enclose the sealed envelope in a second outer envelope addressed to the Department, at the place designated in the Advertisement. For a Proposal that is not submitted by mail, deliver the Proposal to the Contracts Office of the Department, or to the place as designated in the Advertisement. The Department will not consider Proposals received after the time set for opening bids. The Department will retain these Proposals unopened.

2-9 Withdrawal or Revision of Proposals.

2-9.1 Internet Bid Submittals: A Bidder may withdraw a Proposal any time prior to the bid submittal deadline specified in the Advertisement. The resubmission of any Proposal so withdrawn must be made as a complete Proposal, subject to the provisions of 2-8.

A Bidder may revise a Proposal any time prior to the bid submittal deadline specified in the Advertisement. Revisions may be made via Internet in accordance with 2-8.1 or by fax in accordance with 2-9.2.

The Department will not be responsible for any communications or machine breakdowns, transmission interruptions, delays, or any other problems that interfere with the receipt of revisions to Proposals as required above either at the Bidder's transmitting location, at the Department's receiving location, or anywhere between these locations. Receipt or non-receipt of revisions to a Proposal will not be considered grounds for a bid protest. The Department will not be held responsible if the Bidder cannot complete or submit revisions to a bid due to failure or incomplete delivery of the files submitted via the Internet.

2-9.2 Hard Copy Bid Submittals: A Bidder may withdraw or revise a Proposal after submission, provided the Department receives a written request to withdraw or revise the Proposal prior to the time set for opening of bids. The resubmission of any Proposal withdrawn under this provision is subject to the provisions of 2-8.

Legible facsimile (FAX) Proposal changes will be accepted if received in full at the fax number listed in the Bid Solicitation Notice by the time Proposals are due on the day of the letting and provided that all of the following conditions are met:

1. The Bidder's name is the same on the faxed Proposal change as shown on the original Proposal.
2. The Proposal change includes the following:
    a. The correct Proposal ID.
    b. The correct bid item number for which the price is being changed and the respective unit price change.
    c. The correct revised total per item.
    d. The revised total bid amount.
    e. The signature of the President or Vice President of the Company.

Faxed Proposal changes failing to meet all of these requirements will not be considered and will not change the original bid.

The Department will not be responsible for any communications or fax machine breakdowns, transmission interruptions, delays, or any other problems that interfere with the receipt of faxed Proposal changes as required above either at the Bidder's fax location, at the Department's fax location, or anywhere between these locations. Receipt or non-receipt of a faxed Proposal change will not be considered grounds for a bid protest.

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2-10 Opening of Proposals.

The Department will open and publicly announce Proposals at the time and place indicated in the Advertisement. The Department invites Bidders, their authorized agents, and other interested parties to attend.

2-11 Disqualification of Bidders.

The Department may disqualify any Bidder and reject the Bidder's Proposal or Proposals for any of the following reasons:

1. The submission of more than one Proposal for the same work from an individual, firm, or corporation under the same or a different name.
2. Evidence that one Bidder has a financial interest in the firm of another Bidder for the same work.
3. Evidence of collusion among Bidders. The Department will not recognize a participant in such collusion as a Bidder for any future work of the Department until the Department reinstates such participant as a qualified Bidder.
4. Failure to qualify in accordance with 2-1.
5. Uncompleted work on other projects that, in the judgment of the Department, could hinder or prevent the prompt completion of the proposed work.
6. Failure to pay or satisfactorily settle all bills due for labor and material on other contracts in force at the time of advertisement for bids.
7. Default under a previous contract.
8. Employment of unauthorized aliens in violation of Section 274A (e) of the Immigration and Nationality Act.
9. Falsification on any form required by the Department.
10. The submission of a Proposal that was not solicited by the Department.

2-12 Material, Samples and Statement.

The Department may require that the Bidder furnish a statement of the origin, composition, and manufacture of any and all materials to be used in the construction of the work, together with samples that may be subjected to the tests provided for in these Specifications to determine the materials' quality and fitness for the work.

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SECTION 3
AWARD AND EXECUTION OF CONTRACT

3-1 Consideration of Bids.

For the purpose of award, after opening and reading the Proposals, the Department will consider as the bid the correct summation of each unit bid price multiplied by the estimated quantities shown in the Proposal. On this basis, the Department will compare the amounts of each bid and make the results of such comparison available to the public. Until the actual award of the Contract, however, the Department reserves the right to reject any or all Proposals and to waive technical errors that the Department determines, in its sole discretion, to be in the best interest of the State.

The Department reserves the right to delete the bid portion of the utility relocation work from the Contract. When the Department deletes utility relocation work from the Contract, the Department will recalculate the Contract bid tabulations based on the remaining project quantities.

In the event that the Department deletes utility relocation work from the Contract, the utility owner will relocate such utilities in accordance with the backup Utility Relocation Schedule contained in the Contract Documents.

3-2 Award of Contract.

3-2.1 General: If the Department decides to award the Contract, the Department will award the Contract to the lowest responsible Bidder whose Proposal complies with all the Contract Document requirements. If awarded, the Department will award the Contract within 50 days after the opening of the Proposals, unless the Special Provisions change this time limit, or the Bidder and the Department extend the time period by mutual consent.

Prior to award of the Contract by the Department, the Bidder must provide proof of authorization to conduct business in the State of Florida.

3-2.2 Bids Exceeding Bidder's Maximum Capacity Rating: Prior to award of the Contract, the Department will address bids exceeding a Bidder's maximum capacity rating, and the resulting impact on the Bidder's qualification to bid, in accordance with Florida Administrative Code Rules 14-22.003 and 14-22.009.

3-3 Cancellation of Award.

The Department reserves the right to cancel the award of any Contract at any time before the execution of the Contract by all parties, with no compensation due any of the Bidders.

3-4 Release of Proposal Guaranty.

The Department will release all Proposal Guaranties except those of the two lowest responsible Bidders immediately following the opening and checking of the Proposals. The Department will immediately release the Proposal Guaranty of the two lowest responsible Bidders after the successful Bidder delivers the executed Contract and a satisfactory Contract Bond to the Department, except that the Department will not retain the Proposal Guaranty of the next-to-lowest responsible Bidder longer than 50 days after the opening of the Proposals unless the Department awards the Contract to the next lowest responsible Bidder prior to the expiration of this time limit.

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3-5 Contract Bond Required.

3-5.1 General Requirements of the Contract Bond: Upon award, furnish to the Department, and maintain in effect throughout the life of the Contract, an acceptable Contract Bond in a sum at least equal to the amount of the Contract. Execute such Contract Bond on Department Form 375-020-27. Obtain the Contract Bond from a Surety licensed to conduct business in the State of Florida, meeting all of the requirements of the laws of Florida and the regulations of the Department, and having the Department's approval. Ensure that the Surety's Florida Licensed Insurance Agent's name, address, and telephone number is clearly stated on the Contract Bond form.

The Department may waive the requirement for all or a portion of a Contract Bond if:

1. The Contract amount is $250,000 or less, and the Department determines that the project is of a noncritical nature and that nonperformance will not endanger the public health, safety, or property;
2. The Contractor is a qualified nonprofit agency for the blind or for the other severely handicapped under Section 413.036(2), Florida Statutes; or,
3. The Contractor uses a subcontractor that is a qualified nonprofit agency for the blind or for the other severely handicapped under Section 413.036(2), Florida Statutes. However, the Department may not waive more than the amount of the subcontract.

The Department may require alternate means of security if it waives the requirement for a Contract Bond.

3-5.2 Continued Acceptability of Surety: Provide a Contract Bond that remains acceptable to the Department throughout the life of the Contract. In the event that the Surety executing the Contract Bond, although acceptable to the Department at the time of execution of the Contract, subsequently becomes insolvent or bankrupt, or becomes unreliable or otherwise unsatisfactory due to any cause that becomes apparent after the Department's initial approval of the Surety, then the Department may require that the Contractor immediately replace the Contract Bond with a similar Contract Bond issued by a Surety that is reliable and acceptable to the Department. In such an event, the Department will bear all costs of the premium for the new Contract Bond, after deducting any amounts that are returned to the Contractor from their payment of premium on the original Contract Bond.

3-5.3 Default by Contractor: In case of default on the part of the Contractor, the Department will charge against the Contract Bond all expenses for services incidental to ascertaining and collecting losses under the Contract Bond, including accounting, engineering, and legal services, together with any and all costs incurred in connection with renegotiation of the Contract.

3-5.4 Surety to Furnish Legal Defense as to Payment and Performance Claims or Suits: The Surety shall indemnify and provide defense for the Department when called upon to do so for all claims or suits against the Department, by third parties, pertaining to Contractor payment or performance issues arising out of the Contract where the Contractor has failed to timely provide the Department such defense. It is expressly understood that the monetary limitation on the extent of the indemnification shall be the approved Contract amount, which shall be the original Contract amount as may be modified by subsequent Supplemental Agreements.

3-5.5 Liability for Wrongful or Criminal Act by Contractor: The principal and Surety executing the Contract Bond shall be liable to the State in any civil action that might be instituted

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by the Department or any officer of the State authorized in such cases, for double any amount in money or property the State might lose, or be overcharged, or otherwise be defrauded of by any wrongful or criminal act of the Contractor, their agent or their employees.

3-6 Execution of Contract and Contract Bond.

Within 10 calendar days, excluding Saturdays, Sundays, and State holidays, after receipt of the Contract award, execute the necessary agreements to enter into a Contract with the Department and return the Contract along with a satisfactory Contract Bond and documentation evidencing all insurance required by 7-13 to the Department's Contracts Office that awarded the Contract. For each calendar day, excluding Saturdays, Sundays, and State holidays, the Contractor is late in delivering to the Department's Contracts Office all required documents in properly executed form, the Department will deduct one day from the Contract Time. The Department will not be bound by any Proposal until the Department executes the associated Contract.

The Department will execute the Contract within 5 calendar days, excluding Saturdays, Sundays, and State holidays, after receipt of the signed Contract, necessary agreements, Contract Bond, and all other required documents from the Contractor.

3-7 Failure by Contractor to Execute Contract and Furnish Bond.

In the event that the Contractor fails to execute the awarded Contract and to submit an acceptable Contract Bond, as prescribed in 3-5 and 3-6, within 10 calendar days, excluding Saturdays, Sundays, and State holidays, of receipt of the Contract award, the Department may annul the award, causing the Contractor to forfeit the Proposal Guaranty to the Department as liquidation of damages sustained. The Department may then award the Contract to the next lowest responsible Bidder, re-advertise, or accomplish the Work using alternate resources.

3-8 Audit of Contractor's Records.

Upon execution of the Contract, the Department reserves the right to conduct an audit of the Contractor's records pertaining to the project. The Department or its representatives may conduct an audit, or audits, at any time prior to final payment, or thereafter pursuant to 5-13. The Department may also require submittal of the records from either the Contractor or any subcontractor or material supplier. As the Department deems necessary, records include all books of account, supporting documents, and papers pertaining to the cost of performance of the Work.

Retain all records pertaining to the Contract for a period of not less than three years from the date of the Engineer's final acceptance of the project, unless a longer minimum period is otherwise specified. Upon request, make all such records available to the Department or its representative(s). For the purpose of this Article, records include but are not limited to all books of account, supporting documents, and papers that the Department deems necessary to ensure compliance with the provisions of the Contract Documents.

If the Contractor fails to comply with these requirements, the Department may disqualify or suspend the Contractor from bidding on or working as a subcontractor on future Contracts.

Ensure that the subcontractors provide access to their records pertaining to the project upon request by the Department.

Comply with Section 20.055(5), Florida Statutes, and incorporate in all subcontracts the obligation to comply with Section 20.055(5), Florida Statutes.

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3-9 Public Records.

The Contractor shall comply with Chapter 119, Florida Statutes. Specifically, the Contractor shall:

1. Keep and maintain public records required by the Department to perform the service.

2. Upon request from the Department's custodian of public records, provide the Department with a copy of the requested records or allow the records to be inspected or copied within a reasonable time at a cost that does not exceed the cost provided in Chapter 119, Florida Statutes, or as otherwise provided by law.

3. Ensure that public records that are exempt or confidential and exempt from public records disclosure requirements are not disclosed except as authorized by law for the duration of the Contract term and following completion of the Contract if the Contractor does not transfer the records to the Department.

4. Upon completion of the Contract, transfer at no cost to the Department, all public records in possession of the Contractor or keep and maintain public records required by the Department to perform the service. If the Contractor transfers all public records to the Department upon completion of the Contract, the Contractor shall destroy any duplicate public records that are exempt or confidential and exempt from public records disclosure requirements. If the Contractor keeps and maintains public records upon completion of the Contract, the Contractor shall meet all applicable requirements for retaining public records. All records stored electronically must be provided to the Department, upon request from the Department's custodian of public records, in a format that is compatible with the information technology systems of the Department.

Failure to comply with Chapter 119, Florida Statutes and the Article 3-9 shall be grounds for immediate unilateral termination of this Contract by the Department pursuant to 8-9.1.

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SECTION 4
SCOPE OF THE WORK

4-1 Intent of Contract.

The intent of the Contract is to provide for the construction and completion in every detail of the work described in the Contract. Furnish all labor, materials, equipment, tools, transportation, and supplies required to complete the work in accordance with the Contract Documents.

Upon execution of the Contract, conduct all written communication associated with the Contract using a paperless electronic means. When the Specifications require a submission of documentation, such documents must be submitted and exchanged electronically using the Department provided web-based collaboration site.

All documents requiring a signature must be executed electronically by both parties in accordance with Chapter 668, Florida Statutes, and have the same force and effect as a written signature. All persons requiring access to the collaboration site shall be identified during the preconstruction conference. Persons may be added or removed during the life of the Contract on an as needed basis. All signatories must acquire a digital signature certificate.

4-2 Work not covered by Standard Specifications.

Proposed construction and any contractual requirements not covered by these Standard Specifications may be covered by Contract Plan notes or by Supplemental Specifications or Special Provisions for the Contract, and all requirements of such Supplemental Specifications or Special Provisions shall be considered as a part of these Specifications.

4-3 Alteration of Plans or of Character of Work.

4-3.1 General: The Engineer reserves the right to make, at any time prior to or during the progress of the work, such increases or decreases in quantities, whether a significant change or not, and such alterations in the details of construction, whether a substantial change or not, including but not limited to alterations in the grade or alignment of the road or structure or both, as may be found necessary or desirable by the Engineer. Such increases, decreases or alterations shall not constitute a breach of Contract, shall not invalidate the Contract, nor release the Surety from any liability arising out of this Contract or the Surety bond. The Contractor agrees to perform the work, as altered, the same as if it had been a part of the original Contract.

The term “significant change” applies only when:

1. The Engineer determines that the character of the work as altered differs materially in kind or nature from that involved or included in the original proposed construction, or

2. A major item of work, as defined in 1-3, is increased in excess of 125% or decreased below 75% of the original Contract quantity. The Department will apply any price adjustment for an increase in quantity only to that portion in excess of 125% of the original Contract item quantity in accordance with 4-3.2 below. In the case of a decrease below 75% the Department will only apply a price adjustment for the additional costs that are a direct result of the reduction in quantity.

In (1) above, the determination by the Engineer shall be conclusive. If the determination is challenged by the Contractor in any proceeding, the Contractor must establish

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by clear and convincing proof that the determination by the Engineer was without any reasonable basis.

4-3.2 Increase, Decrease or Alteration in the Work: The Engineer reserves the right to make alterations in the character of the work which involve a substantial change in the nature of the design or in the type of construction or which materially increases or decreases the cost or time of performance. Such alteration shall not constitute a breach of Contract, shall not invalidate the Contract or release the Surety.

Notwithstanding that the Contractor shall have no formal right whatsoever to any extra compensation or time extension deemed due by the Contractor for any cause unless and until the Contractor follows the procedures set forth in 5-12.2 for preservation, presentation and resolution of the claim, the Contractor may at any time, after having otherwise timely submitted a notice of intent to claim or preliminary time extension request pursuant to 5-12.2 and 8-7.3.2, submit to the Department a request for equitable adjustment of compensation or time or other dispute resolution proposal. The Contractor shall in any request for equitable adjustment of compensation, time, or other dispute resolution proposal certify under oath and in writing, in accordance with the formalities required by Florida law, that the request is made in good faith, that any supportive data submitted is accurate and complete to the Contractor's best knowledge and belief, and that the amount of the request accurately reflects what the Contractor in good faith believes to be the Department's responsibility. Such certification must be made by an officer or director of the Contractor with the authority to bind the Contractor. Any such certified statements of entitlement and costs shall be subject to the audit provisions set forth in 5-12.14. While the submittal or review of a duly certified request for equitable adjustment shall neither create, modify, nor activate any legal rights or obligations as to the Contractor or the Department, the Department will review the content of any duly certified request for equitable adjustment or other dispute resolution proposal, with any further action or inaction by the Department thereafter being in its sole discretion. Any request for equitable adjustment that fails to fully comply with the certification requirements will not be reviewed by the Department.

The monetary compensation provided for below constitutes full and complete payment for such additional work and the Contractor shall have no right to any additional monetary compensation for any direct or indirect costs or profit for any such additional work beyond that expressly provided below. The Contractor shall be entitled to a time extension only to the extent that the performance of any portion of the additional work is a controlling work item and the performance of such controlling work item actually extends completion of the project due to no fault of the Contractor. All time related costs for actual performance of such additional work are included in the compensation already provided below and any time extension entitlement hereunder will be without additional monetary compensation. The Contractor shall have no right to any monetary compensation or damages whatsoever for any direct or indirect delay to a controlling work item arising out of or in any way related to the circumstances leading up to or resulting from additional work (but not relating to the actual performance of the additional work, which is paid for as otherwise provided herein), except only as provided for under 5-12.6.2.1.

4-3.2.1 Allowable Costs for Extra Work: The Engineer may direct in writing that extra work be done and, at the Engineer's sole discretion, the Contractor will be paid pursuant to an agreed Supplemental Agreement or in the following manner:

1. Labor and Burden: The Contractor will receive payment for actual costs of direct labor and burden for the additional or unforeseen work. Labor includes foremen

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actually engaged in the work; and will not include project supervisory personnel nor necessary on-site clerical staff, except when the additional or unforeseen work is a controlling work item and the performance of such controlling work item actually extends completion of the project due to no fault of the Contractor. Compensation for project supervisory personnel, but in no case higher than a Project Manager's position, shall only be for the pro-rata time such supervisory personnel spent on the contract. In no case shall an officer or director of the Company, nor those persons who own more than 1% of the Company, be considered as project supervisory personnel, direct labor or foremen hereunder.

Payment for burden shall be limited solely to the following:

Table 4-1	
Item	Rate
FICA	Rate established by Law
FUTA/SUTA	Rate established by Law
Medical Insurance	Actual
Holidays, Sick & Vacation benefits	Actual
Retirement benefits	Actual
Workers Compensation	Rates based on the National Council on Compensation Insurance basic rate tables adjusted by Contractor's actual experience modification factor in effect at the time of the additional work or unforeseen work.
Per Diem	Actual but not to exceed State of Florida's rate
Insurance*	Actual
*Compensation for Insurance is limited solely to General Liability Coverage and does not include any other insurance coverage (such as, but not limited to, Umbrella Coverage, Automobile Insurance, etc.).	

At the Pre-construction conference, certify to the Engineer the following:

a. A listing of on-site clerical staff, supervisory personnel and their pro-rated time assigned to the contract,

b. Actual Rate for items listed in Table 4-1,

c. Existence of employee benefit plan for Holiday, Sick and Vacation benefits and a Retirement Plan, and,

d. Payment of Per Diem is a company practice for instances when compensation for Per Diem is requested.

Such certification must be made by an officer or director of the Contractor with authority to bind the Contractor. Timely certification is a condition precedent to any right of the Contractor to recover compensations for such costs, and failure to timely submit the certification will constitute a full, complete, absolute and irrevocable waiver by the Contractor of any right to recover such costs. Any subsequent changes shall be certified to the Engineer as part of the cost proposal or seven calendar days in advance of performing such extra work.

2. Materials and Supplies: For materials accepted by the Engineer and used on the project, the Contractor will receive the actual cost of such materials incorporated into the work, including Contractor paid transportation charges (exclusive of equipment as hereinafter

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set forth). For supplies reasonably needed for performing the work, the Contractor will receive the actual cost of such supplies.

3. Equipment: For any machinery or special equipment (other than small tools), including fuel and lubricant, the Contractor will receive 100% of the "Rental Rate Blue Book" for the actual time that such equipment is in operation on the work, and 50% of the "Rental Rate Blue Book" for the time the equipment is directed to standby and remain on the project site, to be calculated as indicated below. The equipment rates will be based on the latest edition (as of the date the work to be performed begins) of the "Rental Rate Blue Book for Construction Equipment" as published by EquipmentWatch, a division of Informa Business Media, Inc., using all instructions and adjustments contained therein and as modified below. On all projects, the Engineer will adjust the rates using regional adjustments and Rate Adjustment Tables according to the instructions in the "Rental Rate Blue Book."

Allowable Equipment Rates will be established as set out below:

a. Allowable Hourly Equipment Rate = Monthly Rate/176 x Adjustment Factors x 100%.

b. Allowable Hourly Operating Cost = Hourly Operating Cost x 100%.

c. Allowable Rate Per Hour = Allowable Hourly Equipment Rate + Allowable Hourly Operating Cost.

d. Standby Rate = Allowable Hourly Equipment Rate x 50%.

The Monthly Rate is The Basic Machine Rate Plus Any Attachments. Standby rates will apply when equipment is not in operation and is directed by the Engineer to standby at the project site when needed again to complete work and the cost of moving the equipment will exceed the accumulated standby cost. Standby rates will not apply on any day the equipment operates for eight or more hours. Standby payment will be limited to only that number of hours which, when added to the operating time for that day equals eight hours. Standby payment will not be made on days that are not normally considered work days on the project.

The Department will allow for the cost of transporting the equipment to and from the location at which it will be used. If the equipment requires assembly or disassembly for transport, the Department will pay for the time to perform this work at the rate for standby equipment.

Equipment may include vehicles utilized only by Labor, as defined above.

4. Indirect Costs, Expenses, and Profit: Compensation for all indirect costs, expenses, and profit of the Contractor, including but not limited to overhead of any kind, whether jobsite, field office, division office, regional office, home office, or otherwise, is expressly limited to the greater of either (a) or (b) below:

a. Solely a mark-up of 17.5% on the payments in (1) through (3), above.

1. Bond: The Contractor will receive compensation for any premium for acquiring a bond for such additional or unforeseen work at the original Contract bond rate paid by the Contractor. No compensation for bond premium will be allowed for additional or unforeseen work paid by the Department via initial contingency pay item.

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2. The Contractor will be allowed a markup of 10% on the first $50,000 and a markup of 5% on any amount over $50,000 on any subcontract directly related to the additional or unforeseen work. Any such subcontractor mark-up will be allowed only by the prime Contractor and a first tier subcontractor, and the Contractor must elect the markup for any eligible first tier subcontractor to do so.

b. Solely the formula set forth below and only as applied solely as to such number of calendar days of entitlement that are in excess of ten cumulative calendar days as defined below.

$$D = \frac{A \times C}{B}$$

Where A = Original Contract Amount
B = Original Contract Time
C = 8%
D = Average Overhead Per Day

Cumulative Calendar Days is defined as the combined total number of calendar days granted as time extensions due to either extra work, excluding overruns to existing contract items, that extend the duration of the project or delay of a controlling work item caused solely by the Department, or the combined total number of calendar days for which a claim of entitlement to a time extension due to delay of a controlling work item caused solely by the Department is otherwise ultimately determined to be in favor of the Contractor.

No compensation, whatsoever, will be paid to the Contractor for any jobsite overhead and other indirect impacts when the total number of calendar days granted for time extension due to delay of a controlling work item caused solely by the Department is, or the total number of calendar days for which entitlement to a time extension due to delay of a controlling work item caused solely by the Department is otherwise ultimately determined in favor of the Contractor to be, equal to or less than ten calendar days and the Contractor also fully assumes all monetary risk of any and all partial or single calendar day delay periods, due to delay of a controlling work item caused solely by the Department, that when combined together are equal to or less than ten calendar days and regardless of whether monetary compensation is otherwise provided for hereunder for one or more calendar days of time extension entitlement for each calendar day exceeding ten calendar days. All calculations under this provision shall exclude weather days, Holidays, and Special Events.

Further, for (a) or (b) above, in the event there are concurrent delays to one or more controlling work items, one or more being caused by the Department and one or more being caused by the Contractor, the Contractor shall be entitled to a time extension for each day that a controlling work item is delayed by the Department but shall have no right to nor receive any monetary compensation for any indirect costs for any days of concurrent delay.

4-3.2.2 Subcontracted Work: Compensation for the additional or unforeseen work performed by a subcontractor shall be limited solely to that provided for in 4-3.2.1 (1), (2), (3) and (4)(a). In addition, the Contractor compensation is expressly limited to the greater of the total provided in either 4-3.2.1(4)(a) or (4)(b), except that the Average Overhead Per-Day calculation is as follows:

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$$Ds = \frac{As \times C}{B}$$

Where As = Original Contract Amount minus Original Subcontract amounts(s)*

B = Original Contract Time
C = 8%
Ds = Average Overhead Per-Day

* deduct Original Subcontract Amount(s) of subcontractor(s) performing the work

The subcontractor may receive compensation for any premium for acquiring a bond for the additional or unforeseen work; provided, however, that such payment for additional subcontractor bond will only be paid upon presentment to the Department of clear and convincing proof that the subcontractor has actually submitted and paid for separate bond premiums for such additional or unforeseen work in such amount and that the subcontractor was required by the Contractor to acquire a bond.

The Contractor shall require the subcontractor to submit a certification, in accordance with 4-3.2.1 (1), as part of the cost proposal and submit such to the Engineer. Such certification must be made by an officer or director of the subcontractor with authority to bind the subcontractor. Timely certification is a condition precedent to any right of the Contractor to recover compensation for such subcontractor costs, and failure to timely submit the certification will constitute a full, complete, absolute and irrevocable waiver by the Contractor of any right to recover such subcontractor costs.

4-3.3 No Waiver of Contract: Changes made by the Engineer will not be considered to waive any of the provisions of the Contract, nor may the Contractor make any claim for loss of anticipated profits because of the changes, or by reason of any variation between the approximate quantities and the quantities of work actually performed. All work shall be performed as directed by the Engineer and in accordance with the Contract Documents.

4-3.4 Conditions Requiring a Supplemental Agreement or Unilateral Payment: A Supplemental Agreement or Unilateral Payment will be used to clarify the Plans and Specifications of the Contract; to provide for unforeseen work, grade changes, or alterations in the Plans which could not reasonably have been contemplated or foreseen in the original Plans and Specifications; to change the limits of construction to meet field conditions; to provide a safe and functional connection to an existing pavement; to settle documented Contract claims; to make the project functionally operational in accordance with the intent of the original Contract and subsequent amendments thereto.

A Supplemental Agreement or Unilateral Payment may be used to expand the physical limits of the project only to the extent necessary to make the project functionally operational in accordance with the intent of the original Contract. The cost of any such agreement extending the physical limits of the project shall not exceed $100,000 or 10% of the original Contract price, whichever is greater.

Perform no work to be covered by a Supplemental Agreement or Unilateral Payment before written authorization is received from the Engineer. The Engineer’s written authorization will set forth sufficient work information to allow the work to begin. The work

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activities, terms and conditions will be reduced to written Supplemental Agreement or Unilateral Payment form promptly thereafter. No payment will be made on a Supplemental Agreement or Unilateral Payment prior to the Department's approval of the document.

4-3.5 Extra Work: Extra work authorized in writing by the Engineer will be paid in accordance with the formula in 4-3.2. Such payment will be the full extent of all monetary compensation entitlement due to the Contractor for such extra work. Any entitlement to a time extension due to extra work will be limited solely to that provided for in 4-3.2 for additional work.

4-3.6 Connections to Existing Pavement, Drives and Walks: Generally adhere to the limits of construction at the beginning and end of the project as detailed in the Plans. However, if the Engineer determines that it is necessary to extend the construction in order to make suitable connections to existing pavement, the Engineer will authorize such a change in writing.

For necessary connections to existing walks and drives that are not indicated in the Plans, the Engineer will submit direction regarding the proper connections in accordance with the Standard Plans.

4-3.7 Differing Site Conditions: During the progress of the work, if subsurface or latent physical conditions are encountered at the site differing materially from those indicated in the Contract, or if unknown physical conditions of an unusual nature differing materially from those ordinarily encountered and generally recognized as inherent in the work provided for in the Contract are encountered at the site, the party discovering such conditions shall promptly notify the other party in writing of the specific differing conditions before the Contractor disturbs the conditions or performs the affected work.

Upon receipt of written notification of differing site conditions from the Contractor, the Engineer will investigate the conditions, and if it is determined that the conditions materially differ and cause an increase or decrease in the cost or time required for the performance of any work under the Contract, an adjustment will be made, excluding loss of anticipated profits, and the Contract will be modified in writing accordingly. The Engineer will notify the Contractor whether or not an adjustment of the Contract is warranted.

The Engineer will not allow a Contract adjustment for a differing site condition unless the Contractor has submitted the required written notice.

The Engineer will not allow a Contract adjustment under this clause for any effects caused to any other Department or non-Department projects on which the Contractor may be working.

4-3.8 Changes Affecting Utilities: The Contractor shall be responsible for identifying and assessing any potential impacts to a utility that may be caused by the changes proposed by the Contractor, and the Contractor shall at the time of making the request for a change notify the Department in writing of any such potential impacts to utilities.

Department approval of a Contractor proposed change does not relieve the Contractor of sole responsibility for all utility impacts, costs, delays or damages, whether direct or indirect, resulting from Contractor initiated changes in the design or construction activities from those in the original Contract Specifications, Design Plans (including Traffic Control Plans) or other Contract Documents and which effect a change in utility work different from that shown in the Utility Plans, joint project agreements or utility relocation schedules.

4-3.9 Cost Savings Initiative Proposal:

4-3.9.1 Intent and Objective:

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1. This Subarticle applies to any cost reduction proposal (hereinafter referred to as a Proposal) that the Contractor initiates and develops for the purpose of refining the Contract to increase cost effectiveness or significantly improve the quality of the end result. A mandatory Cost Savings Initiative Workshop will be held prior to Contract Time beginning for the Contractor and Department to discuss potential Proposals. This mandatory workshop can only be eliminated if agreed to in writing by both the Contractor and Department. This Subarticle does not, however, apply to any such proposal unless the Contractor identifies it at the time of its submission to the Department as a proposal submitted pursuant to this Subarticle.

2. The Department will consider Proposals that would result in net savings to the Department by providing a decrease in the cost of the Contract. Proposals must result in savings without impairing essential functions and characteristics such as safety, service, life, reliability, economy of operation, ease of maintenance, aesthetics and necessary standard design features. The Department will not recognize the Contractor's correction of plan errors that result in a cost reduction, as a Proposal. Deletions of work, approved by the Engineer, that are the sole objective of the Proposal will include a cost sharing percentage with the Contractor as defined in Subarticle 4-3.9.7.

3. The Department shall have the right to reject, at its discretion, any Proposal submitted that proposes a change in the design of the pavement system or that would require additional right-of-way. Pending the Department's execution of a formal supplemental agreement implementing an approved Proposal, the Contractor shall remain obligated to perform the work in accordance with the terms of the existing Contract. The Department may grant time extensions to allow for the time required to develop and review a Proposal.

4. For potential Proposals not discussed at the Cost Savings Initiative Workshop, a mandatory concept meeting will be held for the Contractor and Department to discuss the potential Proposal prior to development of the Proposal. This mandatory meeting can only be eliminated if agreed to in writing by both the Contractor and Department.

4-3.9.2 Subcontractors: The Department encourages the Contractor to include the provisions of this Subarticle in Contracts with subcontractors and to encourage submission of Proposals from subcontractors. However, it is not mandatory to submit Proposals to the Department or to accept or transmit subcontractor proposed Proposals to the Department.

4-3.9.3 Data Requirements: As a minimum, submit the following information with each Proposal:

1. a description of the difference between the existing Contract requirement, including any time extension request, and the proposed change, and the comparative advantages and disadvantages.

2. separate detailed cost estimates for both the existing Contract requirement and the proposed change. Break down the cost estimates by pay item numbers indicating quantity increases or decreases and deleted pay items. Identify additional proposed work not covered by pay items within the Contract, by using pay item numbers in the Basis of Estimates Manual. In preparing the estimates, include overhead, profit, and bond within pay items in the Contract. Separate pay item(s) for the cost of overhead, profit, and bond will not be allowed.

3. an itemization of the changes, deletions or additions to plan details, plan sheets, Standard Plans and Specifications that are required to implement the Proposal if the Department adopts it. Submit preliminary plan drawings sufficient to describe the proposed changes.

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4. engineering or other analysis in sufficient detail to identify and describe specific features of the Contract that must be changed if the Department accepts the Proposal with a proposal as to how these changes can be accomplished and an assessment of their effect on other project elements. The Department may require that engineering analyses be performed by a prequalified consultant in the applicable class of work. Support all design changes that result from the Proposal with drawings and computations signed and sealed by the Contractor's Engineer of Record. Written documentation or drawings will be submitted clearly delineating the responsibility of the Contractor's Engineer of Record.

5. the date by which the Department must approve the Proposal to obtain the total estimated cost reduction during the remainder of the Contract, noting any effect on the Contract completion time or delivery schedule.

6. a revised project schedule that would be followed upon approval of the Proposal. This schedule would include submittal dates and review time for the Department and Peer reviews.

4-3.9.4 Processing Procedures: Submit Proposals to the Engineer or his duly authorized representative. The Department will process Proposals expeditiously; however, the Department is not liable for any delay in acting upon a Proposal submitted pursuant to this Subarticle. The Contractor may withdraw, in whole or in part, a Proposal not accepted by the Department within the period specified in the Proposal. The Department is not liable for any Proposal development cost in the case where the Department rejects or the Contractor withdraws a Proposal.

The Engineer is the sole judge of the acceptability of a Proposal and of the estimated net savings in construction costs from the adoption of all or any part of such proposal. In determining the estimated net savings, the Department reserves the right to disregard the Contract bid prices if, in the judgment of the Engineer, such prices do not represent a fair measure of the value of work to be performed or to be deleted.

Prior to approval, the Engineer may modify a Proposal, with the concurrence of the Contractor, to make it acceptable. If any modification increases or decreases the net savings resulting from the Proposal, the Department will determine the Contractor's fair share upon the basis of the Proposal as modified and upon the final quantities. The Department will compute the net savings by subtracting the revised total cost of all bid items affected by the Proposal from the total cost of the same bid items as represented in the original Contract.

Prior to approval of the Proposal that initiates the supplemental agreement, submit acceptable Contract-quality plan sheets revised to show all details consistent with the Proposal design.

4-3.9.5 Computations for Change in Contract Cost of Performance: If the Proposal is adopted, the Contractor's share of the net savings as defined hereinafter represents full compensation to the Contractor for the Proposal.

The Department will not include its costs to process and implement a Proposal in the estimate. However, the Department reserves the right, where it deems such action appropriate, to require the Contractor to pay the Department's cost of investigating and implementing a Proposal as a condition of considering such proposal. When the Department imposes such a condition, the Contractor shall accept this condition in writing, authorizing the Department to deduct amounts payable to the Department from any monies due or that may become due to the Contractor under the Contract.

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4-3.9.6 Conditions of Acceptance for Major Design Modifications of Category 2 Bridges: A Proposal that proposes major design modifications of a category 2 bridge, as determined by the Engineer, shall have the following conditions of acceptance:

All bridge Plans relating to the Proposal shall undergo an independent peer review conducted by a single independent engineering firm referred to for the purposes of this article as the Independent Review Engineer who is not the originator of the Proposal design, and is pre-qualified by the Department in accordance with Rule 14-75, Florida Administrative Code. The independent peer review is intended to be a comprehensive, thorough verification of the original work, giving assurance that the design is in compliance with all Department requirements. The Independent Review Engineer's comments, along with the resolution of each comment, shall be submitted to the Department. The Independent Review Engineer shall sign and seal the submittal cover letter stating that all comments have been adequately addressed and the design is in compliance with the Department requirements. If there are any unresolved comments the Independent Review Engineer shall specifically list all unresolved issues in the signed and sealed cover letter.

The Contractor shall designate a primary engineer responsible for the Proposal design and as such will be designated as the Contractors Engineer of Record for the Proposal design. The Department reserves the right to require the Contractor's Engineer of Record to assume responsibility for design of the entire structure.

New designs and independent peer reviews shall be in compliance with all applicable Department, FHWA and AASHTO criteria requirements including bridge load ratings.

4-3.9.7 Sharing Arrangements: If the Department approves a Proposal, the Contractor shall receive up to 50% of the net reduction in the cost of the performance of the Contract. The net reduction in the cost of the performance of the Contract will be determined by subtracting the reasonable documented engineering costs, incurred by the contractor to design and develop a Proposal, from the gross reduction in the cost of the performance of the Contract. The reasonable documented engineering costs incurred by the contractor will be paid for as part of the negotiated Supplemental Agreement. Engineering costs incurred by the contractor will be based on the consultant's certified invoice and may include the costs of the Independent Review Engineer in 4-3.9.6. The total engineering costs will be limited to 25% of the gross reduction in the cost of the performance of the Contract and shall not include any markup by the Contractor or the costs for engineering services performed by the Contractor.

If the Department determines that the parties identified in 337.11(17) Florida Statutes have contributed to the reduction in the cost of the performance of the contract, the contractor's share may be 45% of the net reduction.

If the Department approves a Proposal where deletions of work are the sole objective of the Proposal, the Contractor shall receive 14.5% of the net reduction in the cost of the performance of the Contract.

4-3.9.8 Notice of Intellectual Property Interests and Department's Future Rights to a Proposal:

4-3.9.8.1 Notice of Intellectual Property Interests: The Contractor's Proposal submittal shall identify with specificity any and all forms of intellectual property rights that either the Contractor or any officer, shareholder, employee, consultant, or affiliate, of the Contractor, or any other entity who contributed in any measure to the substance of the Contractor's Proposal development, have or may have that are in whole or in part implicated in

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the Proposal. Such required intellectual property rights notice includes, but is not limited to, disclosure of any issued patents, copyrights, or licenses; pending patent, copyright or license applications; and any intellectual property rights that though not yet issued, applied for or intended to be pursued, could nevertheless otherwise be subsequently the subject of patent, copyright or license protection by the Contractor or others in the future. This notice requirement does not extend to intellectual property rights as to stand-alone or integral components of the Proposal that are already on the Department's Approved Product List (APL) or Standard Plans, or are otherwise generally known in the industry as being subject to patent or copyright protection.

4-3.9.8.2 Department's Future Rights to a Proposal: Notwithstanding 7-3 nor any other provision of the Standard Specifications, upon acceptance of a Proposal, the Contractor hereby grants to the Department and its contractors (such grant being expressly limited solely to any and all existing or future Department construction projects and any other Department projects that are partially or wholly funded by or for the Department) a royalty-free and perpetual license under all forms of intellectual property rights to manufacture, to use, to design, to construct, to disclose, to reproduce, to prepare and fully utilize derivative works, to distribute, display and publish, in whole or in part, and to permit others to do any of the above, and to otherwise in any manner and for any purpose whatsoever do anything reasonably necessary to fully utilize any and all aspects of such Proposal on any and all existing and future construction projects and any other Department projects.

Contractor shall hold harmless, indemnify and defend the Department and its contractors and others in privity therewith from and against any and all claims, liabilities, other obligations or losses, and reasonable expenses related thereto (including reasonable attorneys' fees), which are incurred or are suffered by any breach of the foregoing grants, and regardless of whether such intellectual property rights were or were not disclosed by the Contractor pursuant to 4-3.9.8.1, unless the Department has by express written exception in the Proposal acceptance process specifically released the Contractor from such obligation to hold harmless, indemnify and defend as to one or more disclosed intellectual property rights.

4-4 Unforeseeable Work.

When the Department requires work that is not covered by a price in the Contract and such work does not constitute a "Significant Change" as defined in 4-3.1, and the Department finds that such work is essential to the satisfactory completion of the Contract within its intended scope, the Department will make an adjustment to the Contract. The Engineer will determine the basis of payment for such an adjustment in a fair and equitable amount.

4-5 Rights in and Use of Materials Found on the Site of the Work.

4-5.1 Ownership and Disposal of Existing Materials: Take ownership and dispose of all materials that are not designated as the property of other parties, in both roadway and structures, found on the right-of-way, and all material in structures designated for removal. Such materials do not include earth or other excavated material required for the construction of the project. During construction, the Contractor may use materials from existing structures that are required to be removed and that are designated to remain the property of the Department. Do not cut or otherwise damage such material during removal unless the Engineer gives permission to do so. Store material in an accessible location as the Engineer directs. The Department is not responsible for the quality or quantity of any material salvaged.

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4-5.2 Ornamental Trees and Shrubs: Take ownership of all ornamental trees or shrubs existing in the right-of-way that are required to be removed for the construction operations and which are not specifically designated in the Plans to be reset, or to be removed by others prior to the construction operations.

4-6 Final Cleaning Up of Right-of-Way.

Upon completion of the work, and before the Department accepts the work and makes final payment, remove from the right-of-way and adjacent property all falsework, equipment, surplus and discarded materials, rubbish and temporary structures; restore in an acceptable manner all property, both public and private, that has been damaged during the prosecution of the work; and leave the waterways unobstructed and the roadway in a neat and presentable condition throughout the entire length of the work under Contract. Do not dispose of materials of any character, rubbish or equipment, on abutting property, with or without the consent of the property owners. The Engineer will allow the Contractor to temporarily store equipment, surplus materials, usable forms, etc., on a well-kept site owned or leased by the Contractor, adjacent to the project. However, do not place or store discarded equipment, materials, or rubbish on such a site.

Shape and dress areas adjacent to the project right-of-way that were used as plant sites, materials storage areas or equipment yards when they are no longer needed for such purposes. Restore these areas in accordance with 7-11.1 and 7-11.2. Grass these areas when the Engineer directs.

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SECTION 5
CONTROL OF THE WORK

5-1 Plans and Working Drawings.

5-1.1 Contract Documents: Have available the Contract Documents on the worksite at all times.

5-1.2 Department's Plans: Plans consist of general drawings showing such details as are necessary to give a comprehensive idea of the construction contemplated. In general, roadway plans will show alignment, profile grades, typical sections and general plan view details. Cross sectional views maybe provided or created from provided surface models. In general, structure plans will show in detail all dimensions of the work contemplated. When the structure plans do not show the dimensions in detail, they will show general features and such details as are necessary to give a comprehensive idea of the structure.

Elevations and B.M. Datum shown are North American Vertical Datum 1988 (NAVD-1988), National Geodetic Vertical Datum of 1929 (NGVD-1929), or other datum as noted in the Plans.

The existing surface is a combination of the following:

1. The natural ground or the original ground line,
2. The bottom of the existing pavement,
3. The bottom of existing features removed by clearing and grubbing,
4. The bottom of the existing base, if the base is to be removed,

The finished graded surface includes the completed grades of side slopes, unpaved shoulders, and the bottom of the base for flexible or rigid pavement.

5-1.3 Alterations in Plans: The Department will issue, in writing, all authorized alterations affecting the requirements and information given on the approved Plans.

5-1.4 Shop Drawings:

5-1.4.1. Definitions: In addition to the definitions below, also refer to Section 1, Definitions and Terms.

1. Bracing: Temporary structural member(s) placed between beams, girders, piles, precast columns, etc. to provide stability during construction activities.
2. Construction Affecting Public Safety: Construction that may jeopardize public safety such as structures and construction operations spanning over or adjacent to functioning vehicular roadways, pedestrian walkways, railroads, navigable waterways and walls supporting fill sections or excavations immediately adjacent to functioning roadways. Construction Affecting Public Safety may also apply to the construction or demolition of a bridge with continuous beams or girders if traffic is being placed under one of the spans within the unit. It does not apply to those areas of the site outside the limits of normal public access. Adjacent as used above applies to any project or property where normal construction operations could impact functioning vehicular roadways, pedestrian walkways, railroads, and navigable waterways.
3. Contractor Originated Designs: Items which the Contract Documents require the Contractor to design, detail and incorporate into the permanent works.
4. Detailer: The steel detailer that prepares the steel shop drawings for the fabrication, geometry and fit-up for all steel members in accordance with the Plans.
5. Falsework: Any temporary construction work used to support the permanent structure until it becomes self-supporting. Falsework includes steel or timber beams,

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girders, columns, bracing, piles and foundations, and any proprietary equipment including modular shoring frames, post shores, and adjustable horizontal shoring.

6. Formwork: Any structure or mold used to retain plastic or fluid concrete in its designated shape until it hardens. Formwork may be comprised of common materials such as wood or metal sheets, battens, soldiers and walers, ties, proprietary forming systems such as stay-in-place metal forms, and proprietary supporting bolts, hangers and brackets. Formwork may be either permanent formwork requiring a shop drawing submittal such as stay-in-place metal or concrete forms or may be temporary formwork which requires certification by the Specialty Engineer for Construction Affecting Public Safety and for Major and Unusual Structures.

7. Major and Unusual Structures: Bridges of complex design. Generally, this includes the following types of structures:

a. Bridges with an individual span longer than 300 feet.

b. Structurally continuous superstructures with spans over 150 feet.

c. Steel box and plate girder bridges.

d. Concrete or steel straddle piers and straddle pier caps.

e. Steel truss bridges including proprietary pedestrian steel truss spans not satisfying the Category 1 conditions of FDOT Design Manual 266.4.

f. Concrete segmental, post-tensioned girder bridges and post-tensioned substructures.

g. Cable stayed, extradosed or suspension bridges.

h. Arch bridges.

i. Tunnels.

j. All movable bridges (including specifically structural, electrical and mechanical components).

k. Rehabilitation, widening, lengthening or jacking of any of the above structures.

8. Permanent Works: All the permanent structures and parts thereof required of the completed Contract.

9. QA/QC Shop Drawing Check Prints: The Engineer of Record is responsible for conducting a review of all shop drawings regardless of whether the shop drawing is originated by the Engineer of Record or by others. QA/QC Shop Drawing Check Prints shall consist of highlighting items that the EOR is able to verify based on the EOR's plans and design information on each sheet reviewed. Each sheet shall be initialed by the reviewer. QA/QC Shop Drawing Check Prints shall be submitted to the Department along with the stamped Shop Drawing.

10. Scaffolding: An elevated work platform used to support workers, materials and equipment, but not intended to support the structure.

11. Shop Drawings: A shop drawing is a drawing or set of drawings produced by the contractor, supplier, manufacturer, subcontractor, or fabricator for prefabricated components. Shop drawings also include all working drawings, erection plans, associated trade literature, material cut-sheets, calculations, schedules, erection manuals, geometry control manuals and other manuals and similar documents submitted by the Contractor to define some portion of the project work. The type of work includes both permanent and temporary works as appropriate to the project.

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12. Shoring: A component of falsework such as horizontal, vertical or inclined support members. In this Section, this term is interchangeable with falsework.

13. Special Erection Equipment: Includes launching gantries, beam and winch equipment, form travelers, segment lifters, beam shifters, erection trusses, launching noses or similar items made purposely for construction of the structure. It does not apply to commonly available proprietary construction equipment such as cranes.

14. Temporary Works: Any temporary construction work necessary for the construction of the permanent works. This includes but is not limited to bracing, falsework, formwork, scaffolding, shoring, stability towers, strong-backs, counterweights, temporary earthworks, sheeting, cofferdams, and special erection equipment.

5-1.4.2 Shop Drawing Submittal and Review Requirements: See table below for **s**hop drawing submittal and review requirements.

Table 5-1
Submittal and Review Requirements

Shop Drawing for:	Originated by Specialty Engineer Not Signed and Sealed	Originated by Detailer Not Signed and Sealed	Originated by Specialty Engineer Signed and Sealed	Originated by Contractor's EOR Signed and Sealed	Requires Review, QA/QC Shop Drawing Check prints and disposition stamp by Design EOR
Steel Fabrication Drawings		Originator			Reviewer
Steel Erection Plan			Originator		Reviewer
Geometry Control Manual				Originator	Reviewer
Segmental Erection Manual				Originator	Reviewer
Segmental Shop Drawings					Reviewer
Post-tensioning Mock-up Plan			Originator		Reviewer
Post-tensioning Systems[1]			Originator		Reviewer
Pretensioned Prestressed Concrete Products Containing FRP Bars or Strands Excluding Standard Piles and Sheet Piles			Originator		Reviewer

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Table 5-1 Submittal and Review Requirements					
Shop Drawing for:	Originated by Specialty Engineer Not Signed and Sealed	Originated by Detailer Not Signed and Sealed	Originated by Specialty Engineer Signed and Sealed	Originated by Contractor's EOR Signed and Sealed	Requires Review, QA/QC Shop Drawing Check prints and disposition stamp by Design EOR
Temporary Works Affecting Public Safety[2]			Originator		Reviewer
Demolition Plans of Bridges with Continuous Beams or Girders Where One Span Within the Unit is Over Traffic			Originator		Reviewer
Prefabricated Bridge Elements and System Connection Mock-Up Plans			Originator		Reviewer
Bridge Formwork Including SIP Forms			Originator		Reviewer
Construction Equipment Placed on Existing Bridges				Originator	Reviewer
Bridge components not fully detailed in the Plans, i.e., post-tensioning details, handrails, temporary operating systems for movable bridges etc.				Originator	Reviewer
Retaining Wall Systems			Originator		Reviewer

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Table 5-1
Submittal and Review Requirements

Shop Drawing for:	Originated by Specialty Engineer Not Signed and Sealed	Originated by Detailer Not Signed and Sealed	Originated by Specialty Engineer Signed and Sealed	Originated by Contractor's EOR Signed and Sealed	Requires Review, QA/QC Shop Drawing Check prints and disposition stamp by Design EOR
Precast Box Culverts			Originator		Reviewer
Non-standard structures and components for drainage, lighting, signalization and signing			Originator		Reviewer
Building structures			Originator [3]		Reviewer [4]
Non-standard crash cushions and other nonstructural items			Originator		Reviewer
Design and structural details furnished by the Contractor in compliance with the Contract				Originator	Reviewer
Material or Product Cut-Sheets	Originator				Reviewer

1. Include integration details of the post-tensioning system.
2. Does not include formwork complying with Standard Plans, Index 102-600 (concrete placement is not permitted directly over traffic). Also, does not include critical temporary walls that are fully detailed in the plans unless redesigned by the Contractor. Does not include specialized equipment if traffic is removed from under equipment while equipment is being loaded, launched, and while loads are being transported by equipment.
3. In lieu of a Specialty Engineer, originator may be a licensed Architect.
4. In lieu of the Design Engineer of Record, the reviewer may be the Design Architect of Record.

5-1.4.3 Schedule of Submittals: Prepare and submit a schedule of submittals that identifies the work for which shop drawings apply. For each planned submittal, define the type, and approximate number of drawings or other documents that are included and the planned submittal date, considering the processing requirements herein. Submit the schedule of submittals to the Department's Shop Drawing Review Office and the Engineer of Record within 60 days of the start of the Contract, and prior to the submission of any shop drawings.

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Coordinate subsequent submittals with construction schedules to allow sufficient time for review, resubmittal and approval prior to beginning fabrication, as necessary.

5-1.4.4 Style, Numbering, and Material of Submittals:

5-1.4.4.1 Drawings: Submit all shop drawings that are necessary to complete the structure in compliance with the design shown in the Plans. Prepare all shop drawings using the same units of measure as those used in the Plans. Consecutively number each sheet in the submittal series and indicate the total number in the series (i.e., 1 of 12, 2 of 12 . . . 12 of 12). Include on each sheet the following items as a minimum requirement: the complete Financial Project Identification Number, Bridge Number(s), drawing title and number, a title block showing the names of the fabricator or producer and the Contractor for which the work is being done, the initials of the person(s) responsible for the drawing, the date on which the drawing was prepared, the location of the item(s) within the project, the Contractor's approval stamp with date and initials, and, when applicable, the documents shall be signed and sealed by the Specialty Engineer or Contractor's Engineer of Record. A re-submittal will be requested when any of the required information is not included.

Shop drawings shall be submitted in Portable Document Format (PDF) files, formatted on sheets 11 by 17 inches.

5-1.4.4.2 Other Documents: Submit PDF files of other documents such as trade literature, catalogue information, calculations, and manuals formatted on sheets no larger than 11 by 17 inches. Clearly label and number each sheet in the submittal to indicate the total number of sheets in the series (i.e., 1 of 12, 2 of 12 . . . 12 of 12).

Prepare all documents using the same units of measure as the Plans and include a Table of Contents cover sheet. List on the cover sheet the total number of pages and appendices, and include the complete Financial Project Identification Number, a title referencing the submittal item(s), the name of the firm and person(s) responsible for the preparation of the document, the Contractor's approval stamp with date and initials, and, when applicable, the documents shall be signed and sealed by the Specialty Engineer or Contractor's Engineer of Record.

Submit appropriately prepared and checked calculations and manuals that clearly outline the design criteria. Include on the internal sheets the complete Financial Project Identification Number and the initials of the person(s) responsible for preparing and checking the document.

Clearly label trade literature and catalogue information on the front cover with the title, Financial Project Identification Number, date and name of the firm and person(s) responsible for that document.

5-1.4.5 Submittal Paths:

5-1.4.5.1 General: Shop drawings are not required for items on the Approved Products List used as intended in the relevant Standard Plans and Standard Specifications. For non-prequalified items, determine the submittal path to be followed based upon the identity of the Engineer of Record as shown adjacent to the title block on the structural plan sheets, and on the key sheets of roadway plans, signing, and pavement marking plans, and/or lighting plans. At the preconstruction conference, the Department will notify the Contractor in writing of any changes in the submittal path and whether the Department's or the Consultant's review stamp will signify an officially reviewed shop drawing.

1. When the Florida Department of Transportation is the Engineer of Record, submit shop drawings to the Resident Engineer and to the appropriate Department

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Review Office. Include in the submittal other information such as catalog data, procedure manuals, fabrication/welding procedures, and maintenance and operating procedures when required by the work. Submit material certifications and material tests to the Resident Engineer.

2. When the Engineer of Record is a consultant hired by the Department, submit shop drawings to the consultant, the Resident Engineer and, when requested, to the appropriate Department Review Office. Include in the submittal other documentation such as catalog data, procedure manuals, fabrication/welding procedures, and maintenance and operating manuals when required by the work. Submit material certifications and material tests to the Resident Engineer.

5-1.4.5.2 Building Structures: Submit shop drawings and all correspondence related to building structures, such as Rest Area Pavilions, Office Buildings, and Maintenance Warehouses, to the Architect of Record and the Resident Engineer for review and approval.

5-1.4.5.3 Contractor-Originated Design: Submit shop drawings and applicable calculations to the Engineer of Record for review. The shop drawings and applicable calculations must be signed and sealed by the Specialty Engineer or the Contractor's Engineer of Record. Submit in accordance with the requirements of 5-1.4.1 through 5-1.4.3, as appropriate.

5-1.4.5.4 Temporary Works: For Construction Affecting Public Safety, submit to the Engineer of Record shop drawings and the applicable calculations for the design of special erection equipment, bracing, falsework, scaffolding, etc. The shop drawings and applicable calculations must be signed and sealed by the Specialty Engineer. Submit in accordance with the requirements of 5-1.4.1through 5-1.4.3, as appropriate.

5-1.4.5.5 Demolition Plans of Bridges with Continuous Beams or Girders when Traffic is Under Any of the Spans of the Unit During Demolition Activities: For demolition plans of bridges with continuous beams or girders when traffic is placed under any of the spans of the unit during demolition activities, the Specialty Engineer shall prepare signed and sealed demolition plans and applicable calculations including a step-by-step sequence of demolition, etc. Clearly denote any traffic restrictions for all demolition steps. Submit in accordance with the requirements of 5-1.4. 1 through 5-1.4. 3, as appropriate.

5-1.4.5.6 Falsework Founded on Shallow Foundations: When vertical displacement limits are provided in the Plans for falsework founded on shallow foundations such as spread footings and mats, submit to the Engineer of Record shop drawings and applicable calculations of the falsework system including subsurface conditions and settlement estimates. The shop drawings and applicable calculations must be signed and sealed by the Specialty Engineer. Submit in accordance with the requirements of 5-1.4.1through 5-1.4.3, as appropriate.

5-1.4.5.7 Formwork and Scaffolding: The Contractor is solely responsible for the safe installation and use of all formwork and scaffolding. The Department does not require any formwork or scaffolding submittals unless such work would be classified as Construction Affecting Public Safety. For formwork, scaffolding, or other temporary works affecting public safety; develop the required designs in accordance with the AASHTO Guide Design Specifications for Bridge Temporary Works, the AASHTO Construction Handbook for Bridge Temporary Works, and Chapter 11 of the Structures Design Guidelines (SDG) using wind loads specified in the SDG.

5-1.4.5.8 Beam, Girder and Column Temporary Bracing: The Contractor is solely responsible for ensuring stability of beams, girders and columns during all handling, storage, shipping and erection. Adequately brace beams, girders and columns to resist

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wind, weight of forms and other temporary loads, especially those eccentric to the vertical axis of the products, considering actual beam geometry and support conditions during all stages of erection and deck construction. At a minimum, provide temporary bracing at each end of each beam or girder. Develop the required bracing designs in accordance with the AASHTO LRFD Bridge Design Specifications (LRFD) and Chapter 11 of the SDG using wind loads specified in the SDG. For information not included in the SDG or LRFD, refer to the AASHTO Guide Design Specifications for Bridge Temporary Works and the AASHTO Construction Handbook for Bridge Temporary Works.

For Construction Affecting Public Safety, when temporary bracing requirements are shown in the Plans, submit plans and calculations signed and sealed by a Specialty Engineer for the design of temporary bracing members and connections based on the forces shown in the Plans. In addition, submit a written certification that construction loads do not exceed the assumed loads shown in the Plans.

For Construction Affecting Public Safety, when temporary bracing requirements are not shown in the Plans or an alternate temporary bracing system is proposed, submit plans and calculations signed and sealed by a Specialty Engineer including the stability analysis and design of temporary bracing members and connections.

5-1.4.5.9 Erection Plan, Geometry Control Manual and Erection Manual: Submit, for the Engineer's review, an Erection Plan that meets the specific requirements of Sections 450, 452 and 460 and this section. Submit in writing for the Engineer's review, an Erection Manual and Geometry Control Manual that meets the specific requirements of Section 462 and this Section. For all Erection Plans and Erection Manuals refer to Standard Plans, Index 102-600 for construction activities not permitted over traffic. For construction activities not covered in Index 102-600, clearly denote what additional construction steps are not allowed over traffic.

5-1.4.5.10 Other Miscellaneous Design and Structural Details Furnished by the Contractor in Compliance with the Contract: The Engineer of Record shall review all shop drawings and the applicable calculations for miscellaneous design and structural details as required by the Contract. The shop drawings and applicable calculations will be signed and sealed by the Specialty Engineer. Submit in accordance with the requirements of 5-1.4.1through 5-1.4.3, as appropriate.

5-1.4.6 Processing of Shop Drawings:

5-1.4.6.1 Contractor Responsibility for Accuracy and Coordination of Shop Drawings: Coordinate, schedule, and control all submittals, with a regard for the required priority, including those of the various subcontractors, suppliers, and engineers, to provide for an orderly and balanced distribution of the work.

Coordinate, review, date, stamp, approve and sign all shop drawings prepared by the Contractor or agents (subcontractor, fabricator, supplier, etc.) prior to submitting them to the Engineer for review. Submittal of the drawings confirms verification of the work requirements, units of measurement, field measurements, construction criteria, sequence of assembly and erection, access and clearances, catalog numbers, and other similar data. Indicate on each series of drawings the Specification section and sheet or drawing number of the Plans to which the submission applies. Indicate on the shop drawings all deviations from the Contract drawings and itemize all deviations in the letter of transmittal. Likewise, whenever a submittal does not deviate from the Plans, clearly state so in the submittal.

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Schedule the submission of shop drawings to allow for a 45 calendar day review period for all submittals associated with a category 2 bridge; tolling components identified in the current FDOT General Tolling Requirements (GTR) Part 3; and the tolling-related signing, DMS and ITS infrastructure. Schedule the submission of shop drawings to allow for a 25 calendar day review period for all other items. The review period commences upon the Engineer's receipt of the valid submittal or valid re-submittal and terminates upon the transmittal of the submittal back to the Contractor. A valid submittal includes all the minimum requirements outlined in 5-1.4.4.

Submit shop drawings to facilitate expeditious review. The Contractor is discouraged from transmitting voluminous submittals of shop drawings at one time. For submittals transmitted in this manner, allow for the additional review time that may result.

Only shop drawings distributed with the approval stamps are valid and all work that the Contractor performs in advance of approval will be at the Contractor's risk. Work affecting Public Safety may not be performed prior to approval of appropriate submittals and work may not proceed at the Contractor's risk.

5-1.4.6.2 Scope of Review by Engineer of Record: The Engineer of Record's review of the shop drawings is for conformity to the requirements of the Contract Documents and to the intent of the design. The Engineer of Record's review of shop drawings which include means, methods, techniques, sequences, and construction procedures are limited to the effects on the permanent works. The Engineer of Record's review of submittals which include means, methods, techniques, sequences, and construction procedures does not include an in-depth check for the ability to perform the work in a safe or efficient manner.

5-1.4.6.3 Special Review by Engineer of Shop Drawings for Construction Affecting Public Safety: The Engineer may request copies of shop drawings related to Construction Affecting Public Safety for review and comment. When shop drawings are requested, do not proceed with construction of the permanent works until receiving the Engineer's written approval.

5-1.4.7 Other Requirements for Shop Drawings for Bridges:

5-1.4.7.1 Shop Drawings for Structural Steel and Miscellaneous Metals: Submit shop drawings for structural steel and miscellaneous metals. Shop drawings shall consist of shop and erection drawings, welding procedures, and other working plans, showing details, dimensions, sizes of material, and other information necessary for the complete fabrication and erection of the metal work.

5-1.4.7.2 Shop Drawings for Concrete Structures: Submit shop drawings for concrete components that are not cast-in-place and are not otherwise exempted from submittal requirements. Also, submit shop drawings for all details that are required for the effective execution of the concrete work and are not included in the Contract Documents such as: special erection equipment, masonry layout diagrams, and diagrams for bending reinforcing steel, in addition to any details required for concrete components for the permanent work.

5-1.4.7.3 Shop Drawings for Major and Unusual Structures: In addition to any other requirements, within 60 days from the Notice to Proceed, submit information to the Engineer outlining the integration of the Major and Unusual Structure into the overall approach to the project. Where applicable to the project, include, but do not limit this information to:

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1. The overall construction program for the duration of the Contract. Clearly show the Milestone dates. (For example, the need to open a structure by a certain time for traffic operations.)

2. The overall construction sequence. The order in which individual structures are to be built, the sequence in which individual spans of girders or cantilevers are erected, and the sequence in which spans are to be made continuous, and the order that components are to be installed (such as mechanical and electrical devices in moveable bridges).

3. The general location of any physical obstacles to construction that might impose restraints or otherwise affect the construction, and an outline of how to deal with such obstacles while building the structure(s). (For example, obstacles might include road, rail and waterway clearances, temporary diversions, transmission lines, utilities, property, and the Contractor's own temporary works, such as haul roads, cofferdams, plant clearances and the like.)

4. The approximate location of any special lifting equipment in relation to the structure, including clearances required for the operation of the equipment. (For example, crane positions, operating radii and the like.)

5. The approximate location of any temporary falsework, and the conceptual outline of any special erection equipment. Provide the precise locations and details of attachments, fixing devices, loads, etc. in later detailed submittals.

6. An outline of the handling, transportation, and storage of fabricated components, such as girders or concrete segments. Provide the precise details in later detailed submittals.

7. Any other information pertinent to the proposed scheme or intended approach.

Clearly and concisely present the above information on as few drawings as possible in order to provide an overall, integrated summary of the intended approach to the project. The Department will use these drawings for information, review planning, and to assess the Contractor's approach in relation to the intent of the original design. Submittal to and receipt by the Engineer does not constitute any Department acceptance or approval of the proposals shown thereon. Include the details of such proposals on subsequent detailed shop drawing submittals. Submit timely revisions and re-submittals for all variations from these overall scheme proposals.

5-1.4.8 Cost of Shop Drawings: Include the cost of shop drawings submittal in the Contract prices for the work requiring the shop drawings. The Department will not pay the Contractor additional compensation for such drawings.

5-1.5 Certifications:

5-1.5.1 Special Erection Equipment: Prior to its use, ensure that the Specialty Engineer personally inspects the special erection equipment and submits a written certification to the Engineer that the equipment has been fabricated in accordance with the submitted drawings and calculations. In addition, after assembly, ensure that the Specialty Engineer observes the equipment in use and submits a written certification to the Engineer that such equipment is being used as intended and in accordance with the submitted drawings and calculations. In each case, the Specialty Engineer must sign and seal the letter of certification.

5-1.5.2 Falsework and Shoring Requiring Shop Drawings: After its erection or installation but prior to the application of any superimposed load, ensure that a Specialty

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Engineer or a designee inspects the falsework and certifies to the Engineer in writing that the falsework has been constructed in accordance with the materials and details shown on the submitted drawings and calculations. The letter of certification must be signed and sealed by the Specialty Engineer. Where so directed in the shop drawings, ensure all welds are performed by welders qualified under AWS D1.5 for the type of weld being performed.

5-1.5.3 Temporary Formwork: For Construction Affecting Public Safety and for Major and Unusual Structures, prior to the placement of any concrete, ensure that a Specialty Engineer or a designee inspects the formwork and submits a written certification to the Engineer that the formwork has been constructed to safely withstand the superimposed loads to which it will be subjected. The Specialty Engineer must sign and seal the letter of certification.

5-1.5.4 Erection: For Construction Affecting Public Safety, submit an erection plan signed and sealed by the Specialty Engineer to the Engineer at least four weeks prior to erection commencing. Include, as part of this submittal, signed and sealed calculations and details for any falsework, bracing or other connection supporting the structural elements shown in the erection plan. Unless otherwise specified in the Plans, erection plans are not required for simple span precast prestressed concrete girder bridges with spans of 170 feet or less.

At least two weeks prior to beginning erection, conduct a Pre-erection meeting to review details of the plan with the Specialty Engineer that signed and sealed the plan, and any Specialty Engineers that may inspect the work and the Engineer.

After erection of the elements, but prior to opening of the facility below the structure, ensure that a Specialty Engineer or a designee has inspected the erected member. Ensure that the Specialty Engineer has submitted a written certification to the Engineer that the structure has been erected in accordance with the signed and sealed erection plan.

For structures without temporary supports but with temporary girder bracing systems, perform, as a minimum, weekly inspections of the bracing until all the diaphragms and cross frames are in place. For structures with temporary supports, perform daily inspections until the temporary supports are no longer needed as indicated in the erection plans. Submit written documentation of the inspections to the Engineer within 24 hours of the inspection.

5-1.6 Request for Correction: For work that the Contractor constructs incorrectly or does not meet the requirements of the Contract Documents, the Contractor has the prerogative to submit an acceptance proposal to the Engineer for review and disposition. The acceptance proposal shall describe the error or defect and either describe remedial action for its correction or propose a method for its acceptance. In either case, the acceptance proposal shall address structural integrity, aesthetics, maintainability, and the effect on Contract Time. The Department will judge any such proposal for its effect on these criteria and for its effect on Contract Administration.

When the Engineer judges that a proposal infringes on the structural integrity or maintainability of the structure, the Contractor’s Engineer of Record will perform a technical assessment and submit it to the Engineer for approval. Do not take any corrective action without the Engineer’s written approval.

Carry out all approved corrective construction measures at no expense to the Department.

Notwithstanding any disposition of the compensation aspects of the defective work, the Engineer’s decision on the technical merits of a proposal is final.

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5-1.7 Request for Information: Submit Requests for Information in writing to the Engineer to request clarification where a provision, detail or drawing in the Contract Documents seems to have more than one meaning, have an unclear meaning, or have conflicts between Plans and Specifications. A Request for Information is not considered a Notice of Claim. Notices of Claim must be submitted in accordance with 5-12.2.

5-1.8 Request for Modification: Where the Engineer allows the Contractor to make modifications to the permanent works for the purposes of expediting the Contractor's chosen construction methods, the Contractor shall submit proposals to the Engineer for review and approval prior to modifying the works. Submit proposals for minor modifications under the shop drawing process. Indicate on all drawings the deviations from the Contract Documents and itemize all deviations in the letter of transmittal. Major modifications must be submitted as a Cost Savings Initiative Proposal.

Minor modifications are those items that, in the opinion of the Engineer, do not significantly affect the quantity of measured work, or the integrity or maintainability of the structure or its components.

The Engineer's decision on the delineation between a minor and a major modification and the disposition of a proposal is final.

5-2 Coordination of Contract Documents.

These Specifications, the Plans, Special Provisions, and all supplementary documents are integral parts of the Contract; a requirement occurring in one is as binding as though occurring in all. All parts of the Contract are complementary and describe and provide for a complete work. In addition to the work and materials specified in the Specifications as being included in any specific pay item, include in such pay items additional, incidental work, not specifically mentioned, when so shown in the Plans, or if indicated, or obvious and apparent, as being necessary for the proper completion of the work under such pay item and not stipulated as being covered under other pay items.

In cases of discrepancy, the governing order of the documents is as follows:

1. Special Provisions.
2. Technical Special Provisions.
3. Plans.
4. Standard Plans.
5. Developmental Specifications.
6. Supplemental Specifications.
7. Standard Specifications.

Computed dimensions govern over scaled dimensions.

5-3 Conformity of Work with Contract Documents.

Perform all work and furnish all materials in reasonably close conformity with the lines, grades, models, dimensions, and material requirements, including tolerances, as specified in the Contract Documents.

In the event that the Engineer finds that the Contractor has used material or produced a finished product that is not in reasonably close conformity with the Contract Documents, but that the Contractor has produced reasonably acceptable work, the Engineer will determine if the Department will accept the work in place. In this event, the Engineer will document the basis of acceptance by Contract modification, which provides for an appropriate reduction in the Contract

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price for such work or materials included in the accepted work as deemed necessary to conform to the determination based on engineering judgment.

In the event that the Engineer finds that the Contractor has used material or produced a finished product that is not in reasonably close conformity with the Contract Documents, and that the Contractor has produced an inferior or unsatisfactory product, the Contractor shall remove and replace or otherwise correct the work or materials at no expense to the Department.

For base and surface courses, the Department will allow the finished grade to vary as much as 0.1 foot from the grade shown in the Plans, provided that the Contractor's work meets all templates and straightedge requirements and contains suitable transitions.

5-4 Errors or Omissions in Contract Documents.

Do not take advantage of any apparent error or omission discovered in the Contract Documents, but immediately notify the Engineer in writing of such discovery. The Engineer will then make such corrections and interpretations as necessary to reflect the actual spirit and intent of the Contract Documents.

5-5 Authority of the Engineer.

Perform all work to the satisfaction of the Engineer.

The Director, Office of Construction will decide all questions, difficulties, and disputes, of whatever nature, that may arise relative to the interpretation of the Plans, construction, prosecution, and fulfillment of the Contract, and as to the character, quality, amount, and value of any work done, and materials furnished, under or by reason of the Contract.

5-6 Authority and Duties of Engineer's Assistants.

The Director, Office of Construction may appoint such assistants and representatives as desired. These assistants and representatives are authorized to inspect all work done and all materials furnished. Such inspection may extend to all or any part of the work and to the manufacture, preparation, or fabrication of the materials to be used. Such assistants and representatives are not authorized to revoke, alter, or waive any requirement of these Specifications. Rather, they are authorized to call to the attention of the Contractor any failure of the work or materials to meet the Contract Documents, and have the authority to reject materials or suspend the work until any questions at issue can be referred to and decided by the Engineer. The Engineer will immediately submit written notification to the Contractor of any such suspension of the work, stating in detail the reasons for the suspension. The presence of the inspector or other assistant in no way lessens the responsibility of the Contractor.

5-7 Engineering and Layout.

5-7.1 Control Points Furnished by the Department: The Engineer will provide centerline control points (Begin Project, End Project, PIs, PTs, etc.) and benchmarks at appropriate intervals along the line of the project to facilitate the proper layout of the work. Normally, the Engineer will furnish only one benchmark for water crossings. Preserve all reference points and benchmarks that the Department furnishes.

As an exception to the above, for projects where the Plans do not show a centerline or other survey control line for construction of the work (e.g., resurfacing, safety modifications, etc.) the Engineer will provide only points marking the beginning and ending of the project, and all exceptions.

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5-7.2 Furnishing of Stake Materials: Furnish all stakes, templates, and other materials necessary for establishing and maintaining the lines and grades necessary for control and construction of the work.

5-7.3 Layout of Work: Utilizing the control points furnished by the Department in accordance with 5-7.1, establish all horizontal and vertical controls necessary to construct the work in conformity to the Contract Documents. Perform all calculations required, and set all stakes needed such as grade stakes, offset stakes, reference point stakes, slope stakes, and other reference marks or points necessary to provide lines and grades for construction of all roadway, bridge, and miscellaneous items.

When performing utility construction as part of the project, establish all horizontal and vertical controls necessary to carry out such work.

5-7.4 Specific Staking Requirements: When performing new base construction as part of the project, set stakes to establish lines and grades for subgrade, base, curb, and related items at intervals along the line of the work. If Automated Machine Guidance is utilized, set stakes as needed. If Automated Machine Guidance is not utilized, set stakes no greater than 50 feet on tangents and 25 feet on curves. Set grade stakes at locations that the Engineer directs to facilitate checking of subgrade, base, and pavement elevations in crossovers, intersections, and irregular shaped areas.

For bridge construction stakes and other control, set references at sufficiently frequent intervals to ensure construction of all components of a structure in accordance with the lines and grades shown in the Plans.

For projects where the Plans do not show a centerline or other survey control line for construction of the work (resurfacing, safety modifications, etc.), provide only such stakes as necessary for horizontal and vertical control of work items.

For resurfacing and resurfacing-widening type projects, establish horizontal controls adequate to ensure that the asphalt mix added matches with the existing pavement. In tangent sections, set horizontal control points at 100-foot intervals by an instrument survey. In curve sections, set horizontal control points at 25-foot intervals by locating and referencing the centerline of the existing pavement.

Establish by an instrument survey, and mark on the surface of the finished pavement at 25-foot intervals, the points necessary for striping of the finished roadway. As an exception, for resurfacing and resurfacing/widening projects, establish these points in the same manner as used for horizontal control of paving operations. Mark the pavement with white paint. If performing striping, the Engineer may approve an alternate method for layout of striping provided that the Contractor achieves an alignment equal to or better than the alignment that would be achieved using an instrument survey.

For projects that include temporary or permanent striping of “no passing zones”, provide the location and length of these zones as shown in the Plans, except projects where the vertical or horizontal alignment is new or altered from preconstruction alignment. For projects that consist of new or altered vertical or horizontal alignment, the Department will provide the location and length of the "no passing zones" during construction. For these projects, submit written notification to the Engineer not less than 21 calendar days prior to beginning striping.

For all projects, set a station identification stake at each right-of-way line at 100-foot intervals and at all locations where a change in right-of-way width occurs. Mark each of these stakes with painted numerals, of a size readable from the roadway, corresponding to the project station at which it is located. As an exception to the above, for projects where Plans do

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not show right-of-way lines, set station identification stakes at locations and intervals appropriate to the type of work being done. For resurfacing and resurfacing/widening projects, set station identification stakes at 200-foot intervals.

5-7.5 Personnel, Equipment, and Record Requirements: Employ only competent personnel and use only suitable equipment in performing layout work. Do not engage the services of any person or persons in the employ of the Department for performance of layout work.

Keep adequate field notes and records while performing as layout work. Make these field notes and records available for the Engineer's review as the work progresses, and submit to the Engineer at the time of completion of the project. The Engineer's inspection, checking, or acceptance of the Contractor's field notes or layout work does not relieve the Contractor of his responsibility to achieve the lines, grades, and dimensions shown in the Contract Documents.

Prior to final acceptance of the project, mark, in a permanent manner on the surface of the completed work, all horizontal control points originally furnished by the Department.

5-7.6 Global Navigation Satellite Systems (GNSS) Work Plan: If used, submit a comprehensive written GNSS Work Plan to the Engineer for Department review and acceptance at the preconstruction conference or at least 30 days before starting work using GNSS. Update the plan as necessary during construction and notify the Department of all changes. The GNSS Work Plan shall describe how GNSS enabled Automated Machine Guidance technology will be integrated into other technologies employed on the project. At a minimum, the GNSS Work Plan will include the following:

1. Designate which portions of the Contract will be done using GNSS enabled Automated Machine Guidance and which portions will be constructed using conventional survey methodology.

2. Describe the manufacturer, model, and software version of the GNSS equipment.

3. Provide information on the qualifications of Contractor staff. Include formal training and field experience. Designate a single staff person as the primary contact for GNSS technology issues.

4. Describe how project control will be established. Include a list and map showing control points enveloping the site.

5. Describe site calibration procedures. Include a map of the control points used for site calibration and control points used to validate the site calibration. Describe the frequency of site calibration and how site calibration will be documented. At a minimum, verify the site calibration twice daily.

6. Describe the Contractor's quality control procedures for verifying mechanical calibration and maintenance of construction and guidance equipment. Include the frequency and type of verification performed to ensure the constructed grades conform to the Contract Documents.

Keep on site and provide upon request, a copy of the project's most up to date GNSS Work Plan at the project site.

5-7.7 Payment: Include the cost of performing layout work as described above in the Contract unit prices for the various items of work that require layout.

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5-8 Contractor's Supervision.

5-8.1 Prosecution of Work: Give the work the constant attention necessary to ensure the scheduled progress, and cooperate fully with the Engineer and with other contractors at work in the vicinity.

5-8.2 Contractor's Superintendent: Maintain a competent superintendent at the site at all times while work is in progress to act as the Contractor's agent. Provide a superintendent who is a competent superintendent capable of properly interpreting the Contract Documents and is thoroughly experienced in the type of work being performed. Provide a superintendent with the full authority to receive instructions from the Engineer and to execute the orders or directions of the Engineer, including promptly supplying any materials, tools, equipment, labor, and incidentals that may be required. Provide such superintendence regardless of the amount of work sublet.

Provide a superintendent who speaks and understands English, and maintain at least one other responsible person who speaks and understands English, on the project during all working hours.

5-8.3 Supervision for Emergencies: Provide a responsible person, who speaks and understands English, and who is available at or reasonably near the worksite on a 24-hour basis, seven days a week. Designate this person as the point of contact for emergencies and in cases that require immediate action to maintain traffic or to resolve any other problem that might arise. Submit the phone numbers and names of personnel designated to be contacted in cases of emergencies, along with a description of the project location, to the Florida Highway Patrol and all other local law enforcement agencies.

5-9 General Inspection Requirements.

5-9.1 Cooperation by Contractor: Do not perform work or furnish materials without obtaining inspection by the Engineer. Provide the Engineer with safe means of access to the work, so the Engineer can determine whether the work performed and materials used are in accordance with the requirements and intent of the Contract Documents. For bridge projects with construction operations accessible only by watercraft, provide safe passage and transport to facilitate the Engineer's inspection of the Work. If the Engineer so requests at any time before final acceptance of the work, remove or uncover such portions of the finished work as directed. After examination, restore the uncovered portions of the work to the standard required by the Contract Documents. If the Engineer determines that the work so exposed or examined is unacceptable, perform the uncovering or removal, and the replacing of the covering or making good of the parts removed, at no expense to the Department. However, if the Engineer determines that the work thus exposed or examined is acceptable, the Department will pay for the uncovering or removing, and the replacing of the covering or making good of the parts removed in accordance with Section 4-4.

5-9.2 Failure of Engineer to Reject Work During Construction: If, during or prior to construction operations, the Engineer fails to reject defective work or materials, whether from lack of discovery of such defect or for any other reason, such initial failure to reject in no way prevents the later rejection when such defect is discovered, or obligates the Department to final acceptance. The Department is not responsible for losses suffered due to any necessary removals or repairs of such defects.

5-9.3 Failure to Remove and Renew Defective Materials and Work: If the Contractor fails or refuses to remove and renew any defective materials used or work performed, or to make any necessary repairs in an acceptable manner and in accordance with the requirements of the

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Contract within the time indicated in writing, the Engineer has the authority to repair, remove, or renew the unacceptable or defective materials or work as necessary, all at the Contractor's expense. The Department will obtain payment for any expense it incurs in making these repairs, removals, or renewals, that the Contractor fails or refuses to make, by deducting such expenses from any moneys due or which may become due the Contractor, or by charging such amounts against the Contract bond.

5-9.4 Inspection by Federal Government: When the United States Government pays a portion of the cost of construction, its representatives may inspect the construction work as they deem necessary. However, such inspection will in no way make the Federal Government a party to the Contract.

5-10 Final Inspection.

5-10.1 Maintenance until Acceptance: Maintain all Work until the Engineer has given final acceptance in accordance with 5-11.

5-10.2 Inspection for Acceptance: Upon submittal of written notification that all Contract Work, or all Contract Work on the portion of the Contract scheduled for acceptance, has been completed, the Engineer will make an inspection for acceptance. The inspection will be made within seven days of such notification. If the Engineer finds that all work has been satisfactorily completed, the Department will consider such inspection as the final inspection. If any or all of the Work is found to be unsatisfactory, the Engineer will detail the remedial work required to achieve acceptance. Immediately perform such remedial work. Subsequent inspections will be made on the remedial work until the Engineer accepts all Work.

Upon satisfactory completion of the Work, the Department will submit written notice of acceptance, either partial or final, to the Contractor.

Until final acceptance in accordance with 5-11, replace or repair any damage to the accepted Work. Payment of such work will be as provided in 7-14.

5-10.3 Partial Acceptance: At the Engineer's sole discretion, the Engineer may accept any portion of the Work under the provisions of 5-10.2.

5-10.4 Conditional Acceptance: The Engineer will not make, or consider requests for conditional acceptance of a project.

5-11 Final Acceptance.

When, upon completion of the final construction inspection of the entire project, the Engineer determines that the Contractor has satisfactorily completed the work, the Engineer will submit written notice of final acceptance to the Contractor.

5-12 Claims by Contractor.

5-12.1 General: When the Contractor deems that extra compensation or a time extension is due beyond that agreed to by the Engineer, whether due to delay, additional work, altered work, differing site conditions, breach of Contract, or for any other cause, the Contractor shall follow the procedures set forth herein for preservation, presentation and resolution of the claim.

Submission of timely notice of intent to file a claim, preliminary time extension request, time extension request, and the certified written claim, together with full and complete claim documentation, are each a condition precedent to the Contractor bringing any circuit court, arbitration, or other formal claims resolution proceeding against the Department for the items and for the sums or time set forth in the Contractor's certified written claim. The failure to provide such notice of intent, preliminary time extension request, time extension request,

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certified written claim and full and complete claim documentation within the time required shall constitute a full, complete, absolute and irrevocable waiver by the Contractor of any right to additional compensation or a time extension for such claim.

5-12.2 Notice of Claim:

5-12.2.1 Claims For Extra Work: Where the Contractor deems that additional compensation or a time extension is due for work or materials not expressly provided for in the Contract or which is by written directive expressly ordered by the Engineer pursuant to 4-3, the Contractor shall submit written notification to the Engineer of the intention to make a claim for additional compensation before beginning the work on which the claim is based, and if seeking a time extension, the Contractor shall also submit a preliminary request for time extension pursuant to 8-7.3.2 within ten calendar days after commencement of a delay and a request for Contract Time extension pursuant to 8-7.3.2 within thirty calendar days after the elimination of the delay. If such written notification is not submitted and the Engineer is not afforded the opportunity for keeping strict account of actual labor, material, equipment, and time, the Contractor waives the claim for additional compensation or a time extension. Such notice by the Contractor, and the fact that the Engineer has kept account of the labor, materials and equipment, and time, shall not in any way be construed as establishing the validity of the claim or method for computing any compensation or time extension for such claim. On projects with an original Contract amount of $3,000,000 or less within 90 calendar days after final acceptance of the project in accordance with 5-11, and on projects with an original Contract amount greater than $3,000,000 within 180 calendar days after final acceptance of the project in accordance with 5-11, the Contractor shall submit full and complete claim documentation as described in 5-12.3 and duly certified pursuant to 5-12.9. However, for any claim or part of a claim that pertains solely to final estimate quantities disputes the Contractor shall submit full and complete claim documentation as described in 5-12.3 and duly certified pursuant to 5-12.9, as to such final estimate claim dispute issues, within 90 or 180 calendar days, respectively, of the Contractor's receipt of the Department's final estimate.

If the Contractor fails to submit a certificate of claim as described in 5-12.9, the Department will so notify the Contractor in writing. The Contractor shall have ten calendar days from receipt of the notice to resubmit the claim documentation, without change, with a certificate of claim as described in 5-12.9, without regard to whether the resubmission is within the applicable 90 or 180 calendar day deadline for submission of full and complete claim documentation. Failure by the Contractor to comply with the ten-calendar day notice shall constitute a waiver of the claim.

5-12.2.2 Claims For Delay: Where the Contractor deems that additional compensation or a time extension is due on account of delay, differing site conditions, breach of Contract, or any other cause other than for work or materials not expressly provided for in the Contract (Extra Work) or which is by written directive of the Engineer expressly ordered by the Engineer pursuant to 4-3, the Contractor shall submit a written notice of intent to the Engineer within ten days after commencement of a delay to a controlling work item expressly notifying the Engineer that the Contractor intends to seek additional compensation, and if seeking a time extension, the Contractor shall also submit a preliminary request for time extension pursuant to 8-7.3.2 within ten calendar days after commencement of a delay to a controlling work item, as to such delay and providing a reasonably complete description as to the cause and nature of the delay and the possible impacts to the Contractor's work by such delay, and a request for Contract Time extension pursuant to 8-7.3.2 within thirty calendar days after the elimination of the delay.

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On projects with an original Contract amount of $3,000,000 or less within 90 calendar days after final acceptance of the project in accordance with 5-11, and on projects with an original Contract amount greater than $3,000,000 within 180 calendar days after final acceptance of the project in accordance with 5-11, the Contractor shall submit full and complete documentation as described in 5-12.3 and duly certified pursuant to 5-12.9.

If the Contractor fails to submit a certificate of claim as described in 5-12.9, the Department will so notify the Contractor in writing. The Contractor shall have ten calendar days from receipt of the notice to resubmit the claim documentation, without change, with a certificate of claim as described in 5-12.9, without regard to whether the resubmission is within the applicable 90 or 180 calendar day deadline for submission of full and complete claim documentation. Failure by the Contractor to comply with the ten-calendar day notice shall constitute a waiver of the claim.

There shall be no Contractor entitlement to any monetary compensation or time extension for any delays or delay impacts, whatsoever, that are not to a controlling work item, and then as to any such delay to a controlling work item entitlement to any monetary compensation or time extension shall only be to the extent such is otherwise provided for expressly under 4-3 or 5-12, except that in the instance of delay to a non-controlling item of work the Contractor may be compensated for the direct costs of idle labor or equipment only, at the rates set forth in 4-3.2.1(1) and (3), and then only to the extent the Contractor could not reasonably mitigate such idleness.

If the Contractor provides the written notice of intent, the preliminary request for time extension, and the request for Contract Time extension in compliance with the aforementioned time and content requirements, the Contractor's claim for delay to a controlling work item will be evaluated as of the date of the elimination of the delay even if the Contractor's performance subsequently overcomes the delay. If the claim for delay has not been settled, the Contractor must also comply with 5-12.3 and 5-12.9 to preserve the claim.

5-12.3 Content of Written Claim: As a condition precedent to the Contractor being entitled to additional compensation or a time extension under the Contract, for any claim, the Contractor shall submit a certified written claim to the Department which will include for each individual claim, at a minimum, the following information:

1. A detailed factual statement of the claim providing all necessary dates, locations, and items of work affected and included in each claim;

2. The date or dates on which actions resulting in the claim occurred or conditions resulting in the claim became evident;

3. Identification of all pertinent documents and the substance of any material oral communications relating to such claim and the name of the persons making such material oral communications;

4. Identification of the provisions of the Contract which support the claim and a statement of the reasons why such provisions support the claim, or alternatively, the provisions of the Contract which allegedly have been breached and the actions constituting such breach;

5. A detailed compilation of the amount of additional compensation sought and a breakdown of the amount sought as follows:

a. documented additional job site labor expenses;

b. documented additional cost of materials and supplies;

c. a list of additional equipment costs claimed, including each piece of equipment and the rental rate claimed for each;

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d. any other additional direct costs or damages and the documents in support thereof;

e. any additional indirect costs or damages and all documentation in support thereof.

6. A detailed compilation of the specific dates and the exact number of calendar days sought for a time extension, the basis for entitlement to time for each day, all documentation of the delay, and a breakout of the number of days claimed for each identified event, circumstance or occurrence.

Further, the Contractor shall be prohibited from amending either the bases of entitlement or the amount of any compensation or time stated for any and all issues claimed in the Contractor's written claim submitted hereunder, and any circuit court, arbitration, or other formal claims resolution proceeding shall be limited solely to the bases of entitlement and the amount of any compensation or time stated for any and all issues claimed in the Contractor's written claim submitted hereunder. This shall not, however, preclude a Contractor from withdrawing or reducing any of the bases of entitlement and the amount of any compensation or time stated for any and all issues claimed in the Contractor's written claim submitted hereunder at any time.

5-12.4 Action on Claim: The Engineer will respond in writing on projects with an original Contract amount of $3,000,000 or less within 90 calendar days of receipt of a complete claim submitted by a Contractor in compliance with 5-12.3, and on projects with an original Contract amount greater than $3,000,000 within 120 calendar days of receipt of a complete claim submitted by a Contractor in compliance with 5-12.3. Failure by the Engineer to respond to a claim in writing within 90 or 120 days, respectively, after receipt of a complete claim submitted by the Contractor in compliance with 5-12.3 constitutes a denial of the claim by the Engineer. If the Engineer finds the claim or any part thereof to be valid, such partial or whole claim will be allowed and paid for to the extent deemed valid and any time extension granted, if applicable, as provided in the Contract. No circuit court or arbitration proceedings on any claim, or a part thereof, may be filed until after final acceptance per 5-11 of all Contract work by the Department or denial hereunder, whichever occurs last.

5-12.5 Pre-Settlement and Pre-Judgment Interest: Entitlement to any pre-settlement or pre-judgment interest on any claim amount determined to be valid subsequent to the Department's receipt of a certified written claim in full compliance with 5-12.3, whether determined by a settlement or a final ruling in formal proceedings, the Department shall pay to the Contractor simple interest calculated at the Prime Rate (as reported by the Wall Street Journal as the base rate on corporate loans posted by at least 75% of the nation's 30 largest banks) as of the 60th calendar day following the Department's receipt of a certified written claim in full compliance with 5-12.3, such interest to accrue beginning 60 calendar days following the Department's receipt of a certified written claim in full compliance with 5-12.3 and ending on the date of final settlement or formal ruling.

5-12.6 Compensation for Extra Work or Delay:

5-12.6.1 Compensation for Extra Work: Notwithstanding anything to the contrary contained in the Contract Documents, the Contractor shall not be entitled to any compensation beyond that provided for in 4-3.2.

5-12.6.2 Compensation for Delay: Notwithstanding anything to the contrary contained in the Contract Documents, the additional compensation set forth in 5-12.6.2.1 shall be the Contractor's sole monetary remedy for any delay other than to perform extra work caused by

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the Department unless the delay shall have been caused by acts constituting willful or intentional interference by the Department with the Contractor's performance of the work and then only where such acts continue after Contractor's written notice to the Department of such interference. The parties anticipate that delays may be caused by or arise from any number of events during the term of the Contract, including, but not limited to, work performed, work deleted, supplemental agreements, work orders, disruptions, differing site conditions, utility conflicts, design changes or defects, time extensions, extra work, right-of-way issues, permitting issues, actions of suppliers, subcontractors or other contractors, actions by third parties, suspensions of work by the Engineer pursuant to 8-6.1, shop drawing approval process delays, expansion of the physical limits of the project to make it functional, weather, weekends, holidays, special events, suspension of Contract Time, or other events, forces or factors sometimes experienced in construction work. Such delays or events and their potential impacts on the performance by the Contractor are specifically contemplated and acknowledged by the parties in entering into this Contract, and shall not be deemed to constitute willful or intentional interference with the Contractor's performance of the work without clear and convincing proof that they were the result of a deliberate act, without reasonable and good-faith basis, and specifically intended to disrupt the Contractor's performance.

5-12.6.2.1 Compensation for Direct Costs, Indirect Costs, Expenses, and Profit thereon, of or from Delay: For any delay claim, the Contractor shall be entitled to monetary compensation for the actual idle labor (including supervisory personnel) and equipment, and indirect costs, expenses, and profit thereon, as provided for in 4-3.2.1(4) and solely for costs incurred beyond what reasonable mitigation thereof the Contractor could have undertaken.

5-12.7 Mandatory Claim Records: After submitting to the Engineer a notice of intent to file a claim for extra work or delay, the Contractor must keep daily records of all labor, material and equipment costs incurred for operations affected by the extra work or delay. These daily records must identify each operation affected by the extra work or delay and the specific locations where work is affected by the extra work or delay, as nearly as possible. The Engineer may also keep records of all labor, material and equipment used on the operations affected by the extra work or delay. The Contractor shall, once a notice of intent to claim has been timely filed, and not less than weekly thereafter as long as appropriate, submit the Contractor's daily records to the Engineer and be likewise entitled to receive the Department's daily records. The daily records to be submitted hereunder shall be done at no cost to the recipient.

5-12.8 Claims for Acceleration: The Department shall have no liability for any constructive acceleration of the work, nor shall the Contractor have any right to make any claim for constructive acceleration nor include the same as an element of any claim the Contractor may otherwise submit under this Contract. If the Engineer gives express written direction for the Contractor to accelerate its efforts, such written direction will set forth the prices and other pertinent information and will be reduced to a written Contract Document promptly. No payment will be made on a Supplemental Agreement for acceleration prior to the Department's approval of the documents.

5-12.9 Certificate of Claim: When submitting any claim, the Contractor shall certify under oath and in writing, in accordance with the formalities required by Florida law, that the claim is made in good faith, that the supportive data are accurate and complete to the Contractor's best knowledge and belief, and that the amount of the claim accurately reflects what

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the Contractor in good faith believes to be the Department's liability. Such certification must be made by an officer or director of the Contractor with the authority to bind the Contractor.

5-12.10 Non-Recoverable Items: The parties agree that for any claim the Department will not have liability for the following items of damages or expense:

1. Loss of profit, incentives or bonuses;
2. Any claim for other than extra work or delay;
3. Consequential damages, including, but not limited to, loss of bonding capacity, loss of bidding opportunities, loss of credit standing, cost of financing, interest paid, loss of other work or insolvency;
4. Acceleration costs and expenses, except where the Department has expressly and specifically directed the Contractor in writing "to accelerate at the Department's expense"; nor
5. Attorney fees, claims preparation expenses and costs of litigation.

5-12.11 Exclusive Remedies: Notwithstanding any other provision of this Contract, the parties agree that the Department shall have no liability to the Contractor for expenses, costs, or items of damages other than those which are specifically identified as payable under 5-12. In the event any legal action for additional compensation, whether on account of delay, acceleration, breach of contract, or otherwise, the Contractor agrees that the Department's liability will be limited to those items which are specifically identified as payable in 5-12.

5-12.12 Settlement Discussions: The content of any discussions or meetings held between the Department and the Contractor to settle or resolve any claims submitted by the Contractor against the Department shall be inadmissible in any legal, equitable, arbitration or administrative proceedings brought by the Contractor against the Department for payment of such claim. Dispute Resolution Board, State Arbitration Board and Claim Review Committee proceedings are not settlement discussions, for purposes of this provision.

5-12.13 Personal Liability of Public Officials: In carrying out any of the provisions of the Contract or in exercising any power or authority granted to the Secretary of Transportation, Engineer or any of their respective employees or agents, there shall be no liability on behalf of any employee, officer or official of the Department for which such individual is responsible, either personally or as officials or representatives of the Department. It is understood that in all such matters such individuals act solely as agents and representatives of the Department.

5-12.14 Auditing of Claims: All claims filed against the Department shall be subject to audit at any time following the filing of the claim, whether or not such claim is part of a suit pending in the Courts of this State. The audit may be performed, at the Department's sole discretion, by employees of the Department or by any independent auditor appointed by the Department, or both. The audit may begin after ten days written notice to the Contractor, subcontractor, or supplier. The Contractor, subcontractor, or supplier shall make a good faith effort to cooperate with the auditors. As a condition precedent to recovery on any claim, the Contractor, subcontractor, or supplier must retain sufficient records, and provide full and reasonable access to such records, to allow the Department's auditors to verify the claim and failure to retain sufficient records of the claim or failure to provide full and reasonable access to such records shall constitute a waiver of that portion of such claim that cannot be verified and shall bar recovery thereunder. Further, and in addition to such audit access, upon the Contractor submitting a written claim, the Department shall have the right to request and receive, and the Contractor shall have the affirmative obligation to submit to the Department any and all documents in the possession of the Contractor or its subcontractors, materialmen or suppliers as

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may be deemed relevant by the Department in its review of the basis, validity or value of the Contractor's claim.

Without limiting the generality of the foregoing, the Contractor shall upon written request of the Department make available to the Department's auditors, or upon the Department's written request, submit at the Department's expense, any or all of the following documents:

1. Daily time sheets and foreman's daily reports and diaries;
2. Insurance, welfare and benefits records;
3. Payroll register;
4. Earnings records;
5. Payroll tax return;
6. Material invoices, purchase orders, and all material and supply acquisition contracts;
7. Material cost distribution worksheet;
8. Equipment records (list of company owned, rented or other equipment used);
9. Vendor rental agreements and subcontractor invoices;
10. Subcontractor payment certificates;
11. Canceled checks for the project, including, payroll and vendors;
12. Job cost report;
13. Job payroll ledger;
14. General ledger, general journal, (if used) and all subsidiary ledgers and journals together with all supporting documentation pertinent to entries made in these ledgers and journals;
15. Cash disbursements journal;
16. Financial statements for all years reflecting the operations on this project;
17. Income tax returns for all years reflecting the operations on this project;
18. All documents which reflect the Contractor's actual profit and overhead during the years this Contract was being performed and for each of the five years prior to the commencement of this Contract;
19. All documents related to the preparation of the Contractor's bid including the final calculations on which the bid was based;
20. All documents which relate to each and every claim together with all documents which support the amount of damages as to each claim;
21. Worksheets used to prepare the claim establishing the cost components for items of the claim including, but not limited to, labor, benefits and insurance, materials, equipment, subcontractors, and all documents that establish which time periods and individuals were involved, and the hours and rates for such individuals.

5-13 Recovery Rights, Subsequent to Final Payment.

The Department reserves the right, if it discovers an error in the partial or final estimates, or if it discovers that the Contractor performed defective work or used defective materials, after the final payment has been made, to claim and recover from the Contractor or his surety, or both, by process of law, such sums as may be sufficient to correct the error or make good the defects in the work and materials.

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SECTION 6
CONTROL OF MATERIALS

6-1 Acceptance Criteria.

6-1.1 General: Acceptance of materials is based on the following criteria. All requirements may not apply to all materials. Use only materials in the work that meet the requirements of these Specifications. The Engineer may inspect and test any material, at points of production, distribution and use.

6-1.2 Sampling and Testing: Use the Department's current sample identification and tracking system to provide related information and attach the information to each sample. Restore immediately any site from which material has been removed for sampling purposes to the pre-sampled condition with materials and construction methods used in the initial construction, at no additional cost to the Department.

Ensure when a material is delivered to the location as described in the Contract Documents, there is enough material delivered to take samples, at no expense to the Department.

6-1.2.1 Pretest by Manufacturers: Submit certified manufacturer's test results to the Engineer for qualification and use on Department projects. Testing will be as specified in the Contract Documents. The Department may require that manufacturers submit samples of materials for independent verification purposes.

6-1.2.2 Point of Production Test: Test the material during production as specified in the Contract Documents.

6-1.2.3 Point of Distribution Test: Test the material at Distribution facilities as specified in the Contract Documents.

6-1.2.4 Point of Use Test: Test the material immediately following placement as specified in the Specifications. After delivery to the project, the Department may require the retesting of materials that have been tested and accepted at the source of supply, or may require the testing of materials that are to be accepted by manufacturer certification. The Department may reject all materials that, when retested, do not meet the requirements of these Specifications.

6-1.3 Certification:

6-1.3.1 Manufacturer Material Certification: Submit material certifications for all materials to the Engineer for approval when required by the Specifications. Materials will not be considered for payment when not accompanied by a material certification. Sample material certification forms are available on the Department's website at the following URL: https://www.fdot.gov/materials/administration/resources/library/publications/certifications/sampleforms.shtm . Ensure that the material certification follows the format of the sample form, is submitted on the manufacturer's letterhead and is signed by a legally responsible person employed by the manufacturer.

6-1.3.1.1 Approved Product List: This list provides assurance to Contractors, consultants, designers, and Department personnel that specific products and materials are approved for use on Department facilities. The Department will limit the Contractor's use of products and materials that require use of APL items to those listed on the APL effective at the time of placement. Where the terms Qualified Products List (QPL) appear in the Contract Documents, they will be synonymous with Approved Product List (APL).

Manufacturers seeking to have a product evaluated for the APL must submit an application, available on the Department's website at the following URL:

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https://www.fdot.gov/programmanagement/ProductEvaluation/Default.shtm. Applications must include the following documentation:

1. Supporting documentation as required by the Specifications, Standard Plans, and APL approval process. A sample may be requested to verify the product, in accordance with the specifications.
2. A photograph displaying the product as shipped with packaging.
3. A list displaying all components within the shipped packaging, if applicable.
4. Installation instructions and materials, if applicable.
5. Product packaging or product labels as required by the Specifications.
6. Construction material percentages and country source of materials.
7. Last two manufacturing steps and country of manufacture.
8. Manufacturer name and material designation (product name, product model/part number/style number, etc.) must be as identified on the product, product packaging, and product labels.
9. Applications must be signed by a legally responsible person employed by the manufacturer of the product.

Required test reports must be conducted by an independent laboratory or other independent testing facility. Required drawings and calculations must be signed and sealed by a Professional Engineer licensed in the State of Florida.

Products that have successfully completed the Department's evaluation process are eligible for inclusion on the APL. Manufacturers are required to submit requests to the Department for approval of any modifications or alterations made to a product listed on the APL. This includes, but is not limited to, design, raw material, or manufacturing process modifications. Modification or alteration requests must be submitted along with supporting documentation that the product continues to meet Section 6, the Specification, or Standard Plans requirements. A product sample and additional product testing and documentation may be required for the modification evaluation. Any marked variations from original test values, failure to notify the Department of any modifications or alterations, or any evidence of inadequate performance of a product may result in removal of the product from the APL.

Manufacturers must submit supporting documentation to the Department for a periodic review and re-approval of their APL products on or before the product's original approval anniversary. APL products that are not re-approved may be removed from the APL. Documentation requirements for the product review and re-approval, including schedule and criteria, are available on the Department's website at the following URL: https://www.fdot.gov/programmanagement/ProductEvaluation/Default.shtm.

6-1.3.2 Contractor Installation Certification: Submit installation certifications as required by the Contract Documents.

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6-2 Applicable Documented Authorities Other Than Specifications.

6-2.1 General: Details on individual materials are identified in various material specific Sections of the Specifications that may refer to other documented authorities for requirements. When specified, meet the requirements as defined in such references.

6-2.2 Test Methods: Methods of sampling and testing materials are in accordance with the Florida Methods (FM). If an FM does not exist for a particular test, perform the testing in accordance with the method specified in the Specification. When test methods or other standards are referenced in the Specifications without identification of the specific time of issuance, use the most current issuance, including interims or addenda thereto, at the time of bid opening.

6-2.3 Construction Aggregates: Aggregates used on Department projects must be in accordance with Rule 14-103, FAC.

6-3 Storage of Materials and Samples.

6-3.1 Method of Storage: Store materials in such a manner as to preserve their quality and fitness for the work, to facilitate prompt inspection, and to minimize noise impacts on sensitive receivers. More detailed specifications concerning the storage of specific materials are prescribed under the applicable Specifications. The Department may reject improperly stored materials.

6-3.2 Use of Right-of-Way for Storage: If the Engineer allows, the Contractor may use a portion of the right-of-way for storage purposes and for placing the Contractor's plant and equipment. Use only the portion of the right-of-way that is outside the clear zone, which is the portion not required for public vehicular or pedestrian travel. When used, restore the right-of-way to pre-construction condition at no additional cost to the Department or as specified in the Contract Documents. Provide any additional space required at no expense to the Department.

6-3.3 Responsibility for Stored Materials: Accept responsibility for the protection of stored materials. The Department is not liable for any loss of materials, by theft or otherwise, or for any damage to the stored materials.

6-3.4 Storage Facilities for Samples: Provide facilities for storage of samples as described in the Contract Documents and warranted by the test methods and Specifications.

6-4 Defective Materials.

Materials not meeting the requirements of these Specifications will be considered defective. The Engineer will reject all such materials, whether in place or not. Remove all rejected material immediately from the site of the work and from storage areas, at no expense to the Department.

Do not use material that has been rejected, until the Engineer has approved the material's use. Upon failure to comply promptly with any order of the Engineer made under the provisions of this Article, the Engineer has the authority to have the defective material removed and replaced by other forces and deduct the cost of removal and replacement from any moneys due or to become due the Contractor.

6-4.1 Engineering Analysis: As an exception to the above, within 30 calendar days of the termination of the LOT or rejection of the material, the Contractor may submit to the Engineer a proposed Engineering Analysis Scope to determine the disposition of the material. The Engineering Analysis Scope must contain at a minimum:

1. Description of the defective materials.

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2. Supporting information, testing or inspection reports with nonconformities, pictures, drawings, and accurately dimensioned deficiency maps as necessary. For cracked elements, provide drawings showing the location, average width, depth, length, and termination points of each crack along the surfaces. Provide the distance from each termination point to a fixed reference point on the component, such as beam end or edge of flange.

3. Proposed approach of investigation and analysis.

4. Name and credentials of the proposed Specialty Engineer or Contractor's Engineer of Record who will perform the engineering analysis.

5. Proposed testing laboratories, qualified in accordance with Section 105-7.

Upon approval of the Engineering Analysis Scope by the Engineer, the Specialty Engineer or Contractor's Engineer of Record may perform the engineering analysis as defined in the approved scope and submit a signed and sealed Engineering Analysis Report (EAR) to the Engineer. The EAR must contain at a minimum:

1. The approved Engineering Analysis Scope.

2. Any investigations performed, and the associated results obtained.

3. Analysis and conclusion.

4. Proposed disposition of the material, addressing the performance and durability of the proposed action.

Provide as appropriate:

1. Written evidence of a previously approved comparable deficiency and its repair.

2. Documented research demonstrating the effectiveness of the proposed repair.

3. Engineering calculations.

A Specialty Engineer, who is an independent consultant, or the Contractor's Engineer of Record as stated within each individual Section shall perform any such analysis within 45 calendar days of the Engineer's approval of the Engineering Analysis Scope, complete and submit the EAR. The EAR must be signed and sealed by the Specialty Engineer or the Contractor's Engineer of Record that performed the engineering analysis. Allow for a 45 calendar day review period for all EARs associated with a category 2 bridge; tolling components identified in the current FDOT General Tolling Requirements (GTR) Part 3; and the tolling-related signing, DMS and ITS infrastructure. Allow for a 25 calendar day review period for all other items. The Engineer will determine the final disposition of the material after review of the EAR. No additional monetary compensation or time extension will be granted for the impact of any such analysis or review.

6-5 Products and Source of Supply.

6-5.1 Source of Supply–Convict Labor (Federal-Aid Contracts Only): Do not use materials that were produced after July 1, 1991, by convict labor for Federal-aid highway construction projects unless the prison facility has been producing convict-made materials for Federal-aid highway construction projects before July 1, 1987.

Use materials that were produced prior to July 2, 1991, by convicts on Federal-aid highway construction projects free from the restrictions placed on the use of these materials by 23 U.S.C. 114. The Department will limit the use of materials produced by convict labor for use in Federal-aid highway construction projects to:

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1. Materials produced by convicts on parole, supervised release, or probation from a prison or,

2. Materials produced in a qualified prison facility.

The amount of such materials produced for Federal-aid highway construction during any 12-month period shall not exceed the amount produced in such facility for use in such construction during the 12-month period ending July 1, 1987.

6-5.2 Source of Supply: Comply with 2 CFR 184 and 2 CFR 200.322, which includes the Buy America Sourcing Preferences of the Build America, Buy America Act (BABA). Domestic compliance for all affected products will be listed on the APL.

6-5.2.1 Steel and Iron: Use steel and iron manufactured in the United States, in accordance with the Buy America provisions of 23 CFR 635.410, as amended. Ensure that all manufacturing processes for this material occur in the United States. As used in this specification, a manufacturing process is any process that modifies the chemical content, physical shape or size, or final finish of a product, beginning with the initial melting and continuing through the final shaping and coating. If a steel or iron product is taken outside the United States for any manufacturing process, it becomes foreign source material. When using steel or iron materials as a component of any manufactured product (e.g., concrete pipe, prestressed beams, corrugated steel pipe, etc.), these same provisions apply. Foreign steel and iron may be used when the total actual cost of such foreign materials does not exceed 0.1% of the total Contract amount or $2,500, whichever is greater. These requirements are applicable to all steel and iron materials incorporated into the finished work but are not applicable to steel and iron items that the Contractor uses but does not incorporate into the finished work. Submit a certification from the manufacturer of steel or iron, or any product containing steel or iron, stating that all steel or iron furnished or incorporated into the furnished product was produced and manufactured in the United States or a statement that the product was produced within the United States except for minimal quantities of foreign steel and iron valued at $ (actual cost). Submit each such certification to the Engineer prior to incorporating the material or product into the project. Prior to the use of foreign steel or iron materials on a project, submit invoices to document the actual cost of such material, and obtain the Engineer's written approval prior to incorporating the material into the project.

6-5.2.2 Manufactured Products: Use Manufactured Products that are consumed in, incorporated into, or affixed to an infrastructure project that are manufactured in the United States, in accordance with BABA requirements and applicable waivers.

6-5.2.3 Construction Materials: Use non-ferrous metals, plastic and polymer-based products, glass, lumber, and drywall articles, materials, and supplies that are consumed in, incorporated into, or affixed to an infrastructure project that are manufactured in the United States, in accordance with BABA requirements.

6-5.2.4 Exemptions to Build America, Buy America: Temporary devices, equipment, and other items removed at or before the completion of the project are exempt from BABA funding eligibility requirements. Aggregates, cementitious materials, and aggregate binding agents or additives are exempted from BABA funding eligibility requirements.

6-5.3 Contaminated, Unfit, Hazardous, and Dangerous Materials: Do not use any material that, after approval and/or placement, has in any way become unfit for use. Do not use materials containing any substance that has been determined to be hazardous by the State of Florida Department of Environmental Protection or the U.S. Environmental Protection Agency (EPA). Provide workplaces free from serious recognized hazards and to comply with

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occupational safety and health standards, as determined by the U.S. Department of Labor Occupational Safety and Health Administration (OSHA).

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SECTION 7
LEGAL REQUIREMENTS AND RESPONSIBILITY TO THE PUBLIC

7-1 Laws to be Observed.

7-1.1 General: Become familiar with and comply with all Federal, State, and Local Rules and Regulations that control the action or operation of those engaged or employed in the work or that affect material used. Pay particular attention called to the safety regulations promulgated by the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA). In addition, comply with Chapter 403, of the Florida Statutes, regarding control of air pollution. Direct special attention to that portion of Chapter 62-256, Rules of the Department of Environmental Protection, Florida Administrative Code, pertaining to open burning in land clearing operations. Where work or structures included in the Contract are in "Navigable Waters of the U.S.," (reference 33 of the Code of Federal Regulations, Part 329); "Waters of the U.S.," (reference 33 of the Code of Federal Regulations, Parts 323 and 328); or "Waters of the State," (reference Part 4, Chapters 253 and 373 of the Florida Statutes and Section 62-340 of the Florida Administrative Code); comply with the regulatory provisions of Section 404 of the Federal Clean Water Act of 1977; Sections 9 and 10 of the Federal River and Harbor Act of 1899; Chapter 161 of the Florida Statutes; and any local authority having jurisdiction over such waters.

Comply with Part IV, Chapter 378, of the Florida Statutes regarding land reclamation. Direct special attention to Chapters 62C-36 and 62C-39 of the Florida Administrative Code. Submit the Notice of Intent to Mine to:

Department of Environmental Protection
Collins Building
2051 East Dirac Drive
Tallahassee, Florida 32310-3760

with a copy to the Engineer. The Engineer will determine consistency with the environmental documents prior to commencement of mining.

Obtain certification from the Construction Industry Licensing Board as required by Part I, Chapter 489, of the Florida Statutes, regardless of exemptions allowed by subsection 489.103, prior to removing underground pollutant storage tanks. Dispose of tanks and pollutants in accordance with the requirements and regulations of any Federal, State, or local, agency having jurisdiction.

Prior to building construction or renovation, submit current registrations or certifications issued by the Florida Construction Industry Licensing Board in accordance with Chapter 489, for the appropriate category of construction.

Corporations must be registered with the State of Florida, Department of State, Division of Corporations, and hold a current State Corporate Charter Number in accordance with Chapter 607, Florida Statutes.

The Contractor or the authorized subcontractor applying the roofing material must be licensed or be an approved dealer and applicator of the proposed roofing material.

Indemnify, defend, and save harmless the Department and all of its officers, agents, and employees, in the amount of the Contract price, against all claims or liability arising from or based on the violation of any such Federal, State, and Local Rules and Regulations, whether by himself or his employees.

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The Contractor shall comply with all environmental permits, including measures identified in the National Pollutant Discharge Elimination System (NPDES) Stormwater Pollution Prevention Plan and Sediment and Erosion Control Plan for the work.

The Contractor shall exert every reasonable and diligent effort to ensure that all labor employed by the Contractor and his subcontractors for work on the project work harmoniously and compatibly with all labor used by other building and construction contractors now or hereafter on the site of the work covered by this Contract. Include this provision in all subcontracts, and require all subcontractors to include it in their subcontracts with others. However, do not interpret or enforce this provision so as to deny or abridge, on account of membership or non-membership in any labor union or labor organization, the right of any person to work as guaranteed by Article I, Section 6 of the Florida Constitution.

Comply with Chapter 556 of the Florida Statutes during the performance of excavation or demolition operations.

The Executive Order 11246 Electronic version, dated September 24, 1965 is posted on the Department's website at the following URL address: https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/programmanagement/implemented/urlinspecs/files/deo11246.pdf. Take responsibility to obtain the information posted on this website up through five calendar days before the opening of bids and comply with the provisions contained in Executive Order 11246.

If the Department's website cannot be accessed, contact the Department's Specifications Office Web Coordinator at (850) 414-4101.

7-1.2 Plant Quarantine Regulations: The U.S. Department of Agriculture and the Florida Department of Agriculture and Consumer Services have issued quarantine regulations pertaining to control of the nematodes of citrus, Rule 5B-44, Florida Administrative Code, and other plant pests. Contact the local (or other available) representatives of the Animal and Plant Health Inspection Service of the U.S. Department of Agriculture, and the Division of Plant Industry of the Florida Department of Agriculture and Consumer Services to ascertain all current restrictions regarding plant pests that are imposed by these agencies. Keep advised of current quarantine boundary lines throughout the construction period.

These restrictions may affect operations in connection with such items as clearing and grubbing, earthwork, grassing and mulching, sodding, landscaping, and other items which might involve the movement of materials containing plant pests across quarantine lines.

Obtain quarantine regulations and related information from the following:

Animal and Plant Health Inspection Service
U.S. Department of Agriculture
3029 Lake Alfred Road
Winter Haven, Florida 33881

Director, Division of Plant Industry
Florida Department of Agriculture and Consumer Services
Post Office Box 147100
Gainesville, Florida 32614-7100

7-1.3 Introduction or Release of Prohibited Aquatic Plants, Plant Pests, or Noxious Weeds: Do not introduce or release prohibited aquatic plants, plant pests, or noxious weeds into the project limits as a result of clearing and grubbing, earthwork, grassing and mulching, sodding, landscaping, or other such activities. Immediately notify the Engineer upon discovery

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of all prohibited aquatic plants, plant pests, or noxious weeds within the project limits. Do not move prohibited aquatic plants, plant pests, or noxious weeds within the project limits or to locations outside of the project limits without the Engineer's permission. Maintain all borrow material brought onto the project site free of prohibited aquatic plants, plant pests, noxious weeds, and their reproductive parts. Refer to Rule 5B-64 and Rule 5B-57, of the Florida Administrative Code for the definition of prohibited aquatic plants, plant pests, and noxious weeds.

7-1.4 Compliance with Federal Endangered Species Act and other Wildlife Regulations: The Federal Endangered Species Act requires that the Department investigate the potential impact to a threatened or endangered species prior to initiating an activity performed in conjunction with a highway construction project. If the Department's investigation determines that there is a potential impact to a protected, threatened or an endangered species, the Department will conduct an evaluation to determine what measures may be necessary to mitigate such impact. When mitigation measures and/or special conditions are necessary, these measures and conditions will be addressed in the Contract Documents or in permits as identified in 7-2.1.

In addition, in cases where certain protected, threatened or endangered species are found or appear within close proximity to the project boundaries, the Department has established guidelines that will apply when interaction with certain species occurs, absent of any special mitigation measures or permit conditions otherwise identified for the project.

These guidelines are posted at the following URL address: https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/programmanagement/implemented/urlinspecs/files/endangeredwildlifeguidelines.pdf?sfvrsn=e27baf3f_2.

Take responsibility to obtain this information and take all actions and precautions necessary to comply with the conditions of these guidelines during all project activities.

Prior to establishing any off-project activity in conjunction with a project, notify the Engineer of the proposed activity. Covered activities include but are not necessarily limited to borrow pits, concrete or asphalt plant sites, disposal sites, field offices, and material or equipment storage sites. Include in the notification the Financial Project ID, a description of the activity, the location of the site by township, range, section, county, and city, a site location map including the access route, the name of the property owner, and a person to contact to arrange a site inspection. Submit this notification at least 30 days in advance of planned commencement of the off-site activity, to allow for the Department to conduct an investigation without delaying job progress.

Do not perform any off-project activity without obtaining written clearance from the Engineer. In the event the Department's investigation determines a potential impact to a protected, threatened or endangered species and mitigation measures or permits are necessary, coordinate with the appropriate resource agencies for clearance, obtain permits and perform mitigation measures as necessary. Immediately notify the Engineer in writing of the results of this coordination with the appropriate resource agencies. Additional compensation or time will not be allowed for permitting or mitigation, associated with Contractor initiated off-project activities.

7-1.5 Occupational Safety and Health Requirements: The Contractor shall take all precautions necessary for the protection of life, health, and general occupational welfare of all persons, including employees of both the Contractor and the Department, until the Contractor has completed the work required under the Contract as provided in 5-10 and 5-11.

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Comply at all times with applicable Federal, State, and local laws, provisions, and policies governing safety and health, including 29 CFR 1926, including all subsequent revisions and updates.

7-1.6 Discovery of an Unmarked Human Burial: When an unmarked human burial is discovered, immediately cease all activity that may disturb the unmarked human burial and notify the Engineer. Do not resume activity until specifically authorized by the Engineer.

7-1.7 Insecticides, Herbicides and Fertilizers:

7-1.7.1 Insecticides and Herbicides: Use products found on the following website, https://www.npirs.org/state/, approved by the Florida Department of Agriculture and Consumer Services. The use of restricted products is prohibited. Do not use any products in the sulfonylurea family of chemicals. Herbicide application by broadcast spraying is not allowed.

Procure any necessary licenses, pay all charges and fees, and give all notices necessary for lawful performance of the work.

Ensure that all insecticides and herbicides are applied in accordance with Chapter 5E-9, Florida Administrative Code. Submit a copy of current certificates to the Engineer upon request.

Ensure that employees who work with herbicides comply with all applicable Federal, State, and local regulations.

Comply with all regulations and permits issued by any regulatory agency within whose jurisdiction work is being performed. Post all permit placards in a protected, conspicuous location at the work site.

Acquire any permits required for work performed on the rights-of-way within the jurisdiction of National Forests in Florida. Contact the Local National Forest Ranger District, or the United States Department of Agriculture (USDA) office for the proper permits and subsequent approval.

Acquire all permits required for aquatic plant control as outlined in Chapter 62C-20, Florida Administrative Code Rules of the Florida Department of Environmental Protection. Contact the Regional Field Office of Bureau of Invasive Plant Management of the Florida Department of Environmental Protection for proper permits and subsequent approval. If application of synthetic organo-auxin herbicides is necessary, meet the requirements of Chapter 5E-2, Florida Administrative Code.

7-1.7.2 Fertilizer: Ensure that all employees applying fertilizer, possess a current Florida Department of Agriculture and Consumer Services Commercial Applicator license in accordance with Section 482.1562, F.S. Upon request, submit the current certificates to the Engineer.

7-1.8 Compliance with Section 4(f) of the USDOT Act: Section 4(f) of the USDOT Act prohibits the U. S. Secretary of Transportation from approving a project which requires the use of publicly owned land of a public park, recreation area or a wildlife and waterfowl refuge, or of any historic site of national, state, or local significance unless there is no prudent or feasible alternative to using that land and the program or project includes all possible planning to minimize the harm to the site resulting from the use.

Before undertaking any off-project activity associated with any federally assisted undertaking, ensure that the proposed site does not represent a public park, recreation area, wildlife or waterfowl refuge, or a historic site (according to the results of the Cultural Resources Survey discussed in 120-6.2). If such a site is proposed, notify the Engineer and provide a description of the proposed off-site activity, the Financial Project ID, the location of the site by

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township, range, section, a county or city map showing the site location, including the access route and the name of the property. It is the Contractor's responsibility to submit justification for use of Section 4(f) property that is sufficient for the Florida Department of Transportation and the Federal Highway Administration to make a Section 4(f) determination. Submit this notification sufficiently in advance of planned commencement of the off-site activity to allow a reasonable time for the Engineer to conduct an investigation without delaying job progress. Do not begin any off-project activity without obtaining written clearance from the Engineer.

7-1.9 Florida Minority Business Loan Mobilization Program: The Loan Mobilization Program is established by Section 288.706 of the Florida Statutes, and has as its goal to assist minority business enterprises by facilitating working capital loans to those eligible businesses that are Contractors or subcontractors on Department contracts.

The limits of such advances under this program shall be as specified in Section 288.706 of the Florida Statutes. In the case of a subcontractor, the amount of the advance will be based on the subcontract unit prices, not the contract unit prices.

All prime Contractor vendors shall be required to incorporate the designated loan mobilization payment procedures in subcontract agreements with minority business enterprise vendors participating in this program and to cooperate in the release of designated loan mobilization payments to achieve the objective of providing working capital for minority business enterprise subcontract vendors.

When the Contract has been awarded or, in the case of a subcontractor, a subcontract has been signed with the prime Contractor, application for participation in this program will be submitted in writing to the Engineer. Such application must be made prior to commencement of the work. If the application is made on behalf of a subcontractor, it shall be considered incomplete if the subcontract with the unit prices of the work clearly delineated is not included in the submittal.

When all applicable conditions have been met, approval for participation will be made by the Office of the Comptroller and the applicant will be notified of the approval action taken.

Once approval has been obtained and the Notice to Proceed has been issued, disbursement of the monies will be made at the request of the applicant. The designated loan mobilization payment may be paid prior to the commencement of work on the Contract. However, if the work on the Contract has not commenced and the payment has not been made, then the Contract Time may not commence until the payment is made. All designated loan mobilization payments will be made payable jointly to the prime Contractor and the participating financial institution. When a subcontractor is the participant in the program, such payments shall be paid to the participant within 10 business days after receipt of the funds from the Department.

Repayment of monies advanced through this program will be made after the value of the work accomplished by the participant reaches 50 percent. Contractors are encouraged to make weekly or bi-weekly payments to subcontractors participating in this program.

7-2 Permits and Licenses.

7-2.1 General: Except for permits procured by the Department, as incorporated by Special Provision expanding this Subarticle, if any, procure all permits and licenses, pay all charges and fees, and give all notices necessary and incidental to the due and lawful prosecution of the work.

The Department will also acquire any modifications or revisions to an original permit incorporated by Special Provision to this Subarticle when the Contractor requires such

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modifications or revisions to complete the construction operations specified in the Plans or Special Provisions and within the right-of-way limits.

Acquire all permits for work performed outside the right-of-way or easements for the project.

In carrying out the work in the Contract, when under the jurisdiction of any environmental regulatory agency, comply with all regulations issued by such agencies and with all general, special, and particular conditions relating to construction activities of all permits issued to the Department as though such conditions were issued to the Contractor. Post all permit placards in a protected location at the worksite.

In case of a discrepancy between any permit condition and other Contract Documents, the more stringent condition shall prevail.

7-2.2 Work or Structures in Navigable Waters of the U.S., Waters of the U.S., and Waters of the State: In general, one or more governmental agencies will exercise regulatory authority over work or structures, including related construction operations, in all tidal areas (channelward of the mean high water lines on the Atlantic and Gulf Coast); in the ocean and gulf waters to the outer limits of the continental shelf; in all rivers, streams, and lakes to the ordinary high water line; in marshes and shallows that are periodically inundated and normally characterized by aquatic vegetation capable of growth and reproduction; in all artificially created channels and canals used for recreational, navigational, or other purposes that are connected to navigable waters; and in all tributaries of navigable waters up to their headwaters.

Whenever the work under or incidental to the Contract requires structures or dredge/fill/construction activities in “Navigable Waters of the U.S.,” “Waters of the U.S.,” and “Waters of the State,” the Federal, State, county, and local regulatory agencies may require the Department to obtain a permit. For such dredge/fill /construction specified in the Plans to be accomplished within the limits of the project, or for any dredge/fill/construction within the limits of Department-furnished borrow areas, the Department will procure the necessary permits prior to advertising for bids.

7-2.3 As-Built Drawings and Certified Surveys:

7-2.3.1 Surface Water Management Systems for Water Management Districts: As a condition precedent to final acceptance of the project, submit to the Engineer the as-built drawings and a certified survey verifying the as-built conditions for all installed and constructed surface water management systems. The as-built drawings and certified survey must be PDF files in the same scale as the Plans, formatted on 11 inch by 17 inch sheets, and satisfy all the requirements and special conditions listed in the Water Management District’s Environmental Resource Permit (ERP) and any applicable local permit. The as-built drawings and certified survey must be signed and sealed by an appropriately licensed professional registered in the State of Florida.

If the ERP does not contain specific requirements, submit as-built drawings with the following information as a minimum:

1. Discharge structures: structure identification number, type, locations (latitude and longitude), dimensions and elevations of all, including weirs, bleeders, orifices, gates, pumps, pipes, and oil and grease skimmers.

2. Side bank and underdrain filters, or exfiltration trenches: locations, dimensions and elevations of all, including clean-outs, pipes, connections to control structures and points of discharge to receiving waters.

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3. Storage areas for treatment and attenuation: storage area identification number, dimensions, elevations, contours or cross-sections of all, sufficient to determine stage-storage relationships of the storage area and the permanent pool depth and volume below the control elevation for normally wet systems.

4. System grading: dimensions, elevations, contours, final grades or cross-sections to determine contributing drainage areas, flow directions and conveyance of runoff to the system discharge points.

5. Conveyance: dimensions, elevations, contours, final grades or cross-sections of systems utilized to divert off-site runoff around or through the new system.

6. Water levels: existing water elevations and the date determined.

7. Benchmarks: location and description (minimum of one per major water control structure).

7-2.3.2 Bridge Clearances for Projects under the Authority of a U.S. Coast Guard Permit: As a condition precedent to final acceptance of the project, submit to the Engineer a certified survey verifying the as-built clearances described in the U.S. Coast Guard Owner's Certification of Bridge Completion. The certified survey must be signed and sealed by a Professional Engineer or Professional Surveyor and Mapper registered in the State of Florida.

7-2.3.3 Projects Under the Authority of a U.S. Army Corps of Engineers Permit: As a condition precedent to final acceptance of the project, submit to the Engineer the as-built drawings and a certified survey verifying the as-built conditions. The as-built drawings and certified survey must be submitted in PDF files formatted in the same scale as the Plans, formatted on 11 inch by 17 inch sheets, and satisfy all of the requirements and special conditions listed in the U.S. Army Corps of Engineers permit. The as-built drawings and certified survey must be signed and sealed by a Professional Engineer or Professional Surveyor and Mapper registered in the State of Florida.

7-3 Patented Devices, Materials and Processes.

Include all royalties and costs arising from patents, trademarks, and copyrights, in any way involved in the work in the Contract price. Whenever using any design, device, material, or process covered by letters patent or copyright, obtain the right for such use by suitable legal agreement with the patentee or owner of the copyright. File a copy of such agreement with the Engineer. However, whether or not such agreement is made or filed as noted, the Contractor and the surety in all cases shall indemnify, defend, and save harmless, the Department from all claims for infringement by reason of the use of any such patented design, device, material, or process on work under the Contract, and shall indemnify the Department for all costs, expenses, and damages that it may be obliged to pay by reason of any such infringement, at any time during the prosecution or after the completion of the work.

7-4 Right-of-Way Furnished by the Department.

Except as otherwise stipulated in these Specifications or as shown in the Plans, the Department will furnish all rights-of-way necessary for the proper completion of the work at no expense to the Contractor.

Should Department-furnished areas for obtaining borrow material, contain limerock material do not remove such material from the pit unless the Engineer gives specific approval.

Use of Department owned right-of-way for the purpose of equipment or material storage, lay-down facilities, pre-cast material fabrication sites, batch plants for the production of asphalt, concrete or other construction related materials, or other similar activities, shall require advance

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written approval by the Department prior to making use of said Department owned right of way. Use of Department owned right of way for these purposes is expressly limited to the storage of equipment and materials for the Project or production of materials or products for the Project.

7-5 Restoration of Surfaces Opened by Permit.

Upon the presentation of a duly authorized and satisfactory permit that provides that all necessary repair work will be paid for by the party holding such permit, the Engineer may authorize the Contractor to allow parties bearing such permits to make openings in the highway. Upon the Engineer's written order, perform, in an acceptable manner, all necessary repairs due to such openings, and such necessary work that the Engineer orders, subject to the same conditions as the original work performed. The Department will pay the Contractor for such work either under applicable Contract items or in accordance with 4-4 when Contract items are not applicable.

7-6 Sanitary Provisions.

The Contractor shall provide and maintain, in a neat and sanitary condition, such accommodations for the use of his employees as are necessary to comply with the requirements and regulations of the State and local boards of health. Commit no public nuisance.

7-7 Control of the Contractor's Equipment.

7-7.1 Traffic Interference: Do not allow equipment, while it is on or traversing a road or street, to unreasonably interfere with traffic.

7-7.2 Overloaded Equipment: Do not operate on any road, street or bridge including a Department owned temporary bridge, any hauling unit or equipment loaded in excess of:

1. the maximum weights specified in the Florida Highway Patrol, Commercial Motor Vehicle Manual (Trucking Manual), or
2. lower weight limits legally established and posted for any section of road or bridge by the Department or local authorities.

The governmental unit having jurisdiction over a particular road or bridge may provide exceptions by special permit under the provisions of 7-7.3.

This restriction applies to all roads and bridges inside and outside the Contract limits as long as these roads and bridges are open for public use. The Contractor may overload roads and bridges which are to be demolished after they are permanently closed to the public. The Contractor is responsible for all loss or damages resulting from equipment operated on a structure permanently closed to the public.

7-7.3 Crossings: Where it is necessary to cross an existing road or street, including specifically the existing traveled lanes of a divided highway within the limits of the project, obtain permits from the Department, for crossing overloaded or oversized equipment. Cross existing roads or streets only at Engineer-designated points. The Engineer may require the Contractor to protect the pavement or Roadway at the crossing by using lumber, planks, or fill. Movement of equipment around the project site must be in accordance with requirements of the Standard Plans and not create an undue hazard to the traveling public or workers. Provide flagging and watchman service, or approved signal devices, for the protection of traffic at all such crossings, in accordance with an approved written plan for that activity.

7-7.4 Protection from Damage by Tractor-Type Equipment: Take positive measures to ensure that tractor-type equipment does not damage the road. If any such damage should

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occur, repair it without delay, at no expense to the Department and subject to the Engineer's approval.

7-7.5 Contractor's Equipment on Bridge Structures: The Contractor's Engineer of Record shall analyze the effect of imposed loads on bridge structures, including Department owned temporary bridges, within the limits of a construction contract, resulting from the following operations:

1. Overloaded Equipment as defined in 7-7.2:
    a. Operating on or crossing over completed bridge structures.
    b. Operating on or crossing over partially completed bridge structures.
2. Equipment within legal load limits:
    a. Operating on or crossing over partially completed bridge structures.
3. Construction cranes:
    a. Operating on completed bridge structures.
    b. Operating on partially completed bridge structures.
4. Asphalt Milling Equipment:
    a. In excess of 90,000 lbs crossing bridge structures.
    b. Less than 90,000 lbs crossing bridge structures listed on the overweight routing map CRN-2 located on the Office of Maintenance Over-Weight Dimension Permits website at https://www.fdot.gov/maintenance/owod-permit-documents#BlanketAttachments.

Any pipe culvert(s) or box culvert(s) qualifying as a bridge under 1-3 is excluded from the requirements above.

A completed bridge structure is a bridge structure in which all elemental components comprising the load carrying assembly have been completed, assembled, and connected in their final position. The components to be considered shall also include any related members transferring load to any bridge structure.

The Contractor's Engineer of Record shall determine the effect that equipment loads have on the bridge structure and develop the procedures for using the loaded equipment without exceeding the structure's design load capacity.

Submit to the Department for approval the design calculations, layout drawings, and erection drawings showing how the equipment is to be used so that the bridge structure will not be overstressed. The Contractor's Engineer of Record shall sign and seal the drawings and the cover sheet of the calculations for the Department's Record Set.

7-7.6 Posting of the Legal Gross Vehicular Weight: Display the maximum legal gross weight, as specified in the Florida Uniform Traffic Code, in a permanent manner on each side of any dump truck or dump type tractor-trailer unit hauling embankment material, construction aggregates, road base material, or hot bituminous mixture to the project over any public road or street. Display the weight in a location clearly visible to the scale operator, in numbers that contrast in color with the background and that are readily visible and readable from a distance of 50 feet.

7-8 Structures over Navigable Waters.

7-8.1 Compliance with Federal and Other Regulations: When working on structures in, adjacent to, or over, navigable waters, observe all regulations and instructions of Federal and other authorities having control over such waters. Do not obstruct navigation channels without permission from the proper authority, and provide and maintain navigation lights and signals in accordance with the Federal requirements for the protection of the structure, of false work, and of navigation.

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When working on moveable bridges, requests for temporarily changing the operating requirements for the moveable bridge must be submitted in writing to the appropriate Coast Guard District Bridge Branch, 90 days before the start of any action.

For all other bridges, notify the appropriate Coast Guard District Bridge Branch, at least 60 days prior to the start of any operations including construction and 30 days prior to any channel operations, closures, or opening restrictions.

When work platforms are indicated in the permit for construction, submit work platform construction plans to the appropriate Coast Guard District for approval. Obtain approval prior to beginning construction on the platform.

7-8.2 Maintenance of Channel: Where the work includes the excavation of a channel or other underwater areas to a required section, maintain the section from shoaling or other encroachment until final acceptance of the project.

In the event of accidental blocking of the navigation channel, immediately notify the U.S. Coast Guard of the blockage and upon removal of the blockage.

7-9 Use of Explosives.

When using explosives for the prosecution of the work, exercise the utmost care not to endanger life or property, including new work. The Contractor is responsible for all damage resulting from the use of explosives.

Store all explosives in a secure manner in compliance with all laws and ordinances, and clearly mark all such storage places with the words: “DANGEROUS - EXPLOSIVES”. Place such storage in the care of a competent watchman. Where no local laws or ordinances apply, provide storage satisfactory to the Engineer and, in general, not closer than 1,000 feet from the road or from any building, camping area, or place of human occupancy.

Notify each public utility company having structures in proximity to the site of the work of the intention to use explosives. Give such notice sufficiently in advance to enable the companies to take precautionary steps to protect their property from injury.

7-10 Forest Protection.

7-10.1 Compliance with State and Federal Regulations: In carrying out work within or adjacent to State or National forests or parks, comply with all of the regulations of the State or Federal authority having jurisdiction, governing the protection of and the carrying out of work in forests or parks, and observe all sanitary laws and regulations with respect to the performance of work in these areas. Keep the areas in an orderly condition, dispose of all refuse, and obtain permits for the construction, installation, and maintenance of any construction camps, living quarters, stores, warehouses, sanitary facilities, and other structures; all in accordance with the requirements of the forest or park official.

7-10.2 Prevention and Suppression of Forest Fires: Take all reasonable precautions to prevent and suppress forest fires. Require employees and subcontractors, both independently and at the request of forest officials, to do all reasonably within their power to prevent and suppress forest fires. Assist in preventing and suppressing forest fires, and make every possible effort to notify a forest official at the earliest possible moment of the location and extent of all fires. Extinguish the fire if practicable.

7-11 Preservation of Existing Property.

7-11.1 General: Preserve from damage all existing property within the project limits of or in any way affected by the Work, the removal or destruction of which is not specified in the

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Plans. This applies to, but is not limited to, public and private property, public and private utilities (except as modified by the provisions of 7-11.5), trees, shrubs, crops, sod, signs, monuments, fences, guardrail, pipe and underground structures, Intelligent Transportation Systems (ITS) facilities, traffic control signals and devices, highway lighting, and public highways (except natural wear and tear of highway resulting from legitimate use thereof by the Contractor).

Department owned underground facility locations shown in the Plans are approximate. Unless otherwise shown in the Plans, Department owned underground facilities will not be located by the Department nor through notification to "Sunshine 811". Locate all fiber optic cables. Provide a fiber optic cable locator in accordance with Section 633.

Whenever the Contractor's activities damage such existing property, immediately restore it to a condition equal to or better than that existing at the time such damage occurred, at no expense to the Department. Temporary repairs may be used to immediately restore ITS facilities and traffic control signals and devices. Permanent repairs to ITS facilities and traffic control signals and devices shall be made within 90 days of any temporary repairs and prior to final acceptance of the project. Submit permanent ITS facility repair plans to the Engineer prior to beginning repair work.

Protect existing bridges during the entire construction period from damage caused by the Work. Immediately repair, at no expense to the Department, all damage to existing bridges caused by the Work, prior to continuing the Work. The Department will not require the Contractor to provide routine repairs or maintenance for such structures.

Direct special attention to the protection of all geodetic monuments, horizontal or vertical, and Public Land Survey Corners located within the project. If any geodetic monument or Public Land Survey Corner, located within the project, is at risk of being damaged or destroyed, immediately notify the Engineer. Locate and replace any damaged or destroyed geodetic monuments or Public Land Survey Corners under the direction of a Professional Surveyor and Mapper registered in the State of Florida.

Whenever the actions of a third party damage such existing property and is not otherwise due to any fault or activities of the Contractor, either restore it to a condition equal to or better than that existing at the time such damage occurred or provide access and coordinate with the Department's maintenance Contractor in accordance with 8-4.4 as directed by the Engineer. The Department will compensate the Contractor for the costs associated with the repairs for restoring the existing property in accordance with 4-4. Theft and vandalism are considered damage caused by a third party.

7-11.2 Failure to Restore Damaged Existing Property: In case of failure on the part of the Contractor to restore such property, bridge, road or street, or to make good such damage or injury, the Engineer may, upon 48 hours notice, proceed to repair, rebuild, or otherwise restore such property, road, or street as may be deemed necessary, and the Department will deduct the cost thereof from any monies due or which may become due the Contractor under the Contract. Nothing in this clause prevents the Contractor from receiving proper compensation for the removal, damage, or replacement of any public or private property, not shown in the Plans, that is made necessary by alteration of grade or alignment. The Engineer will authorize such work, provided that the Contractor, or his employees or agents, have not, through their own fault, damaged such property.

7-11.3 Contractor's Use of Streets and Roads:

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7-11.3.1 On Systems Other than the State Highway System: When hauling materials or equipment to the project over roads and bridges on the State park road system, county road system, or city street system, and such use causes damage, immediately, at no expense to the Department, repair such road or bridge to as good a condition as before the hauling began.

The Department may modify the above requirement in accordance with any agreement the Contractor might make with the governmental unit having jurisdiction over a particular road or bridge, provided that the Contractor submits written evidence of such agreement to the Engineer.

7-11.3.2 On the State Highway System: The Department is responsible for the repair of any damage that hauling materials to the site causes to roads outside the limits of the project, that are either on the State highway system (roads under the jurisdiction of the Department) or specifically designated in the Plans as haul roads from Department-furnished material pits, except in the event damage is due to failure to comply with 7-7.2. The Contractor is responsible for all damages to any road or bridge caused by the Contractor's failure to comply with 7-7.2.

7-11.3.3 Within the Limits of a Construction Project: The Department will not allow the operation of equipment or hauling units of such weight as to cause damage to previously constructed elements of the project, including but not necessarily limited to bridges, drainage structures, base course, and pavement. Do not operate hauling units or equipment loaded in excess of the maximum weights specified in 7-7.2 on existing pavements that are to remain in place (including pavement being resurfaced), cement-treated subgrades and bases, concrete pavement, any course of asphalt pavement, and bridges. The Engineer may allow exceptions to these weight restrictions for movement of necessary equipment to and from its worksite, for hauling of offsite fabricated components to be incorporated into the project, and for crossings as specified in 7-7.3.

7-11.4 Operations within Railroad Right-of-Way: Submit written advanced notification of the flagging services and railroad right-of-way access required, construction timeframe, and duration to the Engineer and District Rail Office at least 45 calendar days prior to beginning any operation within the limits of the railroad right-of-way or the adjoining 15 feet. Operations include the movement of employees, equipment, and trucks in areas other than public crossings or any traffic signal work within 500 feet of a signalized at-grade railroad crossing. The Railroad Company will notify the District Rail Office when flaggers are available for use in project scheduling.

No operations shall be conducted that affect railroad operations and property without written approval from the railroad.

7-11.4.1 Notification to the Railroad Company: Submit written notification to the Engineer, District Rail Office and the authorized Railroad Representative at least 72 hours before beginning any operation within the limits of the railroad right-of-way; any operation requiring movement of employees, trucks, or other equipment across the tracks of the railroad company at locations other than an established public crossing; and any other work that may affect railroad operations or property.

7-11.4.1.1 Florida East Coast Railway (FEC): Contact the FEC Signal Office at 904-279-3182 and FEC Railway at 1-800-342-1131, ext. 2377 in addition to the requirements in Section 7-11.4.1.

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7-11.4.2 Contractor's Responsibilities: Unless instructed otherwise in writing by the Railroad Company, do not perform work within or adjacent to the railroad right-of-way without a flagger present (including temporary lane closures, lane shifts or detours). Comply with requirements deemed necessary by the railroad company's authorized representative to safeguard the railroad's property and operations.

The Contractor is responsible for all damages, delays, or injuries and all suits, actions, or claims brought on account of damages or injuries resulting from the Contractor's operations within or adjacent to railroad company right-of-way. The work includes all items necessary to relieve the flagger from providing protective services.

Costs incurred by the Railroad Company for Contractor-caused delays that adversely impact railway operations will be forwarded to the Contractor for payment. If the Contractor fails to pay said cost, the Department will deduct the amount from payments owed to the Contractor.

7-11.4.2.1 CSXT: Comply with the Construction Submission Criteria of the CSXT Public Project Information document and Construction Requirements sections of the CSXT Pipeline and Wireline Design and Construction Specifications prior to beginning work. These documents are available at the following URL: https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/CSXT.shtm.

Perform no work within the limits of the railroad right-of-way on CSXT holidays (except with permission of CSXT for emergencies such as natural disasters). CSXT holidays are New Year's Day, President's Day, Good Friday, Memorial Day, Independence Day, Labor Day, Thanksgiving Day and the following Friday, Christmas Eve, Christmas Day, and New Year's Eve. Holidays falling on Saturday are observed on Friday and those falling on Sunday are observed on Monday.

7-11.4.2.2 Norfolk Southern (NS): Comply with the NS Special Provisions for Protection of Railway Interests (Appendix E) and the Construction Requirements (Appendix 4.3) of the NS Public Projects Manual document prior to beginning and during all work. These documents are available at the following URL: https://www.norfolksouthern.com/en/rail-development-property/public-projects/contacts.

7-11.4.2.3 FEC: Complete the On-Track Contractor Roadway Worker Training Course for FEC Railway. Contact FEC Railway at 1-800-342-1131 for training information.

7-11.4.2.4 South Florida Rail Corridor (SFRC): Complete the On-Track Contractor Roadway Worker Training Course for South Florida Regional Transportation Authority (SFRTA) Railway. Contact SFRTA at 954-788-7920 for training information.

7-11.4.3 Watchman or Flagging Services: The railroad company will furnish protective services (i.e., watchman or flagging services) to ensure the safety of railroad operations during certain periods of the project. The Department will reimburse the railroad company for the cost thereof. Schedule work that affects railroad operations so as to minimize the need for protective services by the railroad company.

Submit construction schedules and schedule changes to the Engineer and District Rail Office which include an estimated start date, weekly construction schedule, daily hours of operation, and the calendar day duration for which flagging services will be necessary to perform work activities within railroad right-of-way in accordance with 8-3.2.

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7-11.4.3.1 Central Florida Rail Corridor (CFRC) and SFRC: The Department will furnish protective services (i.e., watchman or flagging services) to ensure the safety of railroad operations.

7-11.5 Utilities:

7-11.5.1 Arrangements for Protection or Adjustment: Do not commence work at points where the construction operations are adjacent to utility facilities until all necessary arrangements have been made for removal, temporary removal, relocation, de-energizing, deactivation or adjustment with the utility facilities owner to protect against damage that might result in expense, loss, disruption of service, or other undue inconvenience to the public or to the owners. The Contractor is solely and directly responsible to the owners and operators of such properties for all damages, injuries, expenses, losses, inconveniences, or delays caused by the Contractor's operations.

Do not request utility removal, temporary removal, relocation, de-energizing, deactivation, or adjustment when work can be accomplished within the utility work schedules. In the event that removal, temporary removal, relocation, de-energizing, deactivation, or adjustment of a utility or a particular sequence of timing in the relocation of a utility is necessary and has not been addressed in a utility work schedule, the Engineer will determine the necessity for any such utility work. Coordinate such work as to cause the least impediment to the overall construction operations and utility service. The Department is not responsible for utility removal, temporary removal, relocation, de-energizing, deactivation, or adjustment work where such work is determined not necessary by the Engineer or done solely for the benefit or convenience of the utility owner or its contractor, or the Contractor.

7-11.5.2 Cooperation with Utility Owners: Cooperate with the owners of all underground or overhead utility lines in their removal and rearrangement operations in order that these operations may progress in a reasonable manner, that duplication or rearrangement work may be reduced to a minimum, and that services rendered by the utility owners will not be unnecessarily interrupted.

In the event of interruption of water or other utility services as a result of accidental breakage, exposure, or lack of support, promptly notify the proper authority and cooperate with the authority in the prompt restoration of service. If water service is interrupted and the Contractor is performing the repair work, the Contractor shall work continuously until the service is restored. Do not begin work around fire hydrants until the local fire authority has approved provisions for continued service.

7-11.5.3 Utility Adjustments: Certain utility adjustments and reconstruction work may be underway during the progress of the Contract. Cooperate with the various utility construction crews who are maintaining utility service. Exercise due caution when working adjacent to relocated utilities. The Contractor shall repair all damage to the relocated utilities resulting from his operations at no expense to the Department. The requirements of 7-11.1 and 7-11.5.2 outline the Contractor's responsibility for of protecting utility facilities. The Department will include in the Contract the utility authorities who are scheduled to perform utility work on the project.

7-11.5.4 Weekly Meetings: Conduct weekly meetings on the job site with all the affected utility companies and the Engineer in attendance to coordinate project construction and utility relocation. Submit a list of all attendees one week in advance to the Engineer for approval.

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Submit the approved Work Progress Schedule and Work Plan for the project, as specified in 8-3.2, to document the schedule and plan for road construction and utility adjustments.

When utility relocations no longer affect construction activities, the Contractor may discontinue the meetings with the Engineer's approval.

7-12 Responsibility for Damages, Claims, etc.

7-12.1 Contractor to Provide Indemnification: The Contractor shall indemnify and hold harmless the Department, its officers and employees from liabilities, damages, losses and costs, including, but not limited to, reasonable attorney's fees, to the extent caused by the negligence, recklessness, or intentional wrongful misconduct of the Contractor and persons employed or utilized by the Contractor in the performance of the construction Contract.

It is specifically agreed between the parties executing this Contract that it is not intended by any of the provisions of any part of the Contract to create in the public or any member thereof, a third party beneficiary hereunder, or to authorize anyone not a party to this Contract to maintain a suit for personal injuries or property damage pursuant to the terms or provisions of this Contract.

7-12.2 Guaranty of Payment for Claims: The Contractor guaranties the payment of all just claims for materials, supplies, tools, or labor and other just claims against him or any subcontractor, in connection with the Contract. The Department's final acceptance and payment does not release the Contractor's bond until all such claims are paid or released.

7-13 Insurance.

7-13.1 Workers' Compensation Insurance: Provide Workers' Compensation Insurance in accordance with Florida's Workers' Compensation law for all employees. If subletting any of the work, ensure that the subcontractor(s) have Workers' Compensation Insurance for their employees in accordance with Florida's Workers' Compensation law. If using "leased employees" or employees obtained through professional employer organizations ("PEO's"), ensure that such employees are covered by Workers' Compensation insurance through the PEO's or other leasing entities. Ensure that any equipment rental agreements that include operators or other personnel who are employees of independent Contractors, sole proprietorships or partners are covered by insurance required under Florida's Workers' Compensation law.

7-13.2 Commercial General Liability Insurance: Carry Commercial General Liability insurance providing continuous coverage for all work or operations performed under the Contract. Such insurance shall be no more restrictive than that provided by the latest occurrence form edition of the standard Commercial General Liability Coverage Form (ISO Form CG 00 01) as filed for use in the State of Florida. Cause the Department to be made an Additional Insured as to such insurance. Such coverage shall be on an "occurrence" basis and shall include Products/Completed Operations coverage. The coverage afforded to the Department as an Additional Insured shall be primary as to any other available insurance and shall not be more restrictive than the coverage afforded to the Named Insured. The limits of coverage shall not be less than $1,000,000 for each occurrence and not less than a $5,000,000 annual general aggregate, inclusive of amounts provided by an umbrella or excess policy. The limits of coverage described herein shall apply fully to the work or operations performed under the Contract, and may not be shared with or diminished by claims unrelated to the contract. The policy/ies and coverage described herein may be subject to a deductible. Pay all deductibles as required by the policy. No policy/ies or coverage described herein may contain or be subject to a

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Retention or a Self-Insured Retention. Prior to the execution of the Contract, and at all renewal periods which occur prior to final acceptance of the work, the Department shall be provided with an ACORD Certificate of Liability Insurance reflecting the coverage described herein. The Department shall be notified in writing within ten days of any cancellation, notice of cancellation, lapse, renewal, or proposed change to any policy or coverage described herein. The Department's approval or failure to disapprove any policy/ies, coverage, or ACORD Certificates shall not relieve or excuse any obligation to procure and maintain the insurance required herein, nor serve as a waiver of any rights or defenses the Department may have.

7-13.3 Insurance Required for Construction at Railroads: When the Contract includes the construction of a railroad grade crossing, railroad overpass or underpass structure, or any other work or operations within the limits of the railroad right-of-way, including any encroachments thereon from work or operations in the vicinity of the railroad right-of-way, you shall, in addition to the insurance coverage required pursuant to 7-13.2 above, procure and maintain Railroad Protective Liability Coverage (ISO Form CG 00 35) where the railroad is the Named Insured and where the limits are not less than $2,000,000 combined single limit for bodily injury and/or property damage per occurrence, and with an annual aggregate limit of not less than $6,000,000. The railroad shall also be added along with the Department as an Additional Insured on the policy/ies procured pursuant to subsection 7-13.2 above. At the preconstruction conference, and at all renewal periods which occur prior to final acceptance of the work, both the Department and the railroad shall be provided with an ACORD Certificate of Liability Insurance reflecting the coverage described herein. The insurance described herein shall be maintained through final acceptance of the work. Both the Department and the railroad shall be notified in writing within ten days of any cancellation, notice of cancellation, renewal, or proposed change to any policy or coverage described herein. The Department's approval or failure to disapprove any policy/ies, coverage, or ACORD Certificates shall not relieve or excuse any obligation to procure and maintain the insurance required herein, nor serve as a waiver of any rights the Department may have.

7-13.4 Insurance for Protection of Utility Owners: When the Contract involves work on or in the vicinity of utility-owned property or facilities, the utility shall be added along with the Department as an Additional Insured on the policy/ies procured pursuant to subsection 7-13.2 above.

7-13.5 Marine General Liability Insurance: When the Contract involves work on bridges over navigable waters, carry Marine General Liability insurance providing continuous coverage for third-party personal injury and property damage caused by vessels used by the contractor in the performance of the work. Such insurance shall be no more restrictive than that provided by the latest occurrence form edition of the standard Commercial General Liability Coverage Form (ISO Form CG 00 01) as filed for use in the State of Florida. Cause the Department to be made an Additional Insured as to such insurance. Such coverage shall be on an "occurrence" basis and shall include Products/Completed Operations coverage. The coverage afforded to the Department as an Additional Insured shall be primary as to any other available insurance and shall not be more restrictive than the coverage afforded to the Named Insured. The limits of coverage shall not be less than $1,000,000 for each occurrence and not less than a $4,000,000 annual general aggregate, inclusive of amounts provided by an umbrella or excess policy. The limits of coverage described herein shall apply fully to the work or operations performed under the Contract, and may not be shared with or diminished by claims unrelated to the contract. The policy/ies and coverage described herein may be subject to a deductible. Pay all

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deductibles as required by the policy. No policy/ies or coverage described herein may contain or be subject to a Retention or a Self-Insured Retention. Prior to the execution of the Contract, and at all renewal periods which occur prior to final acceptance of the work, the Department shall be provided with an ACORD Certificate of Liability Insurance reflecting the coverage described herein. The Department shall be notified in writing within ten days of any cancellation, notice of cancellation, lapse, renewal, or proposed change to any policy or coverage described herein. The Department's approval or failure to disapprove any policy/ies, coverage, or ACORD Certificates shall not relieve or excuse any obligation to procure and maintain the insurance required herein, nor serve as a waiver of any rights or defenses the Department may have.

7-14 Contractor's Responsibility for Work.

The Contractor will take charge and custody of the Work and take every necessary precaution against damage to the Work, by the action of the elements or from any other cause whatsoever, until the Department's final acceptance of the Work. The Contractor will rebuild, repair, restore, and make good, all damage to any portion of the Work occasioned by any of the above causes before final acceptance of the Contract.

The Department will have no obligation to pay any reimbursement for damage caused by the execution or nonexecution of the Work by the Contractor or its sub-contractors, or damage the Contractor was negligent in preventing.

For damage to installed material caused by third parties, the Contractor may pursue recovery from the third party or seek reimbursement from the Department, but not both. The Department will not reimburse the Contractor for repair costs due to damage to installed material caused by known third parties unless the Contractor has contacted law enforcement within 14 days of the damage, filed a report, and provided the report to the Department within 14 calendar days of receiving the report from law enforcement. Upon submission of the report to the Department, the Department solely retains the right to pursue recovery from the known third party. If damage to installed material is caused by a known third party, the Department will reimburse the Contractor for costs associated with the repair after reducing the amount of the repair cost by a $2000.00 deductible for each occurrence, borne solely by the Contractor. If the Department is successful in recovery, the Contractor may be reimbursed proportionally, up to the amount of the deductible.

If damage to installed material other than guardrail, guardrail transitions and end treatments, and crash cushions is caused by an unknown third party, the Department will reimburse the contractor for 50% of the cost of the repair after reducing the amount of the repair cost by a $2000.00 deductible for each occurrence, borne solely by the Contractor. Repair costs for damage to guardrail, guardrail transitions and end treatments, and crash cushions installed as part of the work caused by unknown third parties will be reimbursed at the manufacturer's/distributor's invoice price for the new materials/parts plus 20% markup. The 20% markup is compensation for all necessary work, including but not limited to labor, equipment, supplies and profit, as authorized by the Engineer. Payment for any additional MOT required for the repair of guardrail, guardrail transitions and end treatments, and crash cushions installed as part of the work will be paid for under the appropriate MOT pay item.

Repair cost will be determined in accordance with 4-4. Theft and vandalism are considered damage caused by an unknown third party.

The Department may, at its discretion, reimburse the Contractor for the repair of damage to the Work not caused by a third party and due to unforeseeable causes beyond the control of

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and without the fault or negligence of the Contractor, including but not restricted to Acts of God, of the public enemy, or of governmental authorities.

7-15 Opening Sections of the Project to Traffic.

Whenever any section of the project is in acceptable condition for use, the Engineer may direct the Contractor to open it to vehicular or pedestrian traffic. The Department's direction to open a section of the project does not constitute an acceptance of the project, or any part thereof, or waive any Contract provisions. Perform all necessary repairs or renewals, on any section of the project thus opened to traffic under direction from the Engineer, due to defective material or work or to any cause other than ordinary wear and tear, pending completion and the Engineer's acceptance of the project, at no expense to the Department.

7-16 Wage Rates for Federal-Aid Projects.

For all projects that include Federal-aid participation, the Special Provisions contain requirements with regard to payment of predetermined minimum wages. Predetermined Wage Rate Decisions (U.S. Department of Labor provided Wage Rate Tables) exist for Heavy, Highway, and Building Construction Projects.

7-17 Supplemental Agreements.

Section 337.11 of the Florida Statutes as amended, which prescribe certain limitations on the use of supplemental agreements, are a part of the Contract.

7-18 Scales for Weighing Materials.

7-18.1 Applicable Regulations: When determining the weight of material for payment, use scales meeting the requirements of Chapter 531 of Florida Statutes, pertaining to specifications, tolerances, and regulations, as administered by the Bureau of Weights and Measures of the Florida Department of Agriculture.

7-18.2 Base for Scales: Place such scales on a substantial horizontal base to provide adequate support and rigidity and to maintain the level of the scales.

7-18.3 Protection and Maintenance: Maintain all scale parts in proper condition as to level and vertical alignment, and fully protect them against contamination by dust, dirt, and other matter that might affect their operation.

7-19 Source of Forest Products.

As required by Section 255.2575 of the Florida Statutes, where price, fitness and quality are equal, and when available, use only timber, timber piling, or other forest products that are produced and manufactured in the State of Florida. This provision does not apply to Federal-aid projects.

7-20 Regulations of Air Pollution from Asphalt Plants.

7-20.1 General: Perform all work in accordance with all Federal, State, and local laws and regulations regarding air pollution and burning. In particular, pay attention to Chapters 62-210 and 62-256, Rules of the Department of Environmental Protection, Florida Administrative Code, and to any part of the State Implementation Plan applicable to the project. See also 110-9.2 regarding burning of debris.

7-20.2 Dust Control: Control dust during the storage and handling of dusty materials by wetting, covering, or other means as approved by the Engineer.

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7-20.3 Asphalt Material: Use only emulsified asphalt, unless otherwise stated in the Plans and allowed by Chapter 62-210, Rules of the Department of Environmental Protection, Florida Administrative Code. Store and handle asphalt materials and components so as to minimize unnecessary release of hydrocarbon vapors.

7-20.4 Asphalt Plants: Operate and maintain asphalt plants in accordance with Chapter 62-210, Rules of the Department of Environmental Protection, Florida Administrative Code. Provide the plant site with a valid permit as required under Chapter 62-210 prior to start of work.

7-21 Dredging and Filling.

Section 370.033 of the Florida Statutes, requires that all persons, who engage in certain dredge or fill activities in the State of Florida, obtain a certificate of registration from the Florida Department of Environmental Protection, Tallahassee, Florida 32301, and that they keep accurate logs and records of all such activities for the protection and conservation of the natural resources. Obtain details as to the application of this law from the Department of Environmental Protection.

7-22 Available Funds.

For Contracts in excess of $25,000 or a term for more than one year, comply with the following provisions of Chapter 339 of the Florida Statutes:

The Department will not, during any fiscal year, expend money, incur any liability, or enter into any Contract that, by its terms, involves the expenditures of money in excess of the amounts budgeted as available for expenditure during such fiscal year. If the Department enters into such a Contract, verbal or written, in violation of this subsection, such Contract is null and void, and the Department will not make any payments thereon. The Department will require a statement from the Department's comptroller that funds are available prior to entering into any such Contract or other binding commitment of funds. Nothing herein contained prevents the Department from executing Contracts for a period exceeding one year, but the Department will make such Contracts executory only for the value of the services to be rendered or agreed to be paid for in succeeding fiscal years. The Department will incorporate this paragraph verbatim in all Contracts in excess of $25,000 or having a term for more than one year.

7-23 Contractor's Motor Vehicle Registration.

The Contractor shall provide the Department with proof that all motor vehicles operated or caused to be operated by such Contractor are registered in compliance with Chapter 320 of the Florida Statutes. Submit such proof of registration on Department Form 700-010-52.

The Department will not make payment to the Contractor until the required proof of registration is on file with the Department.

If the Contractor fails to register any motor vehicle that he operates in Florida, pursuant to Chapter 320 of the Florida Statutes, the Department may disqualify the Contractor from bidding, or the Department may suspend and revoke the Contractor's certificates of qualification.

7-24 Disadvantaged Business Enterprise Program.

7-24.1 Disadvantaged Business Enterprise Affirmative Action Plan: Prior to award of the Contract, have an approved Disadvantaged Business Enterprise (DBE) Affirmative Action Program Plan filed with the Equal Opportunity Office. Update and resubmit the plan every three

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years. No Contract will be awarded until the Department approves the Plan. The DBE Affirmative Action Program Plan is incorporated into and made a part of the Contract.

7-24.2 Required Contract and Subcontract DBE Assurance Language: In accordance with 49 CFR 26.13 (b), the Contract FDOT signs with the Contractor (and each subcontract the prime contractor signs with a subcontractor) must include the following assurance: "The Contractor, sub-recipient or subcontractor shall not discriminate on the basis of race, color, national origin, or sex in the performance of this contract. The Contractor shall carry out applicable requirements of 49 CFR Part 26 in the award and administration of DOT-assisted Contracts. Failure by the Contractor to carry out these requirements is a material breach of this Contract, which may result in the termination of this Contract or such other remedy as the recipient deems appropriate, which may include, but is not limited to,

1. Withholding monthly progress payments;
2. Assessing sanctions;
3. Liquidated damages; and/or
4. Disqualifying the Contractor from future bidding as non-responsible."

7-24.3 Plan Requirements: Include the following in the DBE Affirmative Action Program Plan:

1. A policy statement, signed by an authorized representative (president, chief executive officer, or chairman of the contractor), expressing a commitment to use DBEs in all aspects of contracting to the maximum extent feasible, outlining the various levels of responsibility, and stating the objectives of the program. Circulate the policy statement throughout the Contractor's organization.

2. The designation of a Liaison Officer within the Contractor's organization, as well as support staff, necessary and proper to administer the program, and a description of the authority, responsibility, and duties of the Liaison Officer and support staff. The Liaison Officer and staff are responsible for developing, managing, and implementing the program on a day-to-day basis for carrying out technical assistance activities for DBEs and for disseminating information on available business opportunities so that DBEs are provided an equitable opportunity to participate in Contracts let by the Department.

3. Utilization of techniques to facilitate DBE participation in contracting activities which include, but are not limited to:

a. Soliciting price quotations and arranging a time for the review of Plans, quantities, specifications, and delivery schedules, and for the preparation and presentation of quotations.

b. Providing assistance to DBEs in overcoming barriers such as the inability to obtain bonding, financing, or technical assistance.

c. Carrying out information and communication programs or workshops on contracting procedures and specific contracting opportunities in a timely manner, with such programs being bilingual where appropriate.

d. Encouraging eligible DBEs to apply for certification with the Department.

e. Contacting Minority Contractor Associations and city and county agencies with programs for disadvantaged individuals for assistance in recruiting and encouraging eligible DBE contractors to apply for certification with the Department.

7-24.4 DBE Records and Reports: Submit the following through the Equal Opportunity Compliance System:

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1. DBE Commitments - at or before the Pre-Construction Conference.

2. Report monthly, through the Equal Opportunity Compliance System on the Department's Website, actual payments (including retainage) made to DBEs for work performed with their own workforce and equipment in the area in which they are certified. Report payments made to all DBE and Minority Business Enterprise (MBE) subcontractors and DBE and MBE construction material and major suppliers.

The Equal Opportunity Office will provide instructions on accessing this system. Develop a record keeping system to monitor DBE affirmative action efforts which include the following:

1. the procedures adopted to comply with these Specifications;

2. the number of subordinated Contracts on Department projects awarded to DBEs;

3. the dollar value of the Contracts awarded to DBEs;

4. the percentage of the dollar value of all subordinated Contracts awarded to DBEs as a percentage of the total Contract amount;

5. a description of the general categories of Contracts awarded to DBEs; and

6. the specific efforts employed to identify and award Contracts to DBEs.

Upon request, provide the records to the Department for review.

Maintain all such records for a period of five years following acceptance of final payment and have them available for inspection by the Department and the Federal Highway Administration.

7-24.5 Counting DBE Participation and Commercially Useful Functions:

49 CFR Part 26.55 specifies when DBE credit shall be awarded for work performed by a DBE. DBE credit can only be awarded for work actually performed by DBEs themselves for the types of work for which they are certified. When reporting DBE Commitments, only include the dollars that a DBE is expected to earn for work they perform with their own workforce and equipment. Update DBE Commitments to reflect changes to the initial amount that was previously reported or to add DBEs not initially reported.

When a DBE participates in a contract, the value of the work is determined in accordance with 49 CFR Part 26.55, for example:

1. The Department will count only the value of the work performed by the DBE toward DBE goals. The entire amount of the contract that is performed by the DBE's own forces (including the cost of supplies, equipment and materials obtained by the DBE for the contract work) will be counted as DBE credit.

2. The Department will count the entire amount of fees or commissions charged by the DBE firm for providing a bona fide service, such as professional, technical, consultant, or managerial services or for providing bonds or insurance specifically required for the performance of a Department-assisted contract, toward DBE goals, provided that the Department determines the fees to be reasonable and not excessive as compared with fees customarily followed for similar services.

3. When the DBE subcontracts part of the work of its contract to another firm, the Department will count the value of the subcontracted work only if the DBE's subcontractor is itself a DBE. Work that a DBE subcontracts to a non-DBE firm does not count toward DBE goals.

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4. When a DBE performs as a participant in a joint venture, the Department will count the portion of the dollar value of the contract equal to the distinct, clearly defined portion of the work the DBE performs with its own forces toward DBE goals.

5. The Contractors shall ensure that only expenditures to DBEs that perform a commercially useful function (CUF) in the work of a contract may be counted toward the voluntary DBE goal.

6. A DBE performs a commercially useful function when it is responsible for execution of the work of the contract and is carrying out its responsibilities by actually performing, managing, and supervising the work involved. To perform a commercially useful function, the DBE must also be responsible, with respect to materials and supplies used on the contract, for negotiating price, determining quality and quantity, ordering the material, and installing (where applicable) and paying for the material itself.

7. Contractors wishing to use joint checks involving DBE credit must provide written notice to the District Contract Compliance Office prior to issuance of the joint check. The Contractor must also provide a copy of the notice to the DBE subcontractor and maintain a copy with the project records.

8. To determine whether a DBE is performing a commercially useful function, the Department will evaluate the amount of work subcontracted, industry practices, whether the amount the firm is to be paid under the contract is commensurate with the work it is actually performing and the DBE credit claimed for its performance of the work, and other relevant factors.

9. A DBE does not perform a commercially useful function if its role is limited to that of an extra participant in a transaction, contract, or project through which funds are passed in order to obtain the appearance of DBE participation.

10. If a DBE does not perform or exercise responsibility for at least 30% of the total cost of its contract with its own workforce, or if the DBE subcontracts a greater portion of the work of a contract than would be expected on the basis of normal industry practice for the type of work involved, the DBE has not performed a commercially useful function.

7-24.6 Prompt Payments: Meet the requirements of 9-5 for payments to all DBE subcontractors.

7-25 On-The-Job Training Requirements.

As part of the Contractor's equal employment opportunity affirmative action program, training shall be provided as follows:

The Contractor shall provide On-The-Job Training aimed at developing full journeymen in the type of trade or job classification involved in the work. In the event the Contractor subcontracts a portion of the contract work, it shall determine how many, if any, of the trainees are to be trained by the subcontractor provided, that the Contractor shall retain the primary responsibility for meeting the training requirements imposed by this Section. Ensure that, when feasible, 25% of trainees in each occupation are in their first year of training. The Contractor shall incorporate the requirements of this Section into such subcontract.

The number of trainees will be estimated on the number of calendar days of the contract, the dollar value, and the scope of work to be performed. The trainee goal will be finalized at a Post-Preconstruction Trainee Evaluation Meeting and the goal will be distributed among the work classifications based on the following criteria:

1. Determine the number of trainees on Federal Aid Contract:

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a. No trainees will be required for contracts with a Contract Time allowance of less than 275 calendar days.

b. If the Contract Time allowance is 275 calendar days or more, the number of trainees shall be established in accordance with the following chart:

Estimated Contract Amount	Trainees Required
$2,000,000 or less	0
Over $2,000,000 to $4,000,000	2
Over $4,000,000 to $6,000,000	3
Over $6,000,000 to $12,000,000	5
Over $12,000,000 to $18,000,000	7
Over $18,000,000 to $24,000,000	9
Over $24,000,000 to $31,000,000	12
Over $31,000,000 to $37,000,000	13
Over $37,000,000 to $43,000,000	14
Over $43,000,000 to $49,000,000	15
Over $49,000,000 to $55,000,000	16
Over $55,000,000 to $62,000,000	17
Over $62,000,000 to $68,000,000	18
Over $68,000,000 to $74,000,000	19
Over $74,000,000 to $81,000,000	20
Over $81,000,000 to $87,000,000	21
Over $87,000,000 to $93,000,000	22
Over $93,000,000 to $99,000,000	23
Over $99,000,000 to $105,000,000	24
Over $105,000,000 to $112,000,000	25
Over $112,000,000 to $118,000,000	26
Over $118,000,000 to $124,000,000	27
Over $124,000,000 to $130,000,000	28
Over $130,000,000 to *	
*One additional trainee per $6,000,000 of estimated Construction Contract amount over $130,000,000	

Further, if the Contractor or subcontractor requests to utilize banked trainees as discussed later in this Section, a Banking Certificate will be validated at this meeting allowing credit to the Contractor for previously banked trainees. Banked credits of prime Contractors working as Subcontractors may be accepted for credit. The Contractor's Project Manager, the Construction Project Engineer and the Department's District Contract Compliance Manager will attend this meeting. Within ten days after the Post-Preconstruction Training Evaluation Meeting, the Contractor shall submit to the Department for approval an On-The-Job Training Schedule indicating the number of trainees to be trained in each selected classification and the portion of the Contract Time during which training of each trainee is to take place. This schedule may be subject to change if any of the following occur:

1. When a start date on the approved On-The-Job Training Schedule has been missed by 14 or more days;

2. When there is a change in previously approved classifications; or

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3. When replacement trainees are added due to voluntary or involuntary termination

The revised schedule will be resubmitted to and approved by the Department's District Contract Compliance Manager.

The following criteria will be used in determining whether or not the Contractor has complied with this Section as it relates to the number of trainees to be trained:

1. Credit will be allowed for each trainee that is both enrolled and satisfactorily completes training on this Contract. Credit for trainees, over the established number for this Contract, will be carried in a "bank" for the Contractor and credit will be allowed for those surplus trainees in subsequent, applicable projects. A "banked" trainee is described as an employee who has been trained on a project, over and above the established goal, and for which the Contractor desires to preserve credit for utilization on a subsequent project.

2. Credit will be allowed for each trainee that has been previously enrolled in the Department's approved training program on another contract and continues training in the same job classification and completes their training on a different contract.

3. Credit will be allowed for each trainee who, due to the amount of work available in their classification, is given the greatest practical amount of training on the contract regardless of whether or not the trainee completes training.

4. Credit will be allowed for any training position indicated in the approved On-The-Job Training Schedule, if the Contractor can demonstrate that a good faith effort to provide training in that classification was made.

5. No credit will be allowed for a trainee whose employment by the Contractor is involuntarily terminated unless the Contractor can clearly demonstrate good cause for this action.

Training and upgrading of minorities, women and economically disadvantaged persons toward journeyman status is a primary objective of this Section. Accordingly, the Contractor shall make every effort to enroll minority trainees and women (e.g., by conducting systematic and direct recruitment through public and private sources likely to yield minority and women trainees) to the extent such persons are available within a reasonable area of recruitment. If a non-minority male is enrolled into the On-The-Job Training Program, the On-The-Job Training Notification of Personnel Action Form notifying the District Contract Compliance Manager of such action shall be accompanied by a disadvantaged certification or a justification for such action acceptable to the Department's District Contract Compliance Manager. The Contractor will be given an opportunity and will be responsible for demonstrating the steps that it has taken in pursuance thereof, prior to a determination as to whether the Contractor is in compliance with this Section. This training is not intended, and shall not be used, to discriminate against any applicant for training, whether a minority, woman or disadvantaged person.

No employee shall be employed as a trainee in any classification in which they have successfully completed a training course leading to journeyman status, or have been employed as a journeyman. The Contractor may satisfy this requirement by including appropriate questions in the employee application or by other suitable means. Regardless of the method used, the Contractor's records should document the findings in each case.

The minimum length and type of training for each classification will be as established at the Post-Preconstruction Trainee Evaluation Meeting and approved by the Department. Graduation to journeyman status will be based upon satisfactory completion of a Proficiency Demonstration set up at the completion of training and established for the specific training classification, completion of the minimum hours in a training classification range, and the

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employer's satisfaction that the trainee does meet journeyman status in the classification of training. Upon reaching journeyman status, the following documentation must be forwarded to the District Contract Compliance Office:

1. Trainee Enrollment and Personnel Action Form
2. Proficiency Demonstration Verification Form indicating completion of each standard established for the classification signed by representatives of both the Contractor and the Department.

The Department and the Contractor shall establish a program that is tied to the scope of the work in the project and the length of operations providing it is reasonably calculated to meet the equal employment opportunity obligations of the Contractor and to qualify the average trainee for journeyman status in the classifications concerned, by at least, the minimum hours prescribed for a training classification. Furthermore, apprenticeship programs registered with the U.S. Department of Labor, Bureau of Apprenticeship and Training, or with a State apprenticeship agency recognized by the Bureau and training programs approved but not necessarily sponsored by the U.S. Department of Labor, Manpower Administration, Bureau of Apprenticeship and Training shall also be considered acceptable provided it is being administered in a manner consistent with the equal employment obligations of Federal Aid highway construction contract. Approval or acceptance of a training schedule shall be obtained from the Department prior to commencing work on the classifications covered by the program.

A voluntary On-The-Job Training Program is available to a Contractor which has been awarded a state funded project. Through this program, the Contractor will have the option to train employees on state funded projects for "banked credit" as discussed previously in this provision, to be utilized on subsequent Federal Aid Projects where training is required. Those Contractors availing themselves of this opportunity to train personnel on state funded projects and bank trainee hours for credit shall comply with all training criteria set forth in this Section for Federal Aid Projects; voluntary banking may be denied by the Department if staff is not available to monitor compliance with the training criteria.

It is the intention of these provisions that training is to be provided in the construction crafts rather than clerk-typists or secretarial type positions. Training is permissible in lower level management positions such as office engineers, estimators, etc., where the training is oriented toward construction applications. Training in the laborer classifications, except Common/General Laborer, may be permitted provided that significant and meaningful training is provided and approved by the District Contract Compliance Office.

When approved in advance by the District Contract Compliance Manager, credit will be given for training of persons in excess of the number specified herein under the current contract or a Contractor will be allowed to bank trainees who have successfully completed a training program and may apply those trainees to a training requirement in subsequent project(s) upon approval of the Department's District Contract Compliance Manager. This credit will be given even though the Contractor may receive training program funds from other sources, provided such other source do not specifically prohibit the Contractor from receiving other form of compensation. Offsite training is permissible as long as the training is an integral part of an approved training program and does not compromise a significant part of the overall training. Credit for offsite training indicated above may only be made to the Contractor when it does one or more of the following and the trainees are concurrently employed on a Federal Aid Project:

1. Contributes to the cost of the training,
2. Provides the instruction to the trainee,

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3. Pays the trainee's wages during the offsite training period.

The Contractor shall compensate the trainee at no less than the laborer rate established in the Contract at the onset of training. The compensation rate will be increased to the journeyman's wage upon graduation from the training program for the remainder of the time the trainee works in the classification in which they were trained.

The Contractor shall furnish the trainee a copy of the program they will follow in providing the training. The Contractor shall provide each trainee with a certification showing the type and length of training satisfactorily completed. The Contractor shall enroll a trainee in one training classification at a time to completion before the trainee can be enrolled in another classification on the same project.

The Contractor shall maintain records to document the actual hours each trainee is engaged in training on work being performed as a part of this Contract.

The Contractor shall submit to the District Contract Compliance Manager a copy of an On-The-Job Training Notification of Personnel Action form no later than seven days after the effective date of the action when the following actions occur: a trainee is transferred on the project, transferred from the project to continue training on another contract, completes training, is upgraded to journeyman status or voluntary terminates or is involuntary terminated from the project.

The Contractor shall furnish to the District Contract Compliance Manager a copy of a Monthly Time Report for each trainee. The Monthly Time Report for each month shall be submitted no later than the tenth day of the subsequent month. The Monthly Time Report shall indicate the phases and sub-phases of the number of hours devoted to each proficiency.

Highway or Bridge Carpenter Helper, Mechanic Helper, Rodman/Chainman, and Timekeeper classifications will not be approved for the On-The-Job Training Program.

The number of trainees may be distributed among the work classifications on the basis of the Contractor's needs and the availability of journeymen in the various classifications within a reasonable area of recruitment.

The Contractor will have fulfilled the responsibilities of this Specification when acceptable training has been provided to the trainee as specified above.

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SECTION 8
PROSECUTION AND PROGRESS

8-1 Subletting or Assigning of Contracts.

Do not, sell, transfer, assign or otherwise dispose of the Contract or Contracts or any portion thereof, or of the right, title, or interest therein, without written consent of the Department. If the Contractor chooses to sublet any portion of the Contract, the Contractor must submit a written request to sublet work on the Certification of Sublet Work form developed by the Department for this purpose. With the Engineer's acceptance of the request, the Contractor may sublet a portion of the work, but shall perform with its own organization work amounting to not less than 40% of the total Contract amount. The Certification of Sublet Work request will be deemed acceptable by the Department, for purposes of the Department's consent, unless the Engineer notifies the Contractor within 5 business days of receipt of the Certification of Sublet Work that the Department is not consenting to the requested subletting.

Include in the total Contract amount the cost of materials and manufactured component products, and their transportation to the project site. For the purpose of meeting this requirement the Department will not consider off-site commercial production of materials and manufactured component products that the Contractor purchases, or their transportation to the project, as subcontracted work.

If the Contractor sublets a part of a Contract item, the Department will use only the sublet proportional cost in determining the percentage of subcontracted normal work.

Execute all agreements to sublet work in writing and include all pertinent provisions and requirements of the Contract. All other agreements must be in writing and reference all applicable Contract provisions. Upon request, submit to the Department a copy of the subcontract and agreement. The subletting of work does not relieve the Contractor or the surety of their respective liabilities under the Contract.

The Department recognizes a subcontractor only in the capacity of an employee or agent of the Contractor, and the Engineer may require the Contractor to remove the subcontractor as in the case of an employee.

8-2 Work Performed by Equipment-Rental Agreement.

The limitations set forth in 8-1, concerning the amount of work that may be sublet, do not apply to work performed by equipment-rental agreement. However, for any work proposed to be performed by equipment-rental agreement, notify the Engineer in writing of such intention before using the rented equipment, and indicate whether the equipment will be rented on an operated or non-operated basis. Include with the written notice a listing and description of the equipment and a description of the particular work to be performed with such equipment. As an exception to the above requirements, the Department will not require written notice for equipment to be rented (without operators) from an equipment dealer or from a firm whose principal business is the renting or leasing of equipment.

The operators of all rented equipment, whether rented on an operated or a non-operated basis, are subject to all wage rate requirements applicable to the project. When renting equipment without operators, the Contractor shall carry the operators on his own payroll. For equipment that is rented on an operated basis, and when required by the Contract or requested by the Engineer, submit payrolls from the lessor with the names of the operators shown thereon.

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When a lessor provides rentals of equipment on an operated basis that exceed $10,000, such lessor is subject to any Equal Employment Opportunity requirements that are applicable to the project.

8-3 Prosecution of Work.

8-3.1 Compliance with Time Requirements: Commence work in accordance with the accepted working schedule and provide sufficient labor, materials, and equipment to complete the work within the time limit(s) set forth in the proposal. Should the Contractor fail to furnish sufficient and suitable equipment, forces, and materials, as necessary to prosecute the work in accordance with the required schedule, the Engineer may withhold all estimates that are, or may become due, or suspend the work until the Contractor corrects such deficiencies.

8-3.2 Submission of Contract Schedule: Within 21 calendar days after Contract award or at the preconstruction conference, whichever is earlier, submit to the Engineer a Contract Schedule for the project. The Engineer will review and respond to the Contractor within 15 calendar days of receipt.

Provide a Contract Schedule that shows the various activities of work in sufficient detail to demonstrate a reasonable and workable plan to complete the project within the Contract Time. Show the order and interdependence of activities and the sequence for accomplishing the work. Describe all activities in sufficient detail so that the Engineer can readily identify the work and measure the progress on of each activity. Show each activity with a beginning work date, a duration, and a monetary value. Include activities for procurement fabrication, and delivery of materials, plant, and equipment, and review time for shop drawings and submittals. Include milestone activities when milestones are required by the Contract Documents. In a project with more than one phase, adequately identify each phase and its completion date, and do not allow activities to span more than one phase.

Conduct sufficient liaison and provide sufficient information to indicate coordination activities with utility owners that have facilities within the limits of construction have been resolved. Incorporate in the Contract Schedule any utility work schedules included in the Contract Documents unless the utility company and the Department mutually agree to changes to the utility schedules shown in the Contract.

Submit a working plan with the Contract Schedule, consisting of a concise written description of the construction plan.

The Engineer will return inadequate Contract Schedules to the Contractor for corrections. Resubmit a corrected schedule within 15 calendar days from the date of the Engineer’s return transmittal.

Submit an updated Contract Schedule, for Engineer’s acceptance, if there is a significant change in the planned order or duration of an activity. The Engineer will review the corrected schedule and respond within 7 calendar days of receipt.

By acceptance of the Contract Schedule, the Engineer does not endorse or otherwise certify the validity or accuracy of the activity durations or sequencing of activities. The Engineer will use the accepted schedule as the baseline against which to measure the progress.

If the Contractor fails to finalize either the initial or a revised Contract Schedule in the time specified, the Engineer may withhold all Contract payments until the Engineer accepts the schedule.

The Contract Schedule may indicate a completion date in advance of the expiration of Contract Time. However, the Department will not be liable in any way for the

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Contractor's failure to complete the project prior to expiration of Contract Time. Any additional costs, including extended overhead incurred between the Contractor's scheduled completion date and the expiration of Contract Time, shall be the responsibility of the Contractor. The Contractor shall not be entitled to claim or recover any such costs from the Department.

8-3.3 Beginning Work: Notify the Engineer not less than five days in advance of the planned start day of work. Upon the receipt of such notice, the Engineer may give the Contractor Notice to Proceed and may designate the point or points to start the work. In the Notice to Proceed, the Engineer may waive the five-day advance notice and authorize the Contractor to begin immediately. Notify the Engineer in writing at least two days in advance of the starting date of important features of the work. Do not commence work under the Contract until after the Department has issued the Notice to Proceed. The Department will issue the Notice to Proceed within 20 calendar days, excluding Saturdays, Sundays and Holidays, after execution of the Contract.

8-3.4 Provisions for Convenience of Public: Schedule construction operations so as to minimize any inconvenience to adjacent businesses or residences. Where necessary, the Engineer may require the Contractor to first construct the work in any areas along the project where inconveniences caused by construction operations would present a more serious handicap. In such critical locations, where there is no assurance of continuous effective prosecution of the work once the construction operations are begun, the Engineer may require the Contractor to delay removal of the existing (usable) facilities.

8-3.5 Preconstruction Conference: Immediately after awarding the Contract but before the Contractor begins work, the Engineer will call a preconstruction conference at a place the Engineer designates to go over the construction aspects of the project. Attend this meeting, along with the Department and the various utility companies that will be involved with the road construction.

8-4 Limitations of Operations.

8-4.1 Night Work: During active nighttime operations, furnish, place and maintain lighting sufficient to permit proper workmanship and inspection. Use lighting with 5 ft-cd minimum intensity. Arrange the lighting to prevent interference with traffic or produce undue glare to property owners. Operate such lighting only during active nighttime construction activities. Provide a light meter to demonstrate that the minimum light intensity is being maintained.

Lighting may be accomplished by the use of portable floodlights, standard equipment lights, existing street lights, temporary street lights, or other lighting methods approved by the Engineer.

Submit a lighting plan at the Preconstruction Conference for review and acceptance by the Engineer. Submit the plan as a PDF file, in the same scale as the Plans, and formatted on 11 inch by 17 inch sheets. Do not start night work prior to the Engineer's acceptance of the lighting plan.

During active nighttime operations, furnish, place and maintain variable message signs to alert approaching motorists of lighted construction zones ahead. Operate the variable message signs only during active construction activities.

Include compensation for lighting for night work in the Contract prices for the various items of the Contract. Take ownership of all lighting equipment for night work.

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8-4.2 Sequence of Operations: Do not open up work to the prejudice of work already started. The Engineer may require the Contractor to finish a section on which work is in progress before starting work on any additional section.

8-4.3 Interference with Traffic: At all times conduct the work in such manner and in such sequence as to ensure the least practicable interference with traffic. Operate all vehicles and other equipment safely and without hindrance to the traveling public. Park all private vehicles outside the clear zone. Place materials stored along the roadway so as to cause no obstruction to the traveling public as possible.

Where existing pavement is to be widened and stabilizing is not required, prevent any open trench from remaining after working hours by scheduling operations to place the full thickness of widened base by the end of each day. Do not construct widening strips simultaneously on both sides of the road, except where separated by a distance of at least 1/4 mile along the road and where either the work of excavation has not been started or the base has been completed.

8-4.4 Coordination with other Contractors: Sequence the Work and dispose of materials so as not to interfere with the operations of other Contractors engaged upon adjacent work; coordinate the Work, including the placement of work zone signs and temporary traffic control devices, to that of others in a proper manner, in accordance with the spirit of the Contract Documents; and perform the work in the proper sequence in relation to that of other Contractors; all as may be directed by the Engineer.

Each Contractor is responsible for any damage done by it or its agents to the adjoining work being performed by another Contractor.

8-4.5 Drainage: Conduct the operations and maintain the work in such condition to provide adequate drainage at all times. Do not obstruct existing functioning storm sewers, gutters, ditches, and other run-off facilities.

8-4.6 Fire Hydrants: Keep fire hydrants on or adjacent to the highway accessible to fire apparatus at all times, and do not place any material or obstruction within 15 feet of any fire hydrant.

8-4.7 Protection of Structures: Do not operate heavy equipment close enough to pipe headwalls or other structures to cause their displacement.

8-4.8 Fencing: Erect permanent fence as a first order of business on all projects that include fencing where the Engineer determines that the fencing is necessary to maintain the security of livestock on adjacent property, or for protection of pedestrians who are likely to gain access to the project from adjacent property.

8-4.9 Contaminated Materials: When the construction operations encounter or expose any abnormal condition that may indicate the presence of a contaminated material, discontinue such operations in the vicinity of the abnormal condition and notify the Engineer immediately. Be alert for the presence of tanks or barrels; discolored or stained earth, metal, wood, ground water; visible fumes; abnormal odors; excessively hot earth; smoke; or other conditions that appear abnormal as possible indicators of the presence of contaminated materials. Treat these conditions with extraordinary caution.

Make every effort to minimize the spread of any contaminated materials into uncontaminated areas.

Do not resume the construction operations in the vicinity of the abnormal conditions until so directed by the Engineer.

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Dispose of the contaminated material in accordance with the requirements and regulations of any Local, State, or Federal agency having jurisdiction. Where the Contractor performs work necessary to dispose of contaminated material, and the Contract does not include pay items for disposal, the Department will pay for this work as provided in 4-4.

The Department agrees to hold harmless and indemnify the Contractor for damages when the Contractor discovers or encounters contaminated materials or pollutants during the performance of services for the Department when the presence of such materials or pollutants were unknown or not reasonably discoverable. Such indemnification agreement is only effective if the Contractor immediately stops work and notifies the Department of the contaminated material or pollutant problem.

Such indemnification agreement is not valid for damages resulting from the Contractor's willful, wanton, or intentional conduct or the operations of Contaminated and Hazardous Material Contractors.

8-5 Qualifications of Contractor's Personnel.

Provide competent, careful, and reliable superintendents, foremen, and workmen. Provide workmen with sufficient skill and experience to properly perform the work assigned to them. Provide workmen engaged on special work, or skilled work, such as bituminous courses or mixtures, concrete bases, pavements, or structures, or in any trade, with sufficient experience in such work to perform it properly and satisfactorily and to operate the equipment involved. Provide workmen that shall make due and proper effort to execute the work in the manner prescribed in the Contract Documents, or the Engineer may take action as prescribed below.

It is prohibited as a conflict of interest for a Contractor to subcontract with a Consultant to perform Contractor Quality Control when the Consultant is under contract with the Department to perform work on any project described in the Contractor's Contract with the Department. Prior to approving a Consultant for Contractor Quality Control, the Contractor shall submit to the Department a Certificate from the proposed Consultant certifying that no conflict of interest exists.

Whenever the Engineer determines that any person employed by the Contractor is incompetent, unfaithful, intemperate, disorderly, or insubordinate, the Engineer will provide written notice and the Contractor shall discharge the person from the work. Do not employ any discharged person on the project without the written consent of the Engineer. If the Contractor fails to remove such person or persons, the Engineer may withhold all estimates that are or may become due, or suspend the work until the Contractor complies with such orders. Protect, defend, indemnify, and hold the Department, its agents, officials, and employees harmless from all claims, actions, or suite arising from such removal, discharge, or suspension of employees.

8-6 Temporary Suspension of Contractor's Operations.

8-6.1 Authority to Suspend Contractor's Operations: The Engineer has the authority to suspend the Contractor's operations, wholly or in part. The Engineer will order such suspension in writing, giving in detail the reasons for the suspension. Contract Time will be charged during all suspensions of Contractor's operations. The Department may grant an extension of Contract Time in accordance with 8-7.3.2 when determined appropriate in the Department's sole judgment.

No additional compensation or time extension will be paid or granted to the Contractor when the operations are suspended for the following reasons:

1. The Contractor fails to comply with the Contract Documents.

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2. The Contractor fails to carry out orders given by the Engineer.
3. The Contractor causes conditions considered unfavorable for continuing the Work.

Immediately comply with any suspension order. Do not resume operations until authorized to do so by the Engineer in writing. Any operations performed by the Contractor, and otherwise constructed in conformance with the provisions of the Contract, after the issuance of the suspension order and prior to the Engineer's authorization to resume operations will be at no cost to the Department. Further, failure to immediately comply with any suspension order will also constitute an act of default by the Contractor and is deemed sufficient basis in and of itself for the Department to declare the Contractor in default, in accordance with 8-9, with the exception that the Contractor will not have ten calendar days to correct the conditions for which the suspension was ordered.

8-6.1.1 State of Emergency: The Engineer has the authority to suspend the Contractor's operations, wholly or in part, pursuant to a Governor's Declaration of a State of Emergency. The Engineer will order such suspension in writing, giving in detail the reasons for the suspension. Contract Time will be charged during all suspensions of Contractor's operations. The Department, at its sole discretion, may grant an extension of Contract Time and reimburse the Contractor for specific costs associated with such suspension. Further, in such instances, the Department's determination as to entitlement to either time or compensability will be final, unless the Contractor can prove by clear and convincing evidence to a Disputes Review Board that the Department's determination was without any reasonable factual basis.

8-6.2 Prolonged Suspensions: If the Engineer suspends the Contractor's operations for an indefinite period, store all materials in such manner that they will not obstruct or impede the traveling public unnecessarily or become damaged in any way. Take every reasonable precaution to prevent damage to or deterioration of the work performed. Provide suitable drainage of the roadway by opening ditches, shoulder drains, etc., and provide any temporary structures necessary for public travel through the project.

8-6.3 Permission to Suspend Contractor's Operations: Do not suspend operations or remove equipment or materials necessary for completing the work without obtaining the Engineer's written permission. Submit all requests for suspension of operations in writing to the Engineer, and identify specific dates to begin and end the suspension. The Contractor is not entitled to any additional compensation for suspension of operations during such periods.

8-6.4 Suspension of Contractor's Operations - Holidays and Special Events: Unless the Contractor submits a written request to work during one or more days of a Holiday or Special Event at least ten calendar days in advance of the beginning date of the Holiday or Special Event and receives written approval from the Engineer, the Contractor shall not work on the following days: Martin Luther King, Jr. Day; Memorial Day; the Saturday and Sunday immediately preceding Memorial Day; Independence Day; Independence Day (Observed); Labor Day; the Friday, Saturday, and Sunday immediately preceding Labor Day; Veterans Day; Veterans Day (Observed); the Wednesday immediately preceding Thanksgiving Day; Thanksgiving Day; the Friday, Saturday and Sunday immediately following Thanksgiving Day; December 24 through January 2, inclusive; and Special Events noted in the Contract Documents. Contract Time will be charged during these Holiday and Special Event periods. Contract Time will be adjusted in accordance with 8-7.3.2. The Contractor is not entitled to any additional compensation beyond any allowed Contract Time adjustment for suspension of operations during such Holiday and Special Event periods.

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During such suspensions, remove all equipment and materials from the clear zone, except those required for the safety of the traveling public and retain sufficient personnel at the job site to properly meet the requirements of Sections 102 and 104. The Contractor is not entitled to any additional compensation for removal of equipment from clear zones or for compliance with Section 102 and Section 104 during such Holiday and Special Event periods.

8-7 Computation of Contract Time.

8-7.1 General: Perform the contracted work fully, entirely, and in accordance with the Contract Documents within the Contract Time specified in the proposal, or as may be extended in accordance with the provisions herein below.

The Department considers in the computation of the Contract Time the effect that utility relocation and adjustments have on job progress and the scheduling of construction operations required in order to adequately maintain traffic, as detailed in the Plans or as scheduled in the Special Provisions.

8-7.2 Date of Beginning of Contract Time: The date on which Contract Time begins is either the date on which the Contractor actually begins work, or the date for beginning the charging of Contract Time as set forth in the proposal; whichever is earlier.

8-7.3 Adjusting Contract Time:

8-7.3.1 Increased Work: The Department may grant an extension of Contract Time when it increases the Contract amount due to overruns in original Contract items, adds new work items, or provides for unforeseen work. The Department will base the consideration for granting an extension of Contract Time on the extent that the time normally required to complete the additional designated work delays the Contract completion schedule.

8-7.3.2 Contract Time Extensions: The Department may grant an extension of Contract Time when a controlling item of work is delayed by factors not reasonably anticipated or foreseeable at the time of bid. The Department may allow such extension of time only for delays occurring during the Contract Time period or authorized extensions of the Contract Time period. When failure by the Department to fulfill an obligation under the Contract results in delays to the controlling items of work, the Department will consider such delays as a basis for granting a time extension to the Contract.

Whenever the Engineer suspends the Contractor's operations, as provided in 8-6, for reasons other than the fault of the Contractor, the Engineer will grant a time extension for any delay to a controlling item of work due to such suspension. The Department will not grant time extensions to the Contract for delays due to the fault or negligence of the Contractor.

The Department does not include an allowance for delays caused by the effects of inclement weather or suspension of Contractor's operations as defined in 8-6.4, in establishing Contract Time. The Engineer will continually monitor the effects of weather and, when found justified, grant time extensions on either a bimonthly or monthly basis. The Engineer will not require the Contractor to submit a request for additional time due to the effects of weather.

The Department will grant time extensions, on a day for day basis, for delays caused by the effects of rains or other inclement weather conditions, related adverse soil conditions or suspension of operations as defined in 8-6.4 that prevent the Contractor from productively performing controlling items of work resulting in:

1. The Contractor being unable to work at least 50% of the normal work day on pre-determined controlling work items; or

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2. The Contractor must make major repairs to work damaged by weather, provided that the damage is not attributable to the Contractor's failure to perform or neglect; and provided that the Contractor was unable to work at least 50% of the normal workday on pre-determined controlling work items.

When the Department grants a time extension due to rains or other inclement weather, the Contractor shall submit any objection to the additional time in writing within ten calendar days from receipt of written notice from the Engineer. Failure to submit a written appeal within ten calendar days from receipt of the written notice shall constitute a waiver of any and all rights to appeal the Department's decision at a later time.

No additional compensation will be made for delays caused by the effects of inclement weather.

The Department will consider the delays in delivery of materials or component equipment that affect progress on a controlling item of work as a basis for granting a time extension if such delays are beyond the control of the Contractor or supplier. Such delays may include an area-wide shortage, an industry-wide strike, or a natural disaster that affects all feasible sources of supply. In such cases, the Contractor shall submit substantiating letters from a representative number of manufacturers of such materials or equipment clearly confirming that the delays in delivery were the result of an area-wide shortage, an industry-wide strike, etc. No additional compensation will be made for delays caused by delivery of materials or component equipment.

The Department will not consider requests for time extension due to delay in the delivery of custom manufactured equipment such as traffic signal equipment, highway lighting equipment, etc., unless the Contractor submits documentation that he placed the order for such equipment in a timely manner, the delay was caused by factors beyond the manufacturer's control, and the lack of such equipment caused a delay in progress on a controlling item of work. No additional compensation will be paid for delays caused by delivery of custom manufactured equipment.

The Department will consider the effect of utility relocation and adjustment work on job progress as the basis for granting a time extension only if all the following criteria are met:

1. Delays are the result of either utility work that was not detailed in the Plans, or utility work that was detailed in the Plans but was not accomplished in reasonably close accordance with the schedule included in the Contract Documents.

2. Utility work actually affected progress toward completion of controlling work items.

3. The Contractor took all reasonable measures to minimize the effect of utility work on job progress, including cooperative scheduling of the Contractor's operations with the scheduled utility work at the preconstruction conference and providing adequate advance notification to utility companies as to the dates to coordinate their operations with the Contractor's operations to avoid delays.

The Department will consider requests for time extension due to delay in work operations within the limits of the railroad right-of-way, the adjoining 15 feet, or determined by the Railroad or Department to be able to potentially foul the tracks regardless of distance from railroad right-of-way on job progress as the basis for granting a time extension only if all the following criteria are met:

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1. Delays are due to a lack of availability of Railroad protective services as required by 7-11.4.

2. Work within the limits of the railroad right-of-way or the adjoining 15 feet actually impacted progress toward completion of controlling work items.

3. The Contractor took all reasonable measures to minimize the effect of work operations within the limits of the railroad right-of-way or the adjoining 15 feet on job progress, including compliance with all provisions of 7-11.4 and 5-12, and cooperative scheduling of the Contractor's operations.

As a condition precedent to an extension of Contract Time the Contractor must submit to the Engineer:

A preliminary request for an extension of Contract Time must be submitted in writing to the Engineer within ten calendar days after the commencement of a delay to a controlling item of work. If the Contractor fails to submit this required preliminary request for an extension of Contract Time, the Contractor fully, completely, absolutely and irrevocably waives any entitlement to an extension of Contract Time for that delay. In the case of a continuing delay only a single preliminary request for an extension of Contract Time will be required. Each such preliminary request for an extension of Contract Time shall include as a minimum the commencement date of the delay, the cause of the delay, and the controlling item of work affected by the delay.

Furthermore, the Contractor must submit to the Engineer a request for a Contract Time extension in writing within 30 days after the elimination of the delay to the controlling item of work identified in the preliminary request for an extension of Contract Time. Each request for a Contract Time extension shall include as a minimum all documentation that the Contractor wishes the Department to consider related to the delay, and the exact number of days requested to be added to Contract Time. If the Contractor contends that the delay is compensable, then the Contractor shall also be required to submit with the request for a Contract Time extension a detailed cost analysis of the requested additional compensation. If the Contractor fails to submit this required request for a Contract Time extension, with or without a detailed cost analysis, depriving the Engineer of the timely opportunity to verify the delay and the costs of the delay, the Contractor waives any entitlement to an extension of Contract Time or additional compensation for the delay.

Upon timely receipt of the preliminary request of Contract Time from the Contractor, the Engineer will investigate the conditions, and if it is determined that a controlling item of work is being delayed for reasons beyond the control of the Contractor the Engineer will take appropriate action to mitigate the delay and the costs of the delay. Upon timely receipt of the request for a Contract Time extension the Engineer will further investigate the conditions, and if it is determined that there was an increase in the time or the cost of performance of the controlling item of work beyond the control of the Contractor, then an adjustment of Contract Time will be made, and a monetary adjustment will be made, excluding loss of anticipated profits, and the Contract will be modified in writing accordingly.

The existence of an accepted schedule, including any required update(s), as stated in 8-3.2, is a condition precedent to the Contractor having any right to the granting of an extension of Contract Time or any monetary compensation arising out of any delay. Contractor failure to have an accepted schedule, including any required update(s), for the period of potential impact, or in the event the currently accepted schedule and applicable updates do not accurately reflect the actual status of the project or fail to accurately show the true controlling or non-

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controlling work activities for the period of potential impact, will result in any entitlement determination as to time or money for such period of potential impact being limited solely to the Department's analysis and identification of the actual controlling or non-controlling work activities. Further, in such instances, the Department's determination as to entitlement as to either time or compensability will be final, unless the Contractor can prove by clear and convincing evidence to a Disputes Review Board that the Department's determination was without any reasonable factual basis.

8-8 Failure of Contractor to Maintain Satisfactory Progress.

8-8.1 General: Pursue the work to completion: Section 337.16 of the Florida Statutes establishes certain requirements pertaining to the suspension or revocation of a Contractor's Certificate of Qualification because of delinquency on a previously awarded Contract.

8-8.2 Regulations Governing Suspension for Delinquency:

1. A Contractor is delinquent when the Contract Time for performing the work has expired, and the Contractor has not completed the Contract work.

2. Once the Department determines that the Contractor is delinquent, the Department will give the Contractor written notice of intent to suspend the Contractor's Certificate of Qualification. If the Contractor disagrees with the delinquency, the Contractor shall file a request for an administrative hearing with the Clerk of Agency Proceedings within ten days of receipt of the notice of intent to suspend. If the Contractor does not file a request, the Department will make the suspension conclusive and final. The request for hearing is filed when the Contractor delivers it to, and it is received by, the Clerk of Agency Proceedings, Mail Station 58, Room 562, Haydon Burns Building, 605 Suwannee Street, Tallahassee, Florida 32399-0450.

3. If the Contractor files a request for a hearing, the Department will schedule the hearing within 30 days of the hearing officer's receipt of the request.

4. The Department will continue the period of suspension of the Contractor's Certificate of Qualification until the Contractor is no longer delinquent. If the Contractor requests an administrative hearing, the Department's final order, depending on the outcome of the hearing, will set forth the time period of suspension for the number of days the Department determines that the Contractor was delinquent, even if the Contractor cures the delinquency during the pendency of the administrative proceedings.

5. During the period of suspension of the Contractor's Certificate of Qualification, the Department will not allow the Contractor and its affiliates to bid on any Department Contract, regardless of dollar amount, and will not approve the Contractor as a subcontractor on any Department contract.

6. The Department may grant extensions of time during the prosecution of the work as allowed under these Specifications regardless of the Contractor's delinquency status.

8-9 Default and Termination of Contract.

8-9.1 Determination of Default: The following acts or omissions constitute acts of default and, except as to subparagraphs 9 and 11, the Department will give notice, in writing, to the Contractor and his surety for any delay, neglect or default, if the Contractor:

1. fails to begin the work under the Contract within the time specified in the Notice to Proceed;

2. fails to perform the work with sufficient workmen and equipment or with sufficient materials to ensure prompt completion of the Contract;

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3. performs the work unsuitably, or neglects or refuses to remove materials or to perform anew such work that the Engineer rejects as unacceptable and unsuitable;

4. discontinues the prosecution of the work, or fails to resume discontinued work within a reasonable time after the Engineer notifies the Contractor to do so;

5. becomes insolvent or is declared bankrupt, or files for reorganization under the bankruptcy code, or commits any act of bankruptcy or insolvency, either voluntarily or involuntarily;

6. allows any final judgment to stand against him unsatisfied for a period of ten calendar days;

7. makes an assignment for the benefit of creditors;

8. fails to comply with Contract requirements regarding minimum wage payments or EEO requirements;

9. fails to comply with the Engineer's written suspension of work order within the time allowed for compliance and which time is stated in that suspension of work order; or

10. for any other cause whatsoever, fails to carry on the work in an acceptable manner, or if the surety executing the bond, for any reasonable cause, becomes unsatisfactory in the opinion of the Department.

11. fails to comply with 3-9.

For a notice based upon reasons stated in subparagraphs (1) through (8) and (10): if the Contractor, within a period of ten calendar days after receiving the notice described above, fails to correct the conditions of which complaint is made, the Department will, upon written certificate from the Engineer of the fact of such delay, neglect, or default and the Contractor's failure to correct such conditions, have full power and authority, without violating the Contract, to take the prosecution of the work out of the hands of the Contractor and to declare the Contractor in default.

If the Contractor, after having received a prior notice described above for any reason stated in subparagraph (2), (3), (4), (5), (6) or (8), commits a second or subsequent act of default for any reason covered by the same subparagraph (2), (3), (4), (5), (6) or (8) as stated in the prior notice, and regardless whether the specific reason is the same, then, regardless of whether the Contractor has cured the deficiency stated in that prior notice, the Department will, upon written certificate from the Engineer of the fact of such delay, neglect or default and the Contractor's failure to correct such conditions, have full power and authority, without any prior written notice to the Contractor and without violating the Contract, to take the prosecution of the work out of the hands of the Contractor and to declare the Contractor in default.

Regarding subparagraph (9), if the Contractor fails to comply with the Engineer's written suspension of work order within the time allowed for compliance and which time is stated in that suspension of work order, the Department will, upon written certificate from the Engineer of the fact of such delay and the Contractor's failure to correct that condition, have full power and authority, without violating the Contract, to immediately take the prosecution of the work out of the hands of the Contractor and to declare the Contractor in default.

Regarding subparagraph (11), if the Contractor fails to comply with 3-9, the Department will have full power and authority, without violating the Contract, to immediately take the prosecution of the work out of the hands of the Contractor and to declare the Contractor in default.

The Department has no liability for anticipated profits for unfinished work on a Contract that the Department has determined to be in default.

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Notwithstanding the above, the Department shall have the right to declare the Contractor (or its "affiliate") in default and immediately terminate this Contract, without any prior notice to the Contractor, in the event the Contractor (or its "affiliate") is at any time "convicted" of a "contract crime," as these terms are defined in Section 337.165(1), Florida Statutes. The Department's right to default the Contractor (or its "affiliate") for "conviction" of a "contract crime" shall extend to and is expressly applicable to any and all Department Contracts that were either advertised for bid; for which requests for proposals or letters of interest were requested; for which an intent to award was posted or otherwise issued; or for which a Contract was entered into, after the date that the underlying or related criminal indictment, criminal information or other criminal charge was filed against the Contractor (or its "affiliate") that resulted in the "conviction." In the event the Department terminates this Contract for this reason, the Contractor shall hereby forfeit any claims for additional compensation, extra time, or anticipated profits. The Contractor shall only be paid for any completed work up to the date of termination. Further, the Contractor shall be liable for any and all additional costs and expenses the Department incurs in completing the Contract work after such termination.

8-9.2 Termination of Contract for Convenience: The Department may terminate the entire Contract or any portion thereof, if the Secretary determines that a termination is in the Department's interest. The Secretary will deliver to the Contractor a Written Notice of Termination specifying the extent of termination and the effective date.

When the Department terminates the entire Contract, or any portion thereof, before the Contractor completes all items of work in the Contract, the Department will make payment for the actual number of units or items of work that the Contractor has completed, at the Contract unit price, and according to the formulas and provisions set forth in 4-3.2 for items of work partially completed, and such payments will constitute full and complete compensation for such work or items. No payment of any kind or amount will be made for items of work not started. The Department will not consider any claim for loss of anticipated profits, or overhead of any kind (including home office and jobsite overhead or other indirect impacts) except as provided in 4-3.2 for partially completed work.

The Department will consider reimbursing the Contractor for actual cost of mobilization (when not otherwise included in the Contract) including moving equipment to the job where the volume of the work that the Contractor has completed is too small to compensate the Contractor for these expenses under the Contract unit prices.

The Department may purchase at actual cost acceptable materials and supplies procured for the work, that the Department has inspected, tested, and approved and that the Contractor has not incorporated in the work. Submit the proof of actual cost, as shown by receipted bills and actual cost records, at such points of delivery as the Engineer may designate.

Termination of a contract or a portion thereof, under the provisions of this Subarticle, does not relieve the Contractor or the surety of its responsibilities for the completed portion of the Contract or its obligations for and concerning any just claims arising out of the work performed.

All Contractor claims for additional payment, due to the Department's termination of the entire Contract or any portion thereof, must meet the requirements of 5-12.

8-9.3 Completion of Work by Department: Upon declaration of default, the Department will have full authority to appropriate or use any or all suitable and acceptable materials and equipment on the site and may enter into an agreement with others to complete the work under the Contract, or may use other methods to complete the work in an acceptable

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manner. The Department will charge all costs that the Department incurs because of the Contractor's default, including the costs of completing the work under the Contract, against the Contractor. If the Department incurs such costs in an amount that exceeds the sum that would have been payable under the Contract, then the Contractor and the surety shall be liable and shall pay the Department the amount of the excess.

If, after the ten day notice period and prior to any action by the Department to otherwise complete the work under the Contract, the Contractor establishes his intent to prosecute the work in accordance with the Department's requirements, then the Department may allow the Contractor to resume the work, in which case the Department will deduct from any monies due or that may become due under the Contract, any costs to the Department incurred by the delay, or from any reason attributable to the delay.

8-10 Liquidated Damages for Failure to Complete the Work.

8-10.1 Highway Code Requirements Pertaining to Liquidated Damages: Section 337.18, paragraph (2) of the Florida Statutes, requires that the Department adopt regulations for the determination of default and provides that the Contractor pay liquidated damages to the Department for any failure of the Contractor to complete the Contract work within the Contract Time. These Code requirements govern, and are herewith made a part of the Contract.

8-10.2 Amount of Liquidated Damages: Applicable liquidated damages are the amounts established in the following schedule:

Original Contract Amount	Daily Charge Per Calendar Day
$299,999 and under	$904
$300,000 but less than $2,000,000	$1,685
$2,000,000 but less than $5,000,000	$2,667
$5,000,000 but less than $10,000,000	$3,813
$10,000,000 but less than $20,000,000	$5,021
$20,000,000 but less than $40,000,000	$7,442
$40,000,000 and over	$10,224 plus 0.00005 of any amount over $40 million (Round to nearest whole dollar)

The Engineer may approve adjustments to the liquidated damages amounts in accordance with the Construction Project Administration Manual (CPAM) provided all contract work is complete.

8-10.3 Determination of Number of Days of Default: For all contracts, regardless of whether the Contract Time is stipulated in calendar days or working days, the Engineer will count default days in calendar days.

8-10.4 Conditions under which Liquidated Damages are Imposed: If the Contractor or, in case of his default, the surety fails to complete the work within the time stipulated in the Contract, or within such extra time that the Department may have granted then the Contractor or, in case of his default, the surety shall pay to the Department, not as a penalty, but as liquidated damages, the amount so due as determined by the Code requirements, as provided in 8-10.2.

8-10.5 Right of Collection: The Department has the right to apply, as payment on such liquidated damages, any money the Department owes the Contractor.

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8-10.6 Allowing Contractor to Finish Work: The Department does not waive its right to liquidated damages due under the Contract by allowing the Contractor to continue and to finish the work, or any part of it, after the expiration of the Contract Time.

8-10.7 Completion of Work by Department: In the case of a default of the Contract and the completion of the work by the Department, the Contractor and his surety are liable for the liquidated damages under the Contract, but the Department will not charge liquidated damages for any delay in the final completion of the Department's performance of the work due to any unreasonable action or delay on the part of the Department.

8-11 Release of Contractor's Responsibility.

The Department considers the Contract complete when the Contractor has completed all work and the Department has accepted the work. The Department will then release the Contractor from further obligation except as set forth in his bond, and except as provided in 5-13.

8-12 Recovery of Damages Suffered by Third Parties.

In addition to the damages provided for in 8-10.2 and pursuant to Section 337.18 of the Florida Statutes, when the Contractor fails to complete the work within the Contract Time the Department may recover from the Contractor amounts that the Department pays for damages suffered by third parties unless the failure to timely complete the work was caused by the Department's act or omission.

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SECTION 9
MEASUREMENT AND PAYMENT

9-1 Measurement of Quantities.

9-1.1 Measurement Standards: The Engineer will measure all work completed under the Contract in accordance with the United States Standard Measures.

9-1.2 Method of Measurements: The Engineer will take all measurements horizontally or vertically.

9-1.3 Determination of Pay Areas:

9-1.3.1 Final Calculation: When measuring items paid for on the basis of area of finished work, where the pay quantity is designated to be determined by calculation, the Engineer will use lengths and widths in the calculations based on the station to station dimensions shown in the Plans; the station to station dimensions actually constructed within the limits designated by the Engineer; or the final dimensions measured along the surface of the completed work within the neat lines shown in the Plans or designated by the Engineer. The Engineer will use the method or combination of methods of measurement that reflect, with reasonable accuracy, the actual surface area of the finished work as the Engineer determines.

9-1.3.2 Plan Quantity: When measuring items paid for on the basis of area of finished work, where the pay quantity is designated to be the plan quantity, the Engineer will determine the final pay quantity based on the plan quantity subject to the provisions of 9-3.2. Generally, the Engineer will calculate the plan quantity using lengths based on station to station dimensions and widths based on neat lines shown in the Plans.

9-1.4 Construction Outside Authorized Limits: The Engineer will not pay for surfaces constructed over a greater area than authorized, or for material that the Contractor has moved from outside of slope stakes and lines shown in the Plans, except where the Engineer provides written instruction for the Contractor to perform such work.

9-1.5 Truck Requirements: Provide all trucks with numbers and certify that all trucks used have a manufacturer's certification or permanent decal showing the truck capacity rounded to the nearest tenth of a cubic yard placed on both sides of the truck. This capacity will include the truck body only and any side boards added will not be included in the certified truck body capacity. Ensure the lettering and numbers are legible for identification purposes at all times.

9-1.6 Ladders and Instrument Stands for Bridge Projects: On bridge projects, in order to facilitate necessary measurements, provide substantial ladders to the tops of piers and bents, and place and move such ladders as the Engineer directs.

For bridge projects crossing water or marshy areas, supply fixed stands for instrument mounting and measurements, in accordance with the details stipulated in the Specifications for the project.

9-2 Scope of Payments.

9-2.1 Items Included in Payment: Accept the compensation as provided in the Contract as full payment for furnishing all materials and for performing all work contemplated and embraced under the Contract; also for all loss or damage arising out of the nature of the work or from the action of the elements, or from any unforeseen difficulties or obstructions which may arise or be encountered in the prosecution of the work until its final acceptance; also for all other costs incurred under the provisions of Division I.

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For any item of work contained in the proposal, except as might be specifically provided otherwise in the basis of payment clause for the item, include in the Contract unit price (or lump sum price) for the pay item or items the cost of all labor, equipment, materials, tools and incidentals required for the complete item of work, including all requirements of the Section specifying such item of work, except as specifically excluded from such payments.

9-2.1.1 Fuel: The Department will, in the Contract Documents, provide an estimated quantity for fuel requirements for diesel to cover the Work specified in the Contract. Price adjustments will be made only for the amount of diesel fuel estimated by the Department as required to complete the Contract. The requirement of fuel for each pay item is estimated by multiplying the Department's standard fuel factor for that pay item by the quantity of that pay item. On Contracts with an original Contract Time in excess of 120 calendar days, the Department will make price adjustments on each applicable progress estimate to reflect increases or decreases in the price of diesel from those in effect during the month in which bids were received. The Contractor will not be given the option of accepting or rejecting these adjustments. Price adjustments for fuel will be made only when the current fuel price (CFP) varies by more than 5% from the price prevailing in the month when bids were received (BFP), and then only on the portion that exceeds 5%.

Price adjustments will be based on the monthly bulk average price for diesel as derived by the Department. These average indexes shall be determined by averaging bulk fuel prices on the first day of each month as quoted by major oil companies that are reasonably expected to furnish fuel for projects in the State of Florida. Average price indices for will be available on the Construction Office website before the 15th of each month, at the following URL:
https://www.fdot.gov/construction/fuel-bit/fuel-bit.shtm.

Payment will be based on the quantities shown on the progress estimate on all items for which established standard fuel factors are on a file maintained by the Department.

Payment on progress estimates will be adjusted to reflect adjustments in the prices for diesel in accordance with the following:

When fuel prices have decreased between month of bid and month of this progress estimate:

Ai = Fi (Pi - 0.95 Pb) during a period of decreasing prices.

Ai = Total dollar amount - positive or negative - of the cost adjustment for fuel used by the Contractor during the month "i."

Fi = Total gallons calculated as being used during the month.

Pi = Average price for fuel prevailing during month "i."

Pb = Average price for fuel prevailing during the month "b" when bids were received on this Contract.

When fuel prices have increased between month of bid and month of this progress estimate:

Ai = Fi (Pi - 1.05 Pb) during a period of increasing prices.

Ai = Total dollar amount - positive or negative - of the cost adjustment for fuel used by the Contractor during the month "i."

Fi = Total gallons calculated as being used during the month.

Pi = Average price for fuel prevailing during month "i."

Pb = Average price for fuel prevailing during the month "b" when bids were received on this Contract.

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Payment will be made on the current progress estimate to reflect the index difference at the time Work was performed.

Adjustments will be paid or charged to the Prime Contractor only. Any Contractor receiving an adjustment under this provision shall distribute the proper proportional part of such adjustment to subcontractors who perform applicable Work.

9-2.1.2 Bituminous Material: Prepare a Contractor's Certification of Quantities, using the Department's current approved form for Superpave Asphalt Base, Driveway Asphalt Base, Asphalt Treated Permeable Base, Superpave Asphaltic Concrete, Miscellaneous Asphalt Pavement, Asphalt Concrete Friction Course, and Asphalt Membrane Interlayer pay items. Submit this certification to the Engineer no later than Twelve O'clock noon Monday after the estimate cut-off or as directed by the Engineer, based on the quantity of asphalt produced and accepted on the roadway per Contract. Ensure the certification includes the Contract Number, Financial Project Identification (FPID) Number, Certification Date and Number, the period the certification represents and the tons produced for each asphalt pay item.

On Contracts having an original Contract Time of more than 365 calendar days, or more than 5,000 tons of asphalt concrete, the Department will adjust the bid unit price for bituminous material, excluding cutback and emulsified asphalt to reflect increases or decreases in the Asphalt Price Index (API) of bituminous material from that in effect during the month in which bids were received. The Contractor will not be given the option of accepting or rejecting this adjustment. Bituminous adjustments will be made only when the current API (CAPI) varies by more than 5% of the API prevailing in the month when bids were received (BAPI), and then only on the portion that exceeds 5%.

The Department will determine the API for each month by averaging quotations in effect on the first day of the month at all terminals that could reasonably be expected to furnish bituminous material to projects in the State of Florida.

The API will be available on the Construction Office website before the 15th day of each month at the following URL: https://www.fdot.gov/construction/fuel-bit/fuel-bit.shtm.

Payment on progress estimates will be adjusted to reflect adjustments in the prices for bituminous materials in accordance with the following:

$ Adjustment = (ID)(Gallons)

Where ID = Index Difference = [CAPI - 0.95(BAPI)] when the API has decreased between the month of bid and month of this progress estimate.

Where ID = Index Difference = [CAPI - 1.05(BAPI)] when the API has increased between the month of bid and month of this progress estimate.

Payment will be made on the current progress estimate to reflect the index difference at the time work was performed.

For asphalt concrete items payable by the ton or square yard, the number of gallons will be determined assuming a mix design with 6.25% liquid asphalt weighing 8.58 pounds per gallon.

For asphalt concrete items payable by the cubic yard, the number of gallons will be determined assuming a mix design with 3% liquid asphalt weighing 8.58 pounds per gallon.

9-2.2 Non-Duplication of Payment: In cases where the basis of payment clause in these Specifications relating to any unit price in the bid schedule requires that the unit price cover and be considered compensation for certain work or material essential to the item, the Department

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will not measure or pay for this same work or material under any other pay item that may appear elsewhere in these Specifications.

9-3 Compensation for Altered Quantities.

9-3.1 General: When alteration in Plans or quantities of work not requiring a supplemental agreement as hereinbefore provided for are offered and performed, the Contractor shall accept payment in full at Contract unit bid prices for the actual quantities of work done, and no allowance will be made for increased expense, loss of expected reimbursement, or loss of anticipated profits suffered or claimed by the Contractor, resulting either directly from such alterations, or indirectly from unbalanced allocation among the Contract items of overhead expense on the part of the bidder and subsequent loss of expected reimbursement therefore, or from any other cause.

Compensation for alterations in Plans or quantities of work requiring supplemental agreements shall be stipulated in such agreement, except when the Contractor proceeds with the work without change of price being agreed upon, the Contractor shall be paid for such increased or decreased quantities at the Contract unit prices bid in the Proposal for the items of work. If no Contract unit price is provided in the Contract, and the parties cannot agree as to a price for the work, the Contractor agrees to do the work in accordance with 4-3.2.

9-3.2 Payment Based on Plan Quantity:

9-3.2.1 Error in Plan Quantity: As used in this Article, the term "substantial error" is defined as the smaller of (1) or (2) below:

1. a difference between the original plan quantity and final quantity of more than 5%,

2. a change in quantity which causes a change in the amount payable of more than $5,000.

On multiple job Contracts, changes made to an individual pay item due to substantial errors will be based on the entire Contract quantity for that pay item.

Where the pay quantity for any item is designated to be the original plan quantity, the Department will revise such quantity only in the event that the Department determines it is in substantial error. In general, the Department will determine such revisions by final measurement, plan calculations, or both, as additions to or deductions from plan quantities.

In the event that either the Department or the Contractor contends that the plan quantity for any item is in error and additional or less compensation is thereby due, the claimant shall submit, at their own expense, evidence of such in the form of acceptable and verifiable measurements or calculations. The Department will not revise the plan quantity solely on the basis of a particular method of construction that the Contractor selects. For earthwork items, the claimant must note any differences in the existing surfaces from that shown in the Plans that would result in a substantial error to the plan quantity, and must be properly documented by appropriate verifiable level notes, acceptable to both the Contractor and the Department, prior to disturbance of the existing surface by construction operations. The claimant shall support any claim based upon a substantial error for differences in the existing surface by documentation as provided above.

9-3.2.2 Authorized Changes in Limits of Work: Where the Department designates the pay quantity for any item to be the original plan quantity and authorizes a plan change which results in an increase or decrease in the quantity of that item, the Department will revise the plan quantity accordingly. In general, the Department will determine such revisions by final measurement, plan calculations or both.

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9-3.2.3 Specified Adjustments to Pay Quantities: Do not apply the limitations specified in 9-3.2.1 and 9-3.2.2 to the following:

1. Where these Specifications or Special Provisions provide that the Department determines the pay quantity for an item on the basis of area of finished work adjusted in accordance with the ratio of measured thickness to nominal thickness.

2. Where these Specifications provide for a deduction due to test results falling outside of the allowable specified tolerances.

3. To payment for extra length fence posts, as specified in 550-6.3.

9-3.3 Lump Sum Quantities:

9-3.3.1 Error in Lump Sum Quantity: Where the Department designates the pay quantity for an item to be a lump sum and the Plans show an estimated quantity, the Department will adjust the lump sum compensation only in the event that either the Contractor submits satisfactory evidence or the Department determines and furnishes satisfactory evidence that the lump sum quantity shown is in substantial error as defined in 9-3.2.1.

9-3.3.2 Authorized Changes in Work: Where the Department designates the pay quantity for an item to be a lump sum and the Plans show an estimated quantity, the Department will adjust compensation for that item proportionately when an authorized plan change is made which results in an increase or decrease in the quantity of that item. When the Plans do not show an estimated plan quantity or the applicable specifications do not provide adjustments for contingencies, the Department will compensate for any authorized plan change resulting in an increase or decrease in the cost of acceptably completing the item by establishing a new unit price through a supplemental agreement as provided in 4-3.2.

9-3.4 Deviation from Plan Dimensions: If the Contractor fails to construct any item to Plan or to authorized dimensions within the specified tolerances, the Engineer, at his discretion will: require the Contractor to reconstruct the work to acceptable tolerances at no additional cost to the Department; accept the work and provide the Contractor no pay; or accept the work and provide the Contractor a reduced final pay quantity or reduced unit price. The Department will not make reductions to final pay quantities for those items designated to be paid on the basis of original plan quantity or a lump sum quantity under the provisions of this Article unless such reduction results in an aggregate monetary change per item of more than $100, except that for earthwork items, the aggregate change must exceed $5,000 or 5% of the original plan quantity, whichever is smaller. If, in the opinion of the Engineer, the Contractor has made a deliberate attempt to take advantage of the construction tolerances as defined in 120-12.1 to increase borrow excavation in fill sections or to decrease the required volume of roadway or lateral ditch excavation or embankment, the Department will take appropriate measurements and will apply reductions in pay quantities. The Department will not use the construction tolerance, as defined in 120-12.1, as a pay tolerance. The construction tolerance is not to be construed as defining a revised authorized template.

9-4 Deleted Work.

The Department will have the right to cancel the portions of the Contract relating to the construction of any acceptable item therein, by making an adjustment in payment to the Contractor of a fair and equitable amount covering the value of all cancelled work less all items of cost incurred prior to the date that the Engineer cancels the work.

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9-5 Partial Payments.

9-5.1 General: The Engineer will make partial payments on monthly estimates based on the amount of work that the Contractor completes during the month (including delivery of certain materials, as specified herein below). The Engineer will make approximate monthly payments, and the Department will correct all partial estimates and payments in the subsequent estimates and in the final estimate and payment.

The Department will base the amount of such payments on the total value of the work that the Contractor has performed to the date of the estimate, based on the quantities completed and the Contract prices, less payments previously made and less any retainage withheld.

Retainage will not be withheld until the percent of Contract Time used exceeds 75%. From that time forward, the Department will withhold retainage of 10% of the amount due on the current estimate as retainage when the percent of Contract Time used exceeds the percent of Contract amount earned by more than 15%.

Contract amount is defined as the original Contract amount adjusted by approved supplemental agreements.

Retainage will be determined for each job on multiple job Contracts. The Department will not accept Securities, Certificates of Deposit or letters of credit as a replacement for retainage. Amounts withheld will not be released until payment of the final estimate.

9-5.2 Unsatisfactory Payment Record: In accordance with Sections 255.05 and 337.16 of the Florida Statutes, and the rules of the Department, the Department may disqualify the Contractor from bidding on future Department contracts if the Contractor's payment record in connection with contract work becomes unsatisfactory.

9-5.3 Withholding Payment:

9-5.3.1 Withholding Payment for Defective Work: If the Department discovers any defective work or material prior to the final acceptance, or if the Department has a reasonable doubt as to the integrity of any part of the completed work prior to final acceptance, then the Department will not allow payment for such defective or questioned work until the Contractor has remedied the defect and removed any causes of doubt.

9-5.3.2 Withholding Payment for Failure to Comply: The Department will withhold progress payments from the Contractor if he fails to comply with any or all of the following within 60 days after beginning work:

1. Comply with and submit required documentation relating to prevailing wage rate provisions, Equal Employment Opportunity, On-The-Job Training, and Affirmative Action;

2. Comply with the requirement to report all necessary information, including actual payments to DBEs, all other subcontractors and major suppliers, through the Internet based Equal Opportunity Reporting System;

3. Comply with or make a good faith effort to ensure employment opportunity for minorities and females in accordance with the required contract provisions for Federal Aid Construction Contracts, and

4. Comply with or make a good faith effort to meet On-The-Job Training goals.

The Department will withhold progress payments until the Contractor has satisfied the above conditions.

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9-5.4 Release of Retainage After Acceptance: When the Contractor has furnished the Department with all submittals required by the Contract, such as invoices, EEO reports, materials certifications, certification of materials procured, etc., (excluding Contractor's letter of acceptance of final amount due and Form 21-A release) and the Engineer has determined that the measurement and computation of pay quantities is correct, the Department may reduce the retainage to $1,000 plus any amount that the Department elects to deduct for defective work as provided in 9-5.3.

The Department may deduct from payment estimates any sums that the Contractor owes to the Department on any account. Where more than one project or job (separate job number) is included in the Contract, the Department will distribute the reduced retainage as provided in the first paragraph of this subarticle to each separate project or job in the ratio that the Contract value of the work for the particular job bears to the total Contract amount.

9-5.5 Partial Payments for Delivery of Certain Materials:

9-5.5.1 General: The Department will allow partial payments for new materials that will be permanently incorporated into the project and are stockpiled in approved locations in the project vicinity. Stockpile materials so that they will not be damaged by the elements and in a manner that identifies the project on which they are to be used.

The following conditions apply to all payments for stockpiled materials:

1. There must be reasonable assurance that the stockpiled material will be incorporated into the specific project on which partial payment is made.
2. The stockpiled material must be approved as meeting applicable specifications.
3. The total quantity for which partial payment is made shall not exceed the estimated total quantity required to complete the project.
4. The Contractor shall submit to the Engineer certified invoices to document the value of the materials received. The amount of the partial payment will be determined from invoices for the material up to the unit price in the Contract.
5. Delivery charges for materials delivered to the jobsite will be included in partial payments if properly documented.
6. Partial payments will not be made for materials which were stockpiled prior to award of the Contract for a project.

9-5.5.2 Partial Payment Amounts: The following partial payment restrictions apply:

1. Partial payments less than $5,000 for any one month will not be processed.
2. Partial payments for structural steel, ITS and signal components, and precast prestressed items will not exceed 85% of the bid price for the item. Partial payments for all other items will not exceed 75% of the bid price of the item in which the material is to be used.
3. Partial payment will not be made for aggregate and base course material received after paving or base construction operations begin except when a construction sequence designated by the Department requires suspension of paving and base construction after the initial paving operations, partial payments will be reinstated until the paving and base construction resumes.

9-5.5.3 Off Site Storage: If the conditions of 9-5.5.1 are satisfied, partial payments will be allowed for materials stockpiled in approved in-state locations. Additionally,

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partial payments for materials stockpiled in approved out-of-state locations will be allowed if the conditions of 9-5.5.1 and the following conditions are met:

1. Furnish the Department a Materials Bond stating the supplier guarantees to furnish the material described in the Contract to the Contractor and Department. Under this bond, the Obligor shall be the material supplier and the Obligees shall be the Contractor and the Florida Department of Transportation. The bond shall be in the full dollar amount of the bid price for the materials described in the contract.

2. The following clauses must be added to the construction Contract between the Contractor and the supplier of the stockpiled materials:

"Notwithstanding anything to the contrary, <supplier> will be liable to the Contractor and the Florida Department of Transportation should <supplier> default in the performance of this agreement."

"Notwithstanding anything to the contrary, this agreement, and the performance bond issued pursuant to this agreement, does not alter, modify, or otherwise change the Contractor's obligation to furnish the materials described in this agreement to the Florida Department of Transportation."

3. The agreement between the Contractor and the supplier of the stockpiled materials must include provisions that the supplier will store the materials and that such materials are the property of the Contractor.

9-5.6 Certification of Payment to Subcontractors: The term "subcontractor," as used herein, includes persons or firms furnishing materials or equipment incorporated into the work or stockpiled for which the Department has made partial payment and firms working under equipment-rental agreements. The Contractor is required to pay all subcontractors for satisfactory performance of their Contracts before the Department will make a further progress (partial) payment. The Contractor shall also return all retainage withheld to the subcontractors within 30 days after the subcontractor's work is satisfactorily complete, as determined by the Department. Prior to receipt of any progress (partial) payment, the prime contractor shall certify that all subcontractors having an interest in the Contract were paid for satisfactory performance of their Contracts and that the retainage is returned to subcontractors within 30 days after satisfactory completion of the subcontractor's work. Submit this certification in the form designated by the Department.

Within 30 days of the Contractor's receipt of the final progress payment or any other payments thereafter, except the final payment, the Contractor shall pay all subcontractors and suppliers having an interest in the Contract for all work completed and materials furnished. The Department will honor an exception to the above when the Contractor demonstrates good cause for not making any required payment and submits written notification of any such good cause to both the Department and the affected subcontractors or suppliers within said 30 day period.

The Contractor shall indemnify and provide defense for the Department when called upon to do so for all claims or suits against the Department, by third parties, pertaining to Contractor payment or performance issues arising out of the Contract. It is expressly understood that the monetary limitation on the extent of the indemnification shall be the approved Contract amount, which shall be the original Contract amount as may be increased by subsequent Supplemental Agreements.

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9-6 Record of Construction Materials.

9-6.1 General: For all construction materials used in the construction of the project, (except materials exempted by 9-6.2), preserve for the Department's inspection the invoices and records of the materials for a period of three years from the date of completion of the project. Apply this requirement when subcontractors purchase materials, and obtain the invoices and other materials records from the subcontractors. By providing the materials, the Contractor certifies that all invoices will be maintained for the required period.

9-6.2 Non-Commercial Materials: The provisions of 9-6.1 do not apply to materials generally classed as non-commercial, such as fill materials, local sand, sand-clay, or local materials used as stabilizer.

9-7 Disputed Amounts Due the Contractor.

The Department reserves the right to withhold from the final estimate any disputed amounts between the Contractor and the Department. The Department will release all other amounts due, as provided in 9-8.

9-8 Acceptance and Final Payment.

9-8.1 Acceptance and Final Payment Documents: Whenever the Contractor has completely performed the work provided for under the Contract and the Engineer has performed a final inspection and made final acceptance (as provided in 5-10 and 5-11), and subject to the terms of 8-11, the Engineer will prepare a final estimate showing the value of the work as soon as the Engineer makes the necessary measurements and computations. The Engineer will correct all prior estimates and payments in the final estimate and payment. The Department will pay the estimate, less any sums that the Department may have deducted or retained under the provisions of the Contract, as soon as practicable after final acceptance of the work, along with all executed supplemental agreements received after final acceptance.

If the Contractor fails to furnish all required Contract Documents as listed in (1) through (9) below within 90 days of the Department's offer of final payment or request for refund of overpayment, the Department may suspend the Contractor's Certificate of Qualification under the provisions of Florida Administrative Code 14-22.

1. The Contractor has agreed in writing to accept the balance due or refund the overpayment, as determined by the Department, as full settlement of his account under the Contract and of all claims in connection therewith, or the Contractor, has through the use of the Qualified Acceptance Letter, accepted the balance due or refunded the overpayment, as determined by the Department, with the stipulation that his acceptance of such payment or the making of such refund does not constitute any bar, admission, or estoppel, or have any effect as to those payments in dispute or the subject of a pending claim between the Contractor and the Department. To receive payment based on a Qualified Acceptance Letter, define in writing the dispute or pending claim with full particular of all items of all issues in dispute, including itemized amounts claimed for all particulars of all items, and submit it as part of the Qualified Acceptance Letter. The Contractor further agrees, by submitting a Qualified Acceptance Letter that any pending or future arbitration claim or suit is limited to those particulars, including the itemized amounts, defined in the original Qualified Acceptance Letter, and that he will commence with any such arbitration claim or suit within 820 calendar days from and after the time of final acceptance of the work and that his failure to file a formal claim within this period constitutes his full acceptance of the Engineer's final estimate and payment. The overpayment

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refund check from the Contractor, if required, will be considered a part of any Acceptance Letter executed.

2. The Contractor has properly maintained the project, as specified hereinbefore.

3. The Contractor has furnished a sworn affidavit to the effect that the Contractor has paid all bills and no suits are pending (other than those exceptions listed, if any) in connection with work performed under the Contract and that the Contractor has not offered or made any gift or gratuity to, or made any financial transaction of any nature with, any employee of the Department in the performance of the Contract. Include with the listed tort liability exceptions, if any, evidence of adequate insurance coverage as required in 7-13.

4. The surety on the Contract bond consents, by completion of their portion of the affidavit and surety release subsequent to the Contractor's completion of his portion, to final payment to the Contractor and agrees that the making of such payment does not relieve the surety of any of its obligations under the bond.

5. The Contractor has complied with and settled all requirements pertaining to any wage-rate provisions.

6. The Contractor has submitted all required mill tests and analysis reports to the Engineer.

7. The Contractor has furnished the Construction Compliance with Specifications and Plans Certification. Provide the Engineer with a notarized final certification of compliance with the requirements of Section 105 to accompany the final estimate. Certification must be on a form provided by the Engineer.

8. The Contractor has submitted and the Department has accepted all as-built drawings and certified surveys.

9. The Contractor has furnished all required manufacturers' warranties to the Engineer.

9-8.2 Review of Engineer's Final Estimate: The Department may review the Engineer's final estimate and make changes as necessary. If changes are made, the Contractor will be so notified in writing in the "Notification of Findings Due to Additional Review". This notification letter will detail the changes made as a result of the review, and will stipulate the actions to be taken by the Department and those required by the Contractor. The issuance of a "Notification of Findings Due to Additional Review" will not impact the requirements of 9-8.1, above.

Complete the required actions and submit the signed "Notification of Findings Due to Additional Review" to the Department within the timeframe specified in 9-8.1. If the "Notification of Findings Due to Additional Review" is received after the time has expired in 9-8.1, submit to the Department within 30 days signifying agreement or disagreement with the findings. For disagreement items, submit a full explanation including the items and amount. For any claim or part of a claim that pertains solely to the "Notification of Findings Due to Additional Review" disputes, submit full and complete claim documentation as described in 5-12.3 as to such claim dispute issues within 90 days of receipt of the notification. Failure to submit the signed notification or to submit such claim documentation within the time frames specified may result in suspension of the Contractor's Certificate of Qualification under the provisions of Florida Administrative Code 14-22.

9-9 Interest Due on Delayed Payments.

The Department will determine and pay any interest due the Contractor for delays in final payment in accordance with Section 337.141 of the Florida Statutes.

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9-10 Offsetting Payments.

Section 337.145 of the Florida Statutes, providing for offsetting payments to the Contractor, is hereby made a part of this Contract:

1. After settlement, arbitration, or final adjudication of any claim of the Department for work done pursuant to a construction contract with any party, the Department may offset such amount from payments due for work done on any construction contract, excluding amounts owed to subcontractors, suppliers, and laborers, which it has with the party owing such amount if, upon demand, payment of the amount is not made within 60 days to the Department.

2. Offsetting any amount pursuant to (1) above shall not be considered a breach of Contract by the Department.

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DIVISION II

Construction Details

GENERAL CONSTRUCTION OPERATIONS

SECTION 100
CONSTRUCTION EQUIPMENT-GENERAL REQUIREMENTS

100-1 General.

Unless restricted to a specific type by the Contract Documents or the Engineer, the Contractor may perform the work using equipment, tools, machinery, etc., of his own choosing. Provide a unique alphanumeric identification number on all equipment (other than small tools) used on the project. This number shall be a minimum of 2 inches high and appear on both sides of the equipment. Place the number in such a manner so as to contrast sharply in color with the background on which it is placed. Ensure that the number, which may be painted or otherwise permanently affixed to the equipment, is clearly legible at all times. Upon submittal of Notice of Intent to Claim or Preliminary Time Extension Request, submit in accordance with 5-12.2, a list showing all equipment (other than small tools) for which the Contractor may request compensation, it's identification number with serial number, manufacturer, year manufactured, model and description. Update this list to account for equipment moving to or from the project and submit certification weekly, by close of business on Friday, the equipment, its unique number and the dates and hours that the equipment was assigned to this project for the proceeding week. No compensation will be made for any equipment used during any time period when the said equipment is not listed in the weekly certification. Failure to submit this information in the time specified may result in the Engineer withholding all Contract Payments until receipt of such information. Note that facilities to be constructed under the Contract are adequate to support only their design loads in their completed construction stage. If the Contractor's equipment or procedures during construction damage any part of the facility, the Contractor will replace or repair it as directed by the Engineer at no expense to the Department.

100-2 Equipment Condition and Approval.

100-2.1 Approval: Provide on site and in due time prior to its need, in working condition, all equipment to be used in construction of the project, subject to approval or disapproval by the Engineer. Use only factory recommended exhaust mufflers on internal combustion engines. Remove from the job, alter, or repair equipment which is disapproved by the Engineer. Ensure that the number of units, the sizes, etc., of the equipment on hand are adequate to complete the work within the Contract Time.

100-2.2 Maintenance: Consistent with public interest, safety, and good practice, maintain all equipment, tools, and machinery used in a satisfactory working condition throughout the period they are on the job site. Also, provide adequate equipment maintenance procedures to promote continuous satisfactory working condition and minimize noise pollution caused by construction equipment.

100-2.3 Stationary Equipment: Screen all stationary equipment such as pumps, compressors, generators, etc., from noise sensitive receivers if that equipment is to operate

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beyond normal working hours. If it is feasible, screen this equipment during normal working hours to reduce noise impacts.

100-3 Experimental Equipment.

100-3.1 General: To encourage the development and use of new or improved equipment, the Engineer may grant the Contractor permission to use equipment other than that normally used and currently accepted, upon approval of the Contractor's written request for permission to use such equipment in place of the normally used equipment. The Engineer, before considering or granting such request, may require that the Contractor establish, at his own expense, satisfactory evidence that the proposed equipment will produce work equal in quality to that produced by the specified equipment, and meets any applicable local, state or federal noise abatement laws, by-laws, ordinances and regulation in effect.

100-3.2 Conditions of Approval: When the Engineer grants permission for the use of new or improved equipment, understand that the Engineer gives such permission for the purpose of testing the quality of work this equipment actually produces. The Engineer will maintain the right to retract permission for use of the equipment at any time that, in his opinion, the Contractor does not obtain results that are at least equal to the results obtainable with currently accepted equipment. Upon the Engineer's withdrawal of such permission for the use of the equipment, use the equipment currently accepted and normal for the work, and remove and dispose of, or otherwise remedy, at no expense to the Department, any work which the Engineer considers defective or unsatisfactory as a result of the use of such experimental equipment. If the Engineer approved the use of particular equipment on a particular project, the Engineer's approval does not extend to the use of the particular equipment on any other project. Furthermore, the Contractor is fully responsible for producing finished work of the quality required by the Contract Documents.

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SECTION 101
MOBILIZATION

101-1 Description.

Perform preparatory work and operations in mobilizing for beginning work on the project, including, but not limited to, those operations necessary for the movement of personnel, equipment, supplies, and incidentals to the project site and for the establishment of temporary offices, buildings, safety equipment and first aid supplies, and sanitary and other facilities.

Include the costs of bonds and any required insurance and any other preconstruction expense necessary for the start of the work, excluding the cost of construction materials.

101-2 Basis of Payment.

101-2.1 When a Separate Item is Included in the Proposal: When the proposal includes a separate item of payment for this work, the work and incidental costs specified as being covered under this Section will be paid for at the Contract lump sum price for the item of Mobilization.

Payment will be made under:

Item No. 101- 1- Mobilization -lump sum.

101-2.2 Partial Payments: When the proposal includes a separate pay item for Mobilization and the Notice to Proceed has been issued, partial payments will be made in accordance with the following:

For contracts of 120 contract days duration or less, partial payment will be made at 50% of the bid price per month for the first two months. For contracts in excess of 120 contract days duration, partial payment will be made at 25% of the bid price per month for the first four months. In no event shall more than 50% of the bid price be paid prior to commencing construction on the project site.

Total partial payments for Mobilization will be limited to 10% of the original Contract amount. Any remaining amount will be paid at Final Acceptance.

Retainage, as specified in 9-5, will be applied to all partial payments.

Partial payments made on this item will in no way act to preclude or limit any of the provisions for partial payments otherwise provided for by the Contract.

101-2.3 When No Separate Item is Included in the Proposal: When the proposal does not include a separate item for Mobilization, all work and incidental costs specified as being covered under this Section will be included for payment under the several scheduled items of the overall Contract, and no separate payment will be made therefore.

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SECTION 102
MAINTENANCE OF TRAFFIC

102-1 Description.

Maintain traffic within the limits of the project for the duration of the construction period, including any temporary suspensions of the work. Construct and maintain detours. Provide facilities for access to residences, businesses, etc., along the project. Furnish, install and maintain traffic control and safety devices during construction. Furnish and install work zone pavement markings for maintenance of traffic (MOT) in construction areas. Provide any other special requirements for safe and expeditious movement of traffic specified in the Temporary Traffic Control Plans. MOT includes all facilities, devices and operations as required for safety and convenience of the public within the work zone.

Do not maintain traffic over those portions of the project where no work is to be accomplished or where construction operations will not affect existing roads. Do not obstruct or create a hazard to any traffic during the performance of the work, and repair any damage to existing pavement open to traffic.

102-2 Materials.

Meet the following requirements:

Raised Pavement Marker Adhesive*	Section 706
Paint*	Section 710
Pavement Marking Materials*	Section 971
Temporary Raised Pavement Markers*	Section 990
Temporary Traffic Control Device Materials*	Section 990
Retroreflective and Nonreflective Sheeting for Temporary Traffic Control Devices*	Section 994

*Use products listed on the Department's APL.

102-2.1 Temporary Traffic Control Devices: Use only the materials meeting the requirements of Section 990, Section 994, Standard Plans and the Manual on Uniform Traffic Control Devices (MUTCD).

102-2.2 Detour: Provide all materials for the construction and maintenance of all detours.

102-2.3 Commercial Materials for Driveway Maintenance: Provide materials of the type typically used for base, including reclaimed asphalt pavement (RAP) material, and having stability and drainage properties that will provide a firm surface under wet conditions.

102-3 Specific Requirements.

102-3.1 Beginning Date of Contractor's Responsibility: Maintain traffic starting the day work begins on the project or on the first day Contract Time is charged, whichever is earlier.

102-3.2 Worksite Traffic Supervisor (WTS): Provide a WTS who is responsible for initiating, installing, and maintaining all temporary traffic control devices as described in this Section and the Contract Documents. Provide all equipment and materials needed to set up, take down, maintain traffic control, and handle traffic-related situations. Provide the WTS or designee with a tablet or smartphone with internet access for recording information into the Department's lane closure notification system. Use approved alternate WTS when necessary.

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The WTS must meet the personnel qualifications specified in Section 105.

The WTS is to perform the following duties:

1. On site direction of all temporary traffic control on the project.

2. Is on site during all set up and take down, and performs a drive through inspection immediately after set up. During operations with lane closures, the WTS or on-site designee shall record lane closure information into the Department's lane closure notification system in accordance with 102-3.3.

3. Is on site during all nighttime operations ensuring proper temporary traffic control.

4. Immediately corrects all safety deficiencies and corrects minor deficiencies that are not immediate safety hazards within 24 hours.

5. Is available on a 24 hour per day basis and present at the site within 45 minutes after notification of an emergency situation and is prepared to respond to maintain temporary traffic control or to provide alternate traffic arrangements.

6. Conducts daily daytime and weekly nighttime inspections of projects with predominately daytime work activities, and daily nighttime and weekly daytime inspections of projects with predominantly nighttime work activities of all traffic control devices, traffic flow, pedestrian, bicyclist, and business accommodations.

Advise the project personnel of the schedule of these inspections and give them the opportunity to join in the inspection as deemed necessary.

The Department may disqualify and remove from the project a WTS who fails to comply with the provisions of this Section. The Department may temporarily suspend all activities, except traffic, erosion control and such other activities that are necessary for project maintenance and safety, for failure to comply with these provisions.

102-3.3 Lane Closures: Approval for all lane closures, mobile operations, and traffic pacing operations is required. Submit routine requests to the Engineer 14 calendar days in advance of planned lane closures, mobile operations, and traffic pacing operations. Requests for planned lane closures are to be submitted through the Department's Lane Closure Notification System (LCNS). For unforeseen events that require cancelling or rescheduling lane closures, mobile operations, and traffic pacing operations, revise the lane closure request as soon as possible.

Record information for lane closures, including but not limited to begin and end lane closure times and locations, into the Department's LCNS. Lane closures are to be activated in the Department's LCNS within 5 minutes of placing the first channelizing device and deactivated within 5 minutes removing the last channelizing device associated with the closure.

At the preconstruction conference, submit a request for access to the Department's LCNS to the Engineer. Include the name, email address, level of access required, and a copy of the individual's certification of training for Contractor personnel requiring access to the Department's LCNS. For change of access requests, submit a request to the Engineer at least ten calendar days in advance of when the change is needed.

102-3.3.1 Traffic Pacing: In addition to dates and locations, include a pacing plan outlining the expected equipment and number of traffic control officers required, the proposed traffic pacing lengths and durations, the available existing egresses in the event of an emergency, and a contingency plan in the event of an equipment failure.

102-3.4 Pedestrian and Bicycle Accommodations: Provide accommodations for pedestrians as shown in the Temporary Traffic Control (TTC) plans or as directed by the

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Engineer. Accommodate pedestrians with a safe, accessible travel path around work sites separated from mainline traffic in compliance with the Americans with Disabilities Act (ADA) Standards for Transportation Facilities (i.e., stable, firm, slip-resistant, and free of any obstruction or hazards such as holes, debris, mud, construction equipment, and stored material. When a work operation requires a sidewalk or pedestrian way closure for 60 minutes or greater, provide a pedestrian detour or temporary pedestrian way. Provide and maintain pedestrian detours and temporary pedestrian ways that are ADA-compliant as described above. Provide appropriate signs for advanced notification of sidewalk closures and marked detours. Only approved pedestrian longitudinal channelizing devices may be used to close or delineate a pedestrian walkway.

Provide accommodations for the closure of bicycle facilities (i.e., marked bicycle lanes or paved outside shoulders 4 feet or greater in width on non-limited access roadways) as shown in the TTC plans or as directed by the Engineer.

Existing businesses in work areas are to be provided with adequate entrances for vehicular and pedestrian traffic during business hours.

102-4 Alternative Temporary Traffic Control Plan.

The Contractor may propose an alternative Temporary Traffic Control Plan (TTCP) to the plan presented in the Contract Documents. The Contractor's Engineer of Record must sign and seal the alternative TTCP and submit to the Engineer. Prepare the alternative TTCP in conformance with and in the form outlined in the current version of the FDOT Design Manual. Provide a TTCP foreach phase of activities. Take responsibility for identifying and assessing any potential impacts to a utility that may be caused by the alternate TTCP proposed by the Contractor, and notify the Department in writing of any such potential impacts to utilities.

For projects with nighttime lane closure restrictions where paving is expected to extend into the winter months, the Contractor may propose an alternative TTCP allowing for daytime lane closures for friction course paving. The alternative TTCP must be a lane closure analysis based on actual traffic counts and prepared in accordance with the FDOT Design Manual.

The Engineer's approval of the alternate TTCP does not relieve the Contractor of sole responsibility for all utility impacts, costs, delays or damages, whether direct or indirect, resulting from Contractor initiated changes in the design or construction activities from those in the original Contract Documents and which effect a change in utility work different from that shown in the Utility Plans, joint project agreements or utility relocation schedules.

The Department reserves the right to reject any alternative TTCP. Obtain the Engineer's written approval before beginning work using an alternative TTCP. The Engineer's written approval is required for all modifications to the alternative TTCP. The Engineer will only allow changes to the TTCP in an emergency without the proper documentation.

The Contractor may propose to extend lane closure times up to one hour in advance of the lane closure start times shown in the Plans for the following conditions:

1. Limited Access roadways with a traffic count of less than 1,300 vehicles per hour per lane

2. Arterials and Collector roadways with a traffic count of less than 1,550 vehicles per hour per lane.

To determine traffic count, record the number of vehicles in the direction of the closure during a 15-minute period. Multiply the number of vehicles by four and divide by the number of lanes in the direction of the closure.

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102-5 Traffic Control.

102-5.1 MUTCD: Comply with the requirements in Part 6 of the MUTCD.

102-5.2 Temporary Traffic Control Plan: The Temporary Traffic Control Plan (TTCP) is the portion of the Plans describing the measures to be used for conveying road users through the work zone. Use the TTCP to maintain traffic for the duration of the work.

For situations or field conditions not addressed by the TTCP follow the Standard Plans. For all other applications, comply with the MUTCD and Standard Plans, Index 102-600. Device location or the number of devices, may be adjusted as recommended by the Work Zone Traffic Supervisor and approved by the Engineer.

102-5.3 Maintenance of Roadway Surfaces: Maintain all lanes that are being used for the MOT, including those on detours and temporary facilities, under all weather conditions. Keep the lanes reasonably free of dust, potholes and rutting. Provide the lanes with the drainage facilities necessary to maintain a smooth riding surface under all weather conditions.

102-5.4 Number of Traffic Lanes: Maintain one lane of traffic in each direction. Maintain two lanes of traffic in each direction at existing four (or more) lane cross roads, where necessary to avoid undue traffic congestion. Do not allow traffic control and warning devices to encroach on lanes used for MOT.

The Engineer may allow the Contractor to restrict traffic to one-way operation for short periods of time provided that the Contractor employs adequate means of traffic control and does not unreasonably delay traffic. When a construction activity requires restricting traffic to one-way operations, locate the flaggers within view of each other when possible. When visual contact between flaggers is not possible, equip them with 2-way radios, official, or pilot vehicles, or use traffic signals.

102-5.5 Crossings and Intersections: Provide and maintain adequate accommodations for intersecting and crossing traffic. Provide signing for the control of traffic entering and leaving work zones by way of intersecting cross roads to make drivers aware of work zone conditions. Do not block or unduly restrict any median opening, road or street crossing the project unless approved by the Engineer. Before beginning any construction, submit to the Engineer the names and phone numbers of persons that can be contacted when signal operation malfunctions.

102-5.6 Access for Residences and Businesses: Provide continuous access to all residences and all places of business.

102-5.7 Protection of the Work from Damage by Traffic: Where traffic would damage a base course, surface course, or structure constructed as a part of the work, control all traffic to remain outside the limits of such areas until the potential for damage no longer exists.

102-5.8 Flagger: Provide flaggers to control traffic when traffic in both directions must use a single lane and in other situations as required.

102-5.9 Conflicting Pavement Markings: Remove all existing pavement markings (paint, tape, thermoplastic, raised pavement markers, etc.) that conflict with temporary paths of vehicles, bicycles, or pedestrians when the conflict will exceed 24 hours. Use any method, other than paint or sprayed asphalt, approved by the Engineer to remove existing pavement markings. Remove conflicting pavement markings using a method that will not damage the surface texture of the pavement and which will eliminate the previous marking pattern regardless of weather and light conditions.

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Remove all pavement markings that will conflict with "the next phase of operation" for vehicle, bicycle, and pedestrian paths as described above, before opening to vehicle or bicycle traffic or use by pedestrians.

102-5.10 Vehicle and Equipment Visibility: Equip all pickups and automobiles used on the project with a minimum of one Class 2 warning light that meets the Society of Automotive Engineers Recommended Practice SAE J595, dated November 1, 2008, or SAE J845, dated December 1, 2007, and incorporated herein by reference. Existing lights that meet SAE J845, dated March, 1992, or SAE J1318, dated April, 1986, may be used to their end of service life. The warning lights must be a high intensity amber or white rotating, flashing, oscillating or strobe light. Lights must be unobstructed by ancillary vehicle equipment such as ladders, racks or booms and be visible 360 degrees around the vehicle. If the light is obstructed, additional lights will be required. The lights must be operating when the vehicle is in a work area where a potential hazard exists, when operating at less than the average speed for the facility while performing work activities, making frequent stops or called for in the Plans or Standard Plans.

Equip all other vehicles and equipment with a minimum of 4 square feet of retroreflective sheeting or warning lights.

102-5.11 No Waiver of Liability: Conduct operations in such a manner that no undue hazard results due to the requirements of this Article. The procedures and policies described herein in no way acts as a waiver of any terms of the liability of the Contractor or his surety.

102-5.12 Work Zone Speed: Use the work zone speed in the TTCP. When field conditions warrant work zone speeds different from those in the TTCP, submit signed and sealed documentation to justify reducing the work zone speed limit to the Engineer for approval, or the Engineer may request the District Traffic Operation Engineer to investigate the need.

Sign work zone speed reductions in accordance with Standard Plans, Index 102-600 and the TTCP.

102-5.13 Limited Access Temporary Openings: When required by the Contract Documents, **c**onstruct temporary openings in accordance with the Standard Plans. Submit a written request identifying the specific locations within the project limits to the Engineer.

Locate temporary openings in areas with adequate sight distance. Do not locate temporary openings with 1.5 miles of interchanges or within 2,000 feet of the acceleration-deceleration lanes at rest areas, median openings, other access openings, or other highway service areas. Do not remove existing guardrail or barrier for temporary openings.

Use temporary pavement for the acceleration-deceleration lane surface of the temporary opening. Commercial material may be used for the driveway surface of the temporary opening. Install a gate at the limited access fence and keep the gate locked when the temporary opening is not in use.

Do not use temporary openings to transport materials to or from any other project.

Failure to comply with this Section and the Standard Plans, 102 Series shall be cause for the Engineer to terminate usage of the temporary opening. When the temporary opening is no longer needed, remove immediately and restore the area to pre-construction condition.

102-6 Detours.

102-6.1 General: Construct and maintain detour facilities wherever it becomes necessary to divert traffic, including pedestrians and bicyclists, from any existing facility, or wherever construction operations block the flow of traffic.

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102-6.2 Construction: Plan, construct, and maintain detours for the safe passage of traffic in all conditions of weather. Provide the detour with all facilities necessary to meet this requirement.

Install detectable warnings on temporary ramps in accordance with Section 522.

When the Plans call for the Department to furnish detour bridge components, construct the pile bents in accordance with the Plans, unless otherwise authorized by the Engineer.

Provide two Contractor representatives, who will be directly involved in the erection of Department-owned temporary bridging, to attend a mandatory one-day training session to be conducted at the Department's storage facility. No bridging will be released to the Contractor prior to the completion of this training.

Submit the following: company name, phone number, office address, project contact person, names of the representatives who will attend the training described above, project number, detour bridge type, bridge length, span length, location and usage time frames, to the Engineer at least 30 calendar days before the intended pick-up date, to obtain the storage facility location and list of components for the project. Upon receipt, the Engineer will, within 10 calendar days submit an approved material list to the Contractor and the appropriate Department storage yard.

Submit the name of the representative with authority to pick up components, to the Engineer at least 10 calendar days before the proposed pick-up date. The Department is not obligated to load the bridge components without this notice. Take responsibility and sign for each item loaded at the time of issuance.

Provide timber dunnage, and transport the bridge components from the designated storage facility to the job site. Unload, erect, and maintain the bridge, then dismantle the bridge and load and return the components to the designated storage facility.

Notify the Engineer in writing at least 10 calendar days before returning the components. Include in this notice the name of the Contractor's representative authorized to sign for return of the bridge components. The yard supervisor is not obligated to unload the bridge components without this notice.

The Department will provide equipment and an operator at the Department's storage facility to assist in loading and unloading the bridge components. Furnish all other labor and equipment required for loading and unloading the components.

The Department's representative will record all bridge components issued or returned on the Detour Bridge Issue and Credit Ticket. The tickets must be signed by a Department and a Contractor representative, after loading or unloading each truck to document the quantity and type of bridging issued or returned.

Bind together all bridge components to be returned in accordance with the instructions given by the storage facility. The yard supervisor will repack components that are not packed in compliance with these instructions. Upon request, written packing instructions will be made available to the Contractor, before dismantling of the bridge for return to the Department's storage facility.

Assume responsibility for any shortage or damage to the bridge components. Monies due the Contractor will be reduced at the rate of $35.00 per hour plus materials for repacking, repairs or replacement of bridge components.

The skid resistance of open steel grid decking on the detour bridge may decrease gradually after opening the bridge to traffic. The Department will furnish a pneumatic floor

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scabbler machine for roughening the roadway surface of the detour bridge decking. Provide an air compressor at the job site with 200 cubic feet per minute capacity, 90 psi air pressure for the power supply of the machine, and an operator. Transport the scabbler machine to and from the Department's structures shop. Repair any damage to the scabbler machine caused by operations at no expense to the Department. Perform scabbling when determined necessary by the Engineer. The Department will pay for the cost of scabbling as Unforeseeable Work in accordance with 4-4.

Return the bridge components to the designated storage facility beginning no later than 10 calendar days after the date the detour bridge is no longer needed, the date the new bridge is placed in service, or the date Contract Time expires, whichever is earliest. Return the detour bridging at an average of not less than 200 feet per week. Upon failure to return the bridge components to the Department within the time specified, compensate the Department for the bridge components not returned at the rate of $5.00 per 10 feet, per day, per bridge, for single lane; and $10.00 per 10 feet, per day, per bridge, for dual lane until the bridge components are returned to the Department.

102-6.3 Construction Methods: Select and use construction methods and materials that provide a stable and safe detour facility. Construct the detour facility to have sufficient durability to remain in good condition, supplemented by maintenance, for the entire period that the detour is required.

102-6.4 Removal of Detours: Remove detours when they are no longer needed and before the Contract is completed. Take ownership of all materials from the detour and dispose of them, except for the materials on loan from the Department with the stipulation that they are returned.

102-6.5 Detours Over Existing Roads and Streets: When the Department specifies that traffic be detoured over roads or streets outside the project area, do not maintain such roads or streets. However, maintain all signs and other devices placed for the purpose of the detour.

102-6.6 Operation of Existing Movable Bridges: The Department will maintain and operate existing moveable bridges that are to be removed by the Contractor until such time as they are closed to traffic. During this period, make immediate repairs of any damage to such structures caused by use or operations related to the work at no expense to the Department, but do not provide routine repairs or maintenance. In the event that use or operations result in damage to a bridge requiring repairs, give such repairs top priority to any equipment, material, or labor available.

102-6.7 Special Detour: A special detour is defined as a diversion or lane shift for vehicular traffic that requires temporary pavement.

102-6.8 Pedestrian or Bicycle Special Detour: A pedestrian or bicycle special detour is defined as a temporary pedestrian or bicycle way that requires temporary pavement or other stable, firm, slip-resistant surface.

102-7 Traffic Control Officer.

Provide uniformed law enforcement officers, including marked law enforcement vehicles, to assist in controlling and directing traffic in the work zone when the following types of work is necessary on projects:

1. When directing traffic/overriding the signal in a signalized intersection.
2. When nighttime mobile operations are used on freeway facilities (interstates, toll roads, and expressways) for work within the travel lane.
3. When traffic pacing is called for in the TTCP or approved by the Engineer.

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4. When pulling conductor/cable above an open traffic lane on limited access facilities, when called for in the TTCP or approved by the Engineer.

5. When a Temporary Road Closure is used.

6. When performing lane closures during nighttime operations on roadways with posted speed limits 55 mph or greater.

At no additional cost to the Department, traffic control officers may be used for operations other than those listed above.

The Department will not consider any claim arising from the failure of a traffic control officer to be present or available on the project. A noncompensable time extension may be granted when a state or local emergency requires all area law enforcement officers to be on-duty and not available for hire.

102-8 Driveway Maintenance.

102-8.1 General: Ensure that each residence and business has safe, stable, and reasonable access.

102-8.2 Construction Methods: Place, level, manipulate, compact, and maintain the material, to the extent appropriate for the intended use.

As permanent driveway construction is accomplished at a particular location, the Contractor may salvage and reuse previously placed materials that are suitable for reuse on other driveways.

102-9 Temporary Traffic Control Devices.

102-9.1 General: Use only devices that are listed on the APL and use in conformance with the APL drawings. Immediately remove or cover, using any method of covering approved by the Engineer, any existing or temporary devices (e.g., signs) that do not apply to current conditions.

The use of NCHRP Report 350 Recommended Procedures for the Safety Performance Evaluation of Highway Features devices purchased prior to January 1, 2020 is permitted on projects let prior to January 1, 2030. All devices manufactured or purchased on or after January 1, 2020, must be MASH compliant in accordance with Section 990.

The APL number is to be permanently marked on the device at a readily visible location. Sheeting used on devices and pavement markings are exempt from this requirement.

Notify the Engineer in writing of any scheduled operation that will affect traffic patterns or safety sufficiently in advance of commencing such operation to permit review of the plan for the proposed installation of temporary traffic control devices.

Assign an employee the responsibility of maintaining the position and condition of all temporary traffic control devices throughout the duration of the Contract. Keep the Engineer advised at all times of the identification and means of contacting this employee on a 24-hour basis.

Maintain temporary traffic control devices in the correct position, properly oriented, clearly visible and clean, at all times. All applicable temporary traffic control devices must meet the classification category of Acceptable as defined in the American Traffic Safety Services Association (ATSSA) Quality Guidelines for Temporary Traffic Control Devices and Features. Temporary concrete barriers must meet the classification category of Acceptable defined in the Department's Temporary Concrete Barrier Evaluation Guide, which may be viewed at the following URL:

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https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/programmanagement/implemented/urlinspecs/files/docs/default-source/content-docs/programmanagement/implemented/urlinspecs/files/temporaryconcretebarrierguide.pdf.pdf?sfvrsn=343b4c97_10. Pedestrian Longitudinal Channelizing Devices (LCDs) must meet the classification category of Acceptable as defined in the Pedestrian LCD Evaluation Guide, which may be viewed at the following URL: https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/programmanagement/implemented/urlinspecs/files/lcdevaluationguide.pdf?sfvrsn=166e0f16_2. Immediately repair, replace or clean damaged, defaced or dirty devices. Traffic control devices must not be cleaned while installed/used. Use of warning lights on any temporary traffic control device is prohibited, with the exception of the trailer mounted portable regulatory signs.

Employ an approved independent Channelizing Device Supplier (CDS) to provide and maintain the condition of the following non-fixed channelizing devices: drums, cones, vertical panels, barricades, temporary tubular markers, and pedestrian longitudinal channelizing devices. Cones may be provided and maintained by the Contractor.

The CDS shall not be affiliated with the Contractor and must be approved by the Department. Department approved CDSs are listed on the State Construction Office website. CDSs seeking inclusion on the list must meet the requirements of 102-9.1.1. The CDS shall submit a monthly certification on letterhead that the channelizing devices mentioned above installed/used within the work zone meet classification category of Acceptable as defined in the Pedestrian LCD Evaluation Guide and the ATSSA Quality Guidelines for Temporary Traffic Control Devices and Features. The CDS shall submit the monthly certification on letterhead for channelizing devices installed/used within the work zone. The CDS certification shall include the following statement, “I certify that I have provided and maintained the following devices <list devices covered under the certification> in accordance with Pedestrian LCD Evaluation Guide and the ATSSA Quality Guidelines for Temporary Traffic Control Devices and Features.” If the Contractor chooses to provide and maintain cones, the Contractor must submit a monthly Contractor certification on letterhead that all cones installed/used within the work zone meet acceptable standards as outlined in the ATSSA Quality Guidelines for Temporary Traffic Control Devices and Features. The Contractor certification shall include the following statement, “I certify that I have provided and maintained cones in accordance with the ATSSA Quality Guidelines for Temporary Traffic Control Devices and Features.”

102-9.1.1 Approved Independent Channelizing Device Supplier (CDS)

Requirements: Submit the following documents to the State Construction Office for review and approval

1. A letter on company letterhead signed and dated by the owner of the company or company officer with the following information and statements:

a. The company’s owners, stockholders, and officers.

b. A statement declaring that the company will not perform as a CDS on any project where there is common ownership, directly or indirectly, between the company and the Contractor.

c. A statement declaring that the company will furnish and maintain the condition of all channelizing devices with the exception of cones as required in 102-9.1 with its own forces.

d. A statement declaring at least five years of experience in providing channelizing device supplier services, with its own inventory of channelizing devices.

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e. On a separate sheet, list a sample project history of the company's experience as a channelizing device supplier for the five years declared in item 1(d) above including the following information:

1. Project name and number and a brief description of CDS work performed,
2. Beginning and ending date of CDS project activities,
3. Location of project (city, state),
4. Monetary amount of CDS work on project,
5. Owner of project, contact person and phone number with area code,
6. Name of Contractor (client) that the work was performed for and phone number with area code.

2. A maintenance plan for approval by the Department that outlines the frequency and methods for maintaining the condition of all channelizing devices, except cones owned and maintained by the Contractor, installed/used in the work zone.

102-9.2 Work Zone Signs: Use work zone signs in accordance with the TTCP and Standard Plans.

102-9.2.1 Post Mounted Signs: Meet the requirements of 990-8.

102-9.2.2 Portable Signs: Portable signs may be used when the work zone condition will be in place for 24 hours or less, or as approved by the Engineer.

102-9.2.3 Barrier-Mounted Signs: If post mounting criteria cannot be achieved and a barrier or traffic railing exists, attach work zone signs to barrier or traffic railing in accordance with the Standard Plans. Use Standard Plans, Index 700-012 only when mounting the sign to the top of the barrier or traffic railing places the sign panel closer than two feet from the traveled way.

102-9.3 Business Signs: Use business signs in accordance with the TTCP and Standard Plans. Furnish signs having retroreflective sheeting meeting the requirements of Section 990.

102-9.4 Channelizing Devices: Use channelizing devices in accordance with the TTCP, Standard Plans, and MUTCD.

102-9.4.1 Cones: Use cones in active work zones where workers are present.

Use cone collars at night designed to properly fit the taper of the cone when installed. Collars may be removeable or attached permanently. Place the upper 6-inch collar a uniform 3-1/2 inches distance from the top of the cone and the lower 4-inch collar a uniform 2 inches distance below the bottom of the upper 6-inch collar.

102-9.4.2 Pedestrian Longitudinal Channelizing Devices (LCDs): Use LCDs listed on the APL for pedestrian use and meeting the requirements of Section 990 and the Standard Plans. Pedestrian LCDs must be interlocked except for the stand-alone unit placed perpendicular to a sidewalk. Ballast pedestrian LCDs as shown on the APL.

Ensure that joints on the pedestrian LCDs are free of sharp edges and have a maximum offset of 1/2 inch in any plane.

102-9.5 Temporary Barrier: Use temporary barrier in accordance with the TTCP and Standard Plans. Obtain and use precast temporary concrete barrier from a manufacturing plant that is on the Department's Production Facility Listing. Temporary concrete barrier must meet the material and construction requirements of Section 521 unless noted otherwise in the Standard Plans. Proprietary temporary concrete, steel, or water filled barrier used must be listed on the APL.

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The maximum allowable height increase between consecutive temporary barrier units in the direction of traffic is one inch.

Temporary barrier must comply with Standard Plans, Index 102-100 or 102-120. Install temporary barriers as either anchored or freestanding as shown in the TTCP or the Standard Plans. An anchored unit is defined as having at least one stake or bolt into the underlying pavement or bridge deck. All other units, including those with keeper pins, are considered freestanding.

Remove temporary asphalt pads and repair all attachment scars to permanent structures and pavements after barrier removal. Make necessary repairs due to defective material, work, or Contractor operations at no cost to the Department. Restore barrier damaged by the traveling public within 24 hours after notification as authorized by the Engineer.

Trailer mounted barriers listed on the APL may be used in lieu of temporary barriers or positive protection the option of the Contractor. Trailer mounted barriers listed on the APL must have an FHWA eligibility letter and be successfully crash tested in accordance with MASH TL-3 criteria. All trailer mounted barriers must be equipped with an APL listed truck mounted attenuator, an APL listed vehicle mounted arrow board and vehicle warning lights in accordance with this Section.

102-9.5.1 Temporary Barrier Meeting the Requirements of Standard Plans, Index 102-120 and 102-110: Ensure the marking requirements of the respective Index are met.

102-9.5.1.1: Proprietary Precast Temporary Concrete Barrier Fabricated prior to 2005: Submit a certification stating that all unmarked barrier units meet the requirements of the Specifications and the Standard Plans. Certifications will be project specific and non-transferable.

102-9.5.1.2 Proprietary Precast Temporary Concrete Barrier Fabricated in 2005 or later: Ensure each barrier unit has permanent clear markings, showing the manufacture date, serial number, manufacturer's name or symbol, and the APL number. Label the markings on a plate, plaque, or cast in the unit. Proprietary barrier fabricated prior to 2016 and marked with the "INDX 521" in lieu of the APL number will be permitted.

102-9.5.1.3 Temporary Concrete Barrier Repair: Before beginning the repair, remove all laitance, loose material, and any other deleterious matter to sound concrete or a minimum depth of one inch. Additionally, when reinforcing bars, inserts or weldments are exposed, remove the concrete to provide a minimum one-inch clearance all around. Fill the repair area with an approved high performance concrete repair material in accordance with 930-5 and the manufacturer's recommendations. Restore surfaces and edges to the original dimensions and shape of the barrier.

Repairs are not allowed on barrier units that have one or more of the following deficiencies: structural cracking or cracks that exist through the entire cross-section; unit-to-unit connection assemblies or anchor slots are broken or no longer in a fixed position.

Do not paint repaired barriers.

102-9.6 Barrier Delineators: Use barrier delineators on top of temporary barriers in accordance with the Standard Plans and the requirements of Section 705.

102-9.7 Temporary Glare Screen: Use temporary glare screens listed on the APL that meet the requirements of Section 990.Use screen systems in conjunction with temporary barrier at locations identified in the Plans.

When glare screen is utilized on temporary barrier, barrier delineators will not be required.

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102-9.8 Temporary Crash Cushion (Redirective or Gating): Use temporary crash cushions in accordance with the details and notes shown in the TTCP, Standard Plans, and requirements of the pre-approved alternatives listed on the APL.

Temporary crash cushions can be either new or used functionally sound refurbished devices. Performance of intended function is the only condition for acceptance. All metallic components must be galvanized in accordance with Section 967.

Anchor abutting temporary barrier in accordance the Standard Plans or APL drawings, as required. Bidirectional installations must have a transition panel installed between the crash cushion and the abutting barrier. Delineate the crash cushion in accordance with Section 544. Maintain the crash cushions until their authorized removal. Do not place any materials or equipment within the length of the crash cushion.

Remove temporary asphalt or concrete pads and repair all attachment scars to permanent structures and pavements after crash cushion removal. Make necessary repairs due to defective material, work, or Contractor operations at no cost to the Department. Restore crash cushions damaged by the traveling public within 24 hours after notification as authorized by the Engineer.

102-9.9 Temporary Guardrail: Use temporary guardrail in accordance with the TTCP and Standard Plans. Install the temporary guardrail in accordance with the Section 536.

102-9.10 Trailer Mounted Devices:

102-9.10.1 Arrow Board: Use arrow boards in accordance with the TTCP, Standard Plans, and that meet the requirements of Section 990. Ensure that the arrow board display panel is raised to a fully upright position and is fully visible to motorists. Use Type B arrow boards on roadways with an existing posted speed of 45 MPH or less for maintenance and mobile operations on any speed facility. Use Type C arrow boards for all other operations on roadways with an existing posted speed of 50 MPH or greater, and may be substituted for Type B arrow boards on any speed facility.

102-9.10.2 Portable Changeable Message Sign (PCMS): Use PCMSs or truck mounted changeable message signs in accordance with the TTCP, Standard Plans and Section 990 to supplement other temporary traffic control devices used in work zones. Ensure that the PCMS display panel is raised to a fully upright position and is fully visible to motorists. Reduce the intensity of the flashers when using PCMS at night. Use PCMS with a minimum letter height of 18 inches. For facilities with posted speed limits of 45 mph or less, PCMS with a minimum letter height of 12 inches may be used.

For roadways with speed limits greater than 45 mph, the message displayed on the PCMS must be unobstructed from 800 feet. For roadways with speed limits of 45 mph or less, the message displayed must be unobstructed from 650 feet.

Messages must have no more than two phases. The display time for each phase must be at least two seconds but no more than three seconds. The sum of the display time must be a maximum of six seconds.

102-9.10.3 Portable Regulatory Signs (PRS): Use PRSs in accordance with the TTCP, Standard Plans, and. Section 990. Ensure that the PRS sign panel is raised to a fully upright position and is fully visible to motorists.

Activate portable regulatory signs only during active work activities and deactivate when no work is being performed.

102-9.10.4 Radar Speed Display Unit (RSDU): Use RSDUs in accordance with the TTCP, Standard Plans and Section 990 to inform motorists of the posted speed and their

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actual speed. Ensure that the RSDU display panel is mounted in accordance with the manufacturer's recommendations.

Activate the radar speed display unit only during active work activities and deactivate when no work is being performed.

102-9.11 Temporary Signalization and Maintenance: Provide and maintain temporary signals and signalization at existing, temporary, and new intersections including, but not limited to, the following:

1. Installation of temporary poles and span wire assemblies as shown in the TTCP,
2. Temporary portable traffic signals as shown in the TTCP,
3. Adding or shifting signal heads,
4. Trouble calls,
5. Maintaining intersection and coordination timing and preemption devices. Coordination timing will require maintaining functionality of system communications.

Phase and time signals in accordance with the Plans. Obtain approval from the District Traffic Operations Engineer for any timing changes that are either reoccurring or last longer than 24 hours.

Restore any loss of operation within 12 hours after notification. Provide alternate temporary traffic control until the signalization is restored.

Provide temporary pedestrian signalization in accordance with the TTCP, and maintain pedestrian signalization at existing, temporary, and new intersections.

Provide traffic signal equipment that meets the requirements of the Standard Plans and 603-2. The Engineer may approve used signal equipment if it is in acceptable condition. Replacement components for traffic signal cabinet assemblies will be provided by the maintaining agency.

102-9.11.1 Temporary Signals for Lane Closures on Two-Lane, Two-Way Roadways: Temporary signals may be used, at the Contractor's option, as an alternate to flaggers for lane closure operations on two-lane, two-way roadways in accordance with Standard Plans, Index 102-606. The Contractor's Engineer of Record must provide the signal timing for the temporary signals. The District Traffic Operations Engineer must approve the installation and timing of temporary signals prior to beginning work. Adjust timing based on changing field conditions as approved by the Worksite Traffic Supervisor. Submit to the Engineer any timing changes that are reoccurring or last longer than 24 hours for District Traffic Operations Engineer's approval Temporary signals can either be portable signals or span wire signals and must be listed on the APL. Provide two signal faces for each approach.

102-9.12 Temporary Traffic Detection and Maintenance: Provide and maintain temporary traffic detection at existing, temporary, and new signalized intersections. Ensure that vehicle detectors and systems can detect vehicles in each movement on each approach and call the correct vehicle phase when vehicle demand is present. Ensure adjacent lanes and opposing movements do not place false calls. Provide temporary pedestrian detection in accordance with the TTCP, and maintain pedestrian detection at existing, temporary, and new intersections. Ensure pedestrian detectors call the correct pedestrian phase when pedestrian demand is present.

Provide temporary traffic detection equipment listed on the APL.

Restore any loss of detection within 12 hours. If permanent traffic detection cannot be restored within 12 hours, provide temporary detection. Ensure 90% accuracy per signal phase, measured at the initial installation and after any lane shifts, by comparing sample data collected

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from the detection system with ground truth data collected by human observation. Collect the sample and ground truth data for a minimum of five minutes during a peak and five minutes during an off-peak period with a minimum three detections for each signal phase. Perform the test in the presence of the Engineer.

102-9.13 Existing ITS Maintenance: Provide maintenance at existing ITS locations. Diagnose any loss of functionality within 8 hours. Restore any loss of functionality within 24 hours. The Engineer may extend the allowable downtime beyond 24 hours. Configure and install Department furnished equipment as necessary. Ensure that all stand-alone functions of replaced ITS devices are tested as detailed in the Contract Documents and as approved by the Engineer. Perform the test in the presence of the Engineer.

102-9.14 Truck Mounted Attenuators and Trailer Mounted Attenuators: Use truck mounted and trailer mounted attenuators in accordance with the manufacturer's recommendations and Standard Plans.

For existing posted speeds of 50 mph or greater, use either truck mounted attenuators or trailer mounted attenuators that meet TL-3 criteria. For existing posted speeds of 45 mph or less, use either truck mounted attenuators or trailer mounted attenuators that meet TL-2 or TL-3 criteria.

102-9.15 Temporary Raised Rumble Strip Set: Use temporary raised rumble strips per the manufacturer's recommendations and in accordance with Standard Plans, Index 102-603.

The temporary raised rumble strip may be either a removable striping type or a portable type. Use a consistent type and color throughout the work zone.

102-9.16 Automated Flagger Assistance Devices (AFAD): Furnish, install, maintain, remove, and relocate AFADs in accordance with the Plans, Standard Plans, Index 102-603, and APL vendor drawings.

Position AFADs where they are clearly visible to oncoming traffic. AFADs may be placed on the centerline if they have been successfully crash tested in accordance with MASH TL-3 criteria. A gate arm is required in accordance with Section 990 if a single AFAD is used on the shoulder to control one direction of traffic.

The devices may be operated either by a single flagger at one end of the traffic control zone, from a central location, or by a separate flagger near each device location. Use only flaggers trained in accordance with Section 105 and in the operation of the AFAD. When in use, each AFAD must be in view of, and attended at all times by, the flagger operating the device.

Provide two flaggers on-site and use one of the following methods in the deployment of AFADs:

1. Place an AFAD at each end of the temporary traffic control zone, or
2. Place an AFAD at one end of the temporary traffic control zone and a flagger at the opposite end.

A single flagger may simultaneously operate two AFADs as described in (1) or a single AFAD as described in (2) if all of the following conditions are met:

1. The flagger has an unobstructed view of the AFAD(s),
2. The flagger has an unobstructed view of approaching traffic in both directions,
3. In the event of an AFAD malfunction, restore normal flagging operations with flaggers or immediately cease the flagging operation and reopen the roadway.

AFADs may be either a remotely controlled Stop/Slow AFAD mounted on either a trailer or a movable cart system, or a remotely controlled Red/Yellow Lens AFAD.

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Illuminate the flagging station when the AFAD is used at night. When the AFAD is not in use, remove or cover signs and move the AFAD device outside the clear zone or shield it with a barrier.

AFADs will not be paid for separately. AFADs may be used as a supplement or an alternate to flaggers in accordance with the Plans, Standard Plans, Index 102-603, and the APL vendor drawings. Include the cost for AFADs in Maintenance of Traffic, Lump Sum.

102-9.17 Temporary Lane Separator: Use temporary lane separators (asphalt or portable) in accordance with the TTCP and Standard Plans.

When using portable temporary lane separators, anchor the portable temporary lane separator with a removable anchor bolt. Use epoxy on bridge decks where anchoring is not allowed. Remove the epoxy from the bridge deck by hydroblasting or other method approved by the Engineer.

Repair any damage to the existing pavement caused by the removal of temporary lane separator.

102-9.18 Type III Barricades: Use type III barricades in accordance with the TTCP and Standard Plans. Ensure stripes are sloping downward in the direction road users are to pass. Mount sign panels in accordance with the manufacturer's instructions. Do not place ballast on any rails, or higher than 13 inches above the driving surface. Do not splice the retroreflective sheeting.

102-10 Work Zone Pavement Marking.

102-10.1 Description: Furnish and install work zone pavement markings for MOT in construction areas and in close conformity with the lines and details shown in the Plans and Standard Plans.

Centerlines, lane lines, edge lines, stop bars, standard crosswalks, and turn arrows will be required in work zones prior to opening the road to traffic.

102.10.2 Painted Pavement Markings:

102-10.2.1 General: Use painted pavement markings meeting the requirements of Section 710. Use standard paint unless otherwise identified in the Plans or approved by the Engineer.

102-10.3 Removable Tape:

102-10.3.1 Application: Apply removable tape with a mechanical applicator to provide pavement lines that are neat, accurate and uniform. Equip the mechanical applicator with a film cut-off device and with measuring devices that automatically and accumulatively measure the length of each line placed within an accuracy tolerance of plus or minus 2%. Ensure removable tape adheres to the road surface. Removable tape may be placed by hand on short sections, 500 feet or less, if it is done in a neat accurate manner.

102-10.3.2 Retroreflectivity: Apply white and yellow removable tape pavement markings that will attain an initial retroreflectivity of not less than 300 mcd/m^2/lx for white and not less than 250 mcd/m^2/lx for yellow markings. Black portions of contrast tapes and black masking tapes must have a retroreflectance of less than 20 mcd/m^2/lx.

Measure, record and certify on the Department approved form and submit to the Engineer, the retroreflectivity of white and yellow removable tape pavement markings in accordance with FM 5-541, Part A.

102-10.3.3 Removability: Provide removable tape capable of being removed from bituminous concrete and portland cement concrete pavement intact or in substantially large

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strips after being in place for a minimum of 90 days, either manually or by a mechanical roll-up device, at temperatures above 40ºF, without the use of heat, solvents, grinding or blasting.

102-10.4 Temporary Raised Pavement Markers (RPMs): Use Class B RPMs except for work that consists of ground-in rumble strips at centerline locations. For ground-in rumble strips at centerline locations, use temporary RPMs in accordance with Section 710. Install all markers in accordance with the manufacturer's recommendations, the Standard Plans, and Section 706. After initial installation, replace broken or missing temporary RPMs in locations where more than three consecutive temporary RPMs are broken or missing at no expense to the Department.

102-11 Method of Measurement.

102-11.1 General: Devices installed/used on the project on any calendar day or portion thereof, within the Contract Time, including time extensions which may be granted, will be paid for at the Contract unit price for the applicable pay item. Include the cost of any work that is necessary to meet the requirements of the Contract Documents for MOT under Maintenance of Traffic, lump sum when separate payment is not provided.

102-11.2 Traffic Control Officers: The quantity to be paid for traffic control officers will be at the Contract unit price per hour (4 hour minimum) for the actual number of officers certified to be on the project site, including any law enforcement vehicles and all other direct and indirect costs. Payment will be made only for those traffic control officers specified in the Plans and authorized by the Engineer.

102-11.3 Special Detours: When a special detour is shown in the Plans, the work of constructing, maintaining, and subsequently removing such detour facilities will be paid for under Special Detour, lump sum. However, traffic control devices, warning devices, barriers, signing, pavement markings, and restoration to final configuration will be paid for under their respective pay items.

102-11.4 Commercial Material for Driveway Maintenance: The quantity to be paid for will be the certified volume, in cubic yards, of all materials authorized by the Engineer, acceptably placed and maintained for driveway maintenance. The volume, which is authorized to be reused, and which is acceptably salvaged, placed, and maintained in other designated driveways will be included again for payment. Commercial Material used for Temporary Openings will not be included for separate payment.

102-11.5 Work Zone Signs: The number of temporary post-mounted signs (temporary regulatory, warning and guide) certified as installed/used on the project will be paid for at the Contract unit price for work zone signs. When multiple signs are located on single or multiple posts, each sign panel will be paid individually. Signs greater than 20 square feet and detailed in the Plans will be paid for under Maintenance of Traffic, lump sum.

Temporary portable signs (excluding mesh signs) and vehicular mounted signs will be included for payment under work zone signs, only if used in accordance with the Standard Plans.

The number of temporary barrier mounted signs (temporary regulatory, warning and guide) certified as installed/used on the project will be paid for at the Contract unit price for barrier mounted work zone signs.

Work zone signs may be installed fourteen days prior to the start of Contract Time with the approval of the Engineer and at no additional cost to the Department.

102-11.6. Business Signs: The number of business signs certified as installed/used on the project will be paid for at the Contract unit price for business signs.

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102-11.7 Channelizing Devices: The number of drums, vertical panels, and Type I, Type II, or direction indicator barricades, certified as installed/used on the project meeting the requirements of Standard Plans, Index 102-600 and have been properly maintained will be paid for at the Contract unit prices for channelizing device.

Payment for drums, vertical panels, and Type I, Type II, and direction indicator barricades will be paid per each per day.

Payment for vehicular LCDs will be paid as the length in feet installed divided by the device spacing for barricades, vertical panels, and drums and certified as installed/used on the project meeting the requirements of Standard Plans, Index 102-600 and have been properly maintained will be paid for at the Contract unit price for channelizing device.

Payment for pedestrian LCDs, certified as installed/used on the project and properly maintained, will be paid per linear foot per day. Placement of pedestrian LCDs at locations not shown in the TTCP, or not authorized by the Engineer, will be at the Contractor's expense. Payment for pedestrian LCD mounted signs will be made under Work Zone Signs.

Payment will not be made for channelizing devices unsatisfactorily maintained, as determined by the Engineer. Payment will be made for each channelizing device that is used to delineate trailer mounted devices. Payment will be made for channelizing devices delineating portable changeable message signs during the period beginning 14 working days before Contract Time begins as authorized by the Engineer.

102-11.8 Temporary Barrier: The quantity to be paid for will be the length, in feet, of freestanding units or anchored units certified as installed/used on the project. The quantity to be paid for relocating barrier will be based on the relocated installation type. No separate payment will be made for the asphalt pad. For freestanding units transitioned to a crash cushion, the cost of anchoring the transition units will be included in the cost of the temporary crash cushion in accordance with 102-11.11.

102-11.9 Barrier Delineators: No separate payment will be made for barrier delineators installed on top of temporary barrier . Include the cost for barrier delineators in the cost of the barrier.

102-11.10 Temporary Glare Screen: The certified quantity to be paid for will be determined by the number of sections times the nominal length of each section.

102-11.11 Temporary Crash Cushions: No separate payment will be made for the concrete or asphalt pad.

102-11.11.1 Redirective: The quantity to be paid for will be the number of temporary crash cushions (redirective) certified as installed/used and maintained on the project, including anchoring of temporary barrier necessary for transition to the crash cushion and delineation.

102-11.11.2 Gating: The quantity to be paid for will be the number of temporary crash cushions (gating) certified as installed/used and maintained on the project, including anchoring of temporary barrier necessary for transition to the crash cushion and delineation.

102-11.12 Temporary Guardrail: The quantity to be paid for will be the length, in feet, of temporary guardrail constructed and certified as installed/used on the project. The length of a run of guardrail will be determined as a multiple of the nominal panel lengths.

102-11.13 Arrow Board: The quantity to be paid at the contract unit price will be for the number of arrow boards certified as installed/used on the project on any calendar day or portion thereof within the Contract Time. Payment will be made for up to two inactive days where the arrow board is used on the two days preceding and following the inactive days as authorized by

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the Engineer. Payment for additional days may be authorized by the Engineer due to inclement weather.

102-11.14 Portable Changeable Message Sign: The quantity to be paid at the Contract unit price will be for the number of PCMSs or truck mounted changeable message signs certified as installed/used on the project on any calendar day or portion thereof within the Contract Time. Payment will be made for each portable changeable message sign that is used during the period beginning 14 working days before Contract Time begins as authorized by the Engineer. Payment will be made for up to two inactive days where the portable changeable message sign is used on the two days preceding and following the inactive days as authorized by the Engineer. Payment for additional days may be authorized by the Engineer due to inclement weather.

102-11.15 Portable Regulatory Signs: The quantity to be paid for will be the number of portable regulatory signs certified as installed/used on the project on any calendar day or portion thereof within the Contract Time, will be paid for the Contract unit price for portable regulatory sign. Payment will be made for up to two inactive days where the portable regulatory sign is used on the two days preceding and following the inactive days as authorized by the Engineer. Payment for additional days may be authorized by the Engineer due to inclement weather.

102-11.16 Radar Speed Display Unit: The quantity to be paid for will be the number of radar speed display units certified as installed/used on the project on any calendar day or portion thereof within the Contract Time, will be paid for the Contract unit price for radar speed display unit. Payment will be made for up to two inactive days where the radar speed display unit is used on the two days preceding and following the inactive days as authorized by the Engineer. Payment for additional days may be authorized by the Engineer due to inclement weather.

102-11.17 Temporary Signalization and Maintenance: For existing intersections, the certified quantity to be paid for will be the number of signalized intersections per day for the full duration of the Contract. For temporary intersections, the certified quantity to be paid for will be the number of signalized intersections per day for the duration of the temporary intersection. No separate payment will be made for temporary signalization and maintenance at new intersections.

102-11.18 Temporary Traffic Detection and Maintenance: For existing intersections, the certified quantity to be paid for will be the number of signalized intersections per day beginning the day Contract Time begins and ending on the day the permanent detection is operational and the final lane configuration is in place. For temporary and new intersections, the certified quantity to be paid for will be the number of signalized intersections per day beginning the day the temporary detection is functional and ending the day: the permanent detection is operational and the final lane configuration is in place for a new intersection; or, when the detection is removed for a temporary intersection.

102-11.19 Existing ITS Maintenance: For existing ITS locations, the certified quantity to be paid for will be the number of calendar days from Contract Time start to Final Acceptance.

102-11.20 Work Zone Pavement Markings: Painted pavement markings will be paid as specified in 710-10. The quantity of removable tape to be paid for solid, 10’-30’ skip, 3’-9’ dotted, 6’-10’ dotted, and 2’-4’ dotted lines will be the length, in gross miles, authorized and acceptably applied under this Section and certified as installed/used on the project. The quantity of removable tape to be paid for transverse lines will be the length, in linear feet, authorized and acceptably applied under this Section and certified as installed/used on the project. The quantity of removable tape to be paid for pavement messages, symbols, and arrows will be per each, authorized and acceptably applied under this Section and certified as installed/used on the project. The quantity of temporary RPMs to be paid will be the number of RPMs authorized and

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acceptably applied. Payment for removing conflicting pavement markings (paint, tape, thermoplastic, raised pavement markers, etc.) will be included in Maintenance of Traffic, lump sum.

102-11.21 Temporary Raised Rumble Strips: The quantity to be paid for will be the number of calendar days, or portions thereof, that temporary raised rumble strips are certified as installed/used on the project within the Contract Time. No adjustment will be made to the per day measurement for the number of strips or sets used, or for the number of times the sets are relocated.

102-11.22 Temporary Lane Separator: The quantity to be paid for will be the field measure, in feet, of temporary lane separator certified as installed/used on the project, including drainage gaps, completed and accepted. The cost of any pavement repairs due to removal is included in the cost of Maintenance of Traffic, lump sum.

102-11.23 Temporary Signals for Lane Closures on Two-Lane, Two-Way Roadways: The quantity to be paid for will be the number of temporary signals per day installed/used at the locations shown in the TTCP. Temporary signals installed/used at the Contractor's option as an alternative to flaggers will be included in Maintenance of Traffic, lump sum.

102-11.24 Temporary Highway Lighting: When temporary highway lighting is required by the Plans, the work of constructing, maintaining, and removing the temporary highway lighting, including all materials and any necessary design work, will be paid for under temporary highway lighting, lump sum.

102-11.25 Pedestrian or Bicycle Special Detours: When a pedestrian or bicycle special detour is shown in the Plans, the work of constructing, maintaining, and subsequently removing such detour facilities will be paid for under pedestrian or bicycle special detour, lump sum. However, traffic control devices, warning devices, barriers, signing, pavement markings, and restoration to final configuration will be paid for under their respective pay items.

102-11.26 Type III Barricades: The number of type III barricades certified as installed/used on the project will be paid for at the Contract unit price for type III barricades.

102-11.27 Limited Access Temporary Openings: Include all construction, maintenance, removal, and restoration costs of temporary openings in Maintenance of Traffic, lump sum. No separate payment will be made for commercial material, gates, or fence.

102-12 Submittals.

102-12.1 Submittal Instructions: Prepare a certification of quantities, using the Department's current approved form, for certified MOT payment items for each project in the Contract. Submit the certification of quantities to the Engineer. The Department will not pay for any disputed items until the Engineer approves the certification of quantities.

102-12.2 Contractor's Certification of Quantities: Request payment by submitting a certification of quantities no later than Twelve O'clock noon Monday after the estimate cut-off date or as directed by the Engineer, based on the amount of work done or completed. Ensure the certification consists of the following:

1. Contract Number, FPID Number, Certification Number, Certification Date and the period that the certification represents.

2. The basis for arriving at the amount of the progress certification, less payments previously made and less an amount previously retained or withheld. The basis will include a detail breakdown provided on the certification of items of payment in accordance with the Basis of Payment. After the initial setup of the MOT items and counts, the interval for recording the

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counts will be made weekly on the certification sheet unless there is a change. This change will be documented on the day of occurrence. Some items may necessitate a daily interval of recording the counts.

102-13 Basis of Payment.

102-13.1 Maintenance of Traffic (General Work): When an item of work is included in the proposal, price and payment will be full compensation for all work and costs specified under this Section except as may be specifically covered for payment under other items.

102-13.2 Traffic Control Officers: Price and payment will be full compensation for the services of the traffic control officers.

102-13.3 Special Detours: Price and payment will be full compensation for providing all detour facilities shown in the Plans and all costs incurred in carrying out all requirements of this Section for general MOT within the limits of the detour, as shown in the Plans.

102-13.4 Commercial Materials for Driveway Maintenance: Price and payment will be full compensation for all work and materials specified for this item, including specifically all required shaping and maintaining of driveways.

102-13.5 Work Zone Signs: Price and payment will be full compensation for all work and materials for furnishing signs, supports and necessary hardware, installation, relocating, maintaining, covering, and removing signs.

102-13.6. Business Signs: Price and payment will be full compensation for all materials and labor required for furnishing, installing, relocating, maintaining, and removing the signs as well as the cost of installing any logos provided by business owners.

102-13.7 Channelizing Devices: Prices and payment will be full compensation for furnishing, installing, relocating, maintaining and removing the channelizing devices.

102-13.8 Temporary Barrier: Price and payment will be full compensation for furnishing, installing, maintaining, and removing the barrier and asphalt pad. When called for, temporary barrier (relocate) will be full compensation for relocating the barrier.

102-13.9 Temporary Glare Screen: Price and payment will be full compensation for furnishing, installing, maintaining, and removing the glare screen certified as installed/used on the project. When called for, glare screen (relocate) will be full compensation for relocating the glare screen.

102-13.10 Temporary Crash Cushion (Redirective or Gating): Price and payment will be full compensation for furnishing, installing, maintaining, and removing crash cushions, object markers, and concrete or asphalt pads.

102-13.11 Temporary Guardrail: Price and payment will be full compensation for furnishing all materials required for a complete installation, including end anchorage assemblies and any end connections to other structures and for installing, maintaining and removing guardrail.

102-13.12 Arrow Board: Price and payment will be full compensation for furnishing, installing, operating, relocating, maintaining and removing arrow boards.

102-13.13 Portable Changeable Message Sign: Price and payment will be full compensation for furnishing, installing, operating, relocating, maintaining and removing portable changeable message signs.

102-13.14 Portable Regulatory Signs: Price and payment will be full compensation for furnishing, installing, relocating, operating, maintaining and removing a completely functioning system as described in these Specifications.

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Payment will include all labor, materials, incidentals, repairs and any actions necessary to operate and maintain the unit at all times that work is being performed or traffic is being affected by construction and/or MOT operations.

102-13.15 Radar Speed Display Unit: Price and payment will be made only for a completely functioning system as described in these Specifications. Payment will include all labor, hardware, accessories, signs, and incidental items necessary for a complete system. Payment will include any measurements needed to ensure that the unit conforms to all Specification requirements.

Payment will include all labor, materials, incidentals, repairs and any actions necessary to operate and maintain the unit at all times that work is being performed or traffic is being affected by construction and MOT operations. Price and payment will be full compensation for furnishing, installing, operating, relocating, maintaining and removing radar speed display unit.

102-13.16 Temporary Signalization and Maintenance: Price and payment will constitute full compensation for furnishing, installing, operating, maintaining and removing temporary traffic control signals including all equipment and components necessary to provide an operable traffic signal. Payment will be withheld for each day at each intersection where the temporary signalization is not operational within 12 hours after notification.

102-13.17 Temporary Traffic Detection and Maintenance: Price and payment will constitute full compensation for furnishing, installing, operating, maintaining and removing temporary traffic detection including all equipment and components necessary to provide an acceptable signalized intersection. Take ownership of all equipment and components. Payment will be withheld for each day at each intersection where the temporary detection is not operational within 12 hours after notification.

102-13.18 Existing ITS Maintenance: Price and payment will constitute full compensation for diagnosing, troubleshooting, configuring, installing, operating, maintaining, and removing existing ITS devices including all auxiliary equipment and device components. Payment will be withheld for each day where the ITS device is not operational within the allowable downtime, beginning at the time of notification. Payment will not be withheld for days of delay when the Department or Maintaining Agency is unable to furnish the replacement ITS device to the Contractor.

102-13.19 Work Zone Pavement Markings: Price and payment will be full compensation for all work specified including, all cleaning and preparing of surfaces, furnishing of all materials, application, curing and protection of all items, protection of traffic, furnishing of all tools, machines and equipment, and all incidentals necessary to complete the work. Final payment will be withheld until all deficiencies are corrected.

Removable tape or durable paint may be substituted for standard paint at no additional cost to the Department.

Payment for temporary RPMs used to supplement line markings will be paid for under temporary raised pavement markers. Install these RPMs as detailed in the Standard Plans.

102-13.20 Temporary Raised Rumble Strips: Price and payment will be full compensation for all work and materials described in this Section, including all cleaning and preparing of surfaces, disposal of all debris, furnishing of all materials, application, curing, removal, reinstalling and protection of all items, protection of traffic, furnishing of all tools, machines and equipment, and all incidentals necessary to complete the work.

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102-13.21 Temporary Lane Separator: Price and payment will be full compensation for all work specified in this Section.

102-13.22 Temporary Signals for Lane Closures on Two-Lane, Two-Way Roadways: Price and payment will be full compensation for furnishing, installing, operating, maintaining and removing temporary traffic signal including all equipment and components necessary to provide an operable portable traffic signal.

102-13.23 Temporary Highway Lighting: Price and payment will be full compensation for providing all temporary highway lighting shown in the Plans.

102-13.24 Pedestrian or Bicycle Special Detours: Price and payment will be full compensation for providing all pedestrian or bicycle special detours shown in the Plans.

102-13.25 Type III Barricades: Prices and payment will be full compensation for furnishing, installing, relocating, maintaining and removing the type III barricades.

102-13.26 Payment Items: Payment will be made under:

Item No. 102- 1-	Maintenance of Traffic - lump sum.
Item No. 102- 2-	Special Detour - lump sum.
Item No. 102- 3-	Commercial Material for Driveway Maintenance - per cubic yard.
Item No. 102- 4-	Pedestrian or Bicycle Special Detour - lump sum.
Item No. 102- 14-	Traffic Control Officer - per hour.
Item No. 102- 30-	Temporary Highway Lighting - lump sum.
Item No. 102- 60-	Work Zone Sign - per each per day.
Item No. 102- 61-	Business Sign - each.
Item No. 102- 62-	Barrier Mounted Work Zone Sign – per each per day
Item No. 102- 71-	Temporary Barrier - per foot.
Item No. 102- 75-	Temporary Lane Separator - per foot
Item No. 102- 73-	Temporary Guardrail - per foot.
Item No. 102- 74-	Channelizing Devices
Item No. 102- 76-	Arrow Board - per each per day.
Item No. 102- 78-	Temporary Raised Pavement Markers - each.
Item No. 102- 81-	Temporary Crash Cushion, Gating - per location.
Item No. 102- 89-	Temporary Crash Cushion, Redirective - per location.
Item No. 102- 94-	Glare Screen - per foot.
Item No. 102- 99-	Portable Changeable Message Sign - per each per day.
Item No. 102-104-	Temporary Signalization and Maintenance - per intersection per day.
Item No. 102-107-	Temporary Traffic Detection and Maintenance - per intersection per day.

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Item No. 102-ABC-	Existing ITS Maintenance – per day
Item No. 102-115-	Type III Barricade - per each per day.
Item No. 102-120-	Temporary Signal for Lane Closures on Two-Lane, Two-Way Roadways – per each per day.
Item No. 102-150-	Portable Regulatory Sign - per each per day.
Item No. 102-150-	Radar Speed Display Unit - per each per day.
Item No. 102-909-	Temporary Raised Rumble Strips - per day.
Item No. 102-913-	Removable Tape.
Item No. 710-	Painted Pavement Markings.
Item No. 711-	Thermoplastic Pavement Markings.

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SECTION 103
TEMPORARY WORK STRUCTURES

103-1 Description.

103-1.1 Scope of Work: Construct temporary work structures used solely to support construction equipment. Temporary structures include but are not limited to work bridges, elevated platforms, floating platforms, and rail systems. Items such as mats, falsework or scaffolding are not included in this Section. If a temporary structure type other than the structure type shown in the plans is chosen, assume responsibility for obtaining all necessary permit revisions and the Engineer's approval. Conform to any limitations contained in the plans and permits. Do not place embankment outside the limits shown in the plans. The cost of the embankment, placing, compaction, and removal will be included in the lump sum price for Temporary Work Structure.

103-1.2 Materials: Construct the temporary work structure using materials sufficient to handle the anticipated loads. Assume responsibility for the design of the temporary structure.

103-1.3 Navigation Requirements: Submit drawings showing the location of the temporary work structures relative to the navigable waterway to the Coast Guard at least 60 days prior to beginning construction of the structure, or as required by conditions of the permit. Provide adequate lighting of the structure during the duration of construction as required by the Coast Guard or local authorities.

103-2 Basis of Payment.

103-2.1 General: The unit price for the temporary work structure will include all costs associated with the design, materials, labor, installation, removal and disposal of the structure.

103-2.2 Partial Payments: When the plans include a separate pay item for temporary work structure, 75% of the lump sum price will be paid upon completion of the temporary work structure, and 25% will be paid upon complete removal of the temporary work structure from the project site. When the project requires numerous structures or multiple setups (leap frog type) of the same system, the 75% will be split evenly between the various structures or setups. Partial payments for any project will be limited to 5% of the original Contract amount for that project. Any remaining amount will be paid upon completion of all work on the project.

When more than one project is included in the Contract, the above percentages will apply separately to each project which has a separate pay item for temporary work structures.

Payment will be made under:

Item No. 103- 1- Temporary Work Structures - lump sum.

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SECTION 104
PREVENTION, CONTROL, AND ABATEMENT OF EROSION AND WATER POLLUTION

104-1 Description.

Provide erosion control measures where work is accomplished in conjunction with the project, to prevent erosion, pollution of water, detrimental effects to public or private property adjacent to the project right-of-way and damage to work on the project.

104-2 General.

Coordinate the installation of temporary erosion control devices with the construction of the permanent erosion control devices to ensure economical, effective, and continuous control of erosion and water pollution throughout the life of the Contract.

104-3 Control of Contractor's Operations Which May Result in Water Pollution.

Prevent contaminants, pollutants or hazardous substances, as defined in Section 376.301, Florida Statutes, from migrating from the construction site or from materials and equipment into any surface waters, wetlands, groundwater or property beyond the project limits. Conduct and schedule operations to avoid and minimize pollution or siltation from the project to surface waters, wetlands, groundwater, or property beyond the project limits.

Do not drive in, operate, or place construction equipment or materials in surface waters, wetlands, groundwater, or property beyond the project limits without permitted authority for permanent or temporary impacts. Water crossings or other wetlands impacts must be authorized by permit. Obstructing or impeding the water flow or movement of the water or wildlife must be authorized by permit.

Where pumps are used to remove highly turbid waters from enclosed construction areas such as cofferdams or forms, treat the water by one or more of the following methods prior to discharge from the project: pumping into grassed swales or appropriate upland vegetated areas or constructed sediment basins, or confined by an appropriate enclosure such as turbidity barriers when other methods are not practical. Do not discharge, water that does not meet State water quality standards or does not meet the criteria specified in any applicable permit.

Remove sediment accumulated during construction from all existing or newly constructed stormwater facilities prior to final acceptance. Ensure that all stormwater conveyances and stormwater facilities meet final grade requirements at final acceptance. Remove silt or regrade as necessary to comply with the lines and grades shown in the Plans.

Do not enter onto lands or waters outside the limits of construction as staked, except as authorized by the Engineer. Do not allow water that does not meet state water quality standards or does not meet the permitted criteria to exit the project limits.

Obtain the Engineer's approval for the location and method of operation in borrow pits, material pits, and disposal areas furnished for waste material from the project (other than commercially operated sources) such that erosion during and after completion of the work will not result in detrimental siltation or water pollution.

104-4 Materials for Temporary Erosion Control.

For materials that are part of the permanent work, meet the testing requirements of the applicable permanent materials.

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For materials not part of the permanent work, no testing is required; acceptance will be based on visual inspection

Use new or used materials for the construction of temporary silt fence, staked turbidity barriers, and floating turbidity barrier not to be incorporated into the completed project

For geotextile fabrics, use a product on the Approved Product List (APL) meeting the requirements of Section 985.

104-5 Preconstruction Requirements.

Prior to the Preconstruction Conference, submit an Erosion and Sediment Control Plan meeting the requirements or special conditions of all permits authorizing project construction. If no permits are required or the approved permits do not contain special conditions or specifically address erosion and water pollution, the project's Erosion and Sediment Control Plan will be governed by 7-1.1, 7-2.2, 7-8.1, 7-8.2, and Section 104.

When a DEP Generic Permit for Stormwater Discharge from Large and Small Construction Activities permit is issued, the Contractor's Erosion and Sediment Control Plan shall be prepared to accompany the Department's Stormwater Pollution Prevention Plan. Ensure the Erosion and Sediment Control Plan includes procedures to control off-site tracking of soil by vehicles and construction equipment and a procedure for cleanup and reporting of non-storm water discharges, such as contaminated groundwater or accidental spills. Do not begin any soil disturbing activities before receiving the Engineer's written approval of the Erosion and Sediment Control Plan, including the required signed certification statements.

Failure to sign and submit any required documents or certification statements will be considered a default of the Contract. Any soil disturbing activities performed without the required signed documents or certification statements is considered a violation of the DEP Generic Permit for Stormwater Discharge from Large and Small Construction Activities.

Prepare a site-specific Erosion and Sediment Control Plan in accordance with the planned sequence of operations and present it in a format acceptable to the Department. The Erosion and Sediment Control Plan shall describe, but not be limited to, the following items or activities:

1. For each phase of construction operations or activities, supply the following information:
    a. Locations of all erosion control devices
    b. Types of all erosion control devices
    c. Estimated time erosion control devices will be in operation
    d. Monitoring schedules for maintenance of erosion control devices
    e. Methods of maintaining erosion control devices
    f. Dewatering plan
    g. Locations of all stored fuel or other containments, pollutants or hazardous waste
    h. Spill prevention and response measures and disposal and removal methods
    i. Submit any changes to the Erosion and Sediment Control Plan within seven calendar days
2. The name and telephone number of the person responsible for monitoring and maintaining the erosion control devices.
3. Submit for approval the Erosion and Sediment Control Plans meeting paragraphs 3a, 3b, or 3c below:

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a. Projects permitted by the Southwest Florida Water Management District (SWFWMD), require the following:

Submit the Erosion and Sediment Control Plan to the Engineer for review and to the appropriate SWFWMD Office for review and approval. Include the SWFWMD permit number on all submitted data or correspondence.

The Contractor may schedule a meeting with the appropriate SWFWMD Office to discuss the Erosion and Sediment Control Plan in detail, to expedite the review and approval process. Advise the Engineer of the time and place of any meetings scheduled with SWFWMD.

Do not begin construction activities until the Erosion and Sediment Control Plan receives written approval from both SWFWMD and the Engineer.

b. Projects permitted by the South Florida Water Management District or the St. Johns River Water Management District, require the following:

Obtain the Engineer's approval of the Erosion and Sediment Control Plan.

Do not begin construction activities until the Erosion and Sediment Control Plan receives written approval from the Engineer.

c. Projects authorized by permitting agencies other than the Water Management Districts or projects for which no permits are required require the following:

The Engineer will review and approve the Contractor's Erosion and Sediment Erosion Control Plan.

Do not begin construction activities until the Erosion and Sediment Control Plan receives written approval from the Engineer.

104-6 Construction Requirements.

104-6.1 Limitation of Exposure of Erodible Earth: Do not allow the surface area of erodible earth that clearing and grubbing operations, excavation and filling operations, or other earth disturbing activities to exceed 750,000 square feet without specific prior written approval by the Engineer. This limitation applies separately to clearing and grubbing operations and excavation and filling operations.

The Engineer may further limit the surface areas of unprotected erodible earth exposed by the construction operation and may direct the Contractor to provide additional erosion or pollution control measures to prevent contamination of any surface waters, wetlands, or groundwater or to prevent detrimental effects on property outside the project limits or damage to the project.

104-6.2 Incorporation of Erosion and Sediment Control Devices: Incorporate permanent erosion and sediment control devices into the project at the earliest practical time. Complete the installation of temporary erosion and sediment control devices prior to the commencement of any earthwork. Use temporary erosion and sediment control devices found in the State of Florida Erosion and Sediment Control Designer and Reviewer Manual (E&SC Manual) to control erosion and sediment generated by construction operations, to correct unforeseen conditions during construction, and to control erosion and sediment prior to the incorporation of permanent erosion and sediment control devices. An electronic version of the E&SC Manual can be found at the following URL:

https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/FLErosionSedimentManual.shtm.

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104-6.3 Scheduling of Successive Operations: Schedule operations such that the area of unprotected erodible earth exposed at any one time is not larger than the minimum area necessary for efficient construction operations, and the duration of exposure of uncompleted construction to the elements is as short as practicable.

Schedule and perform clearing and grubbing such that grading operations can be incorporated immediately thereafter. Schedule and perform grading operations so that permanent erosion control devices can follow immediately thereafter if conditions on the project permit.

104-6.4 Details for Temporary Erosion and Sediment Control Devices:

104-6.4.1 General: Use temporary erosion, sediment and water pollution control devices found in the E&SC Manual. These devices consist of, but are not limited to, temporary sod, rolled erosion control products, sediment containment systems, runoff control structures, sediment barriers, inlet protection systems, silt fences, turbidity barriers, and chemical treatment. For design details for some of these devices, refer to the E&SC Manual. Perform installation, inspection, maintenance, and removal of all temporary erosion and sediment control devices in accordance with applicable permits, manufacturer's directions, and the Contract Documents.

104-6.4.2 Temporary Sod: The Engineer may designate certain areas of sod constructed in accordance with Section 570, as a temporary erosion control device. Do not use seed as a temporary erosion control device. The Engineer may waive the turf establishment requirements of Section 570 for areas of temporary sod that will not be a part of the permanent construction.

104-6.4.3 Runoff Control Structures: Construct runoff control structures in accordance with the details shown in the Contract Documents.

104-6.4.4 Sediment Containment Systems: Construct sediment containment systems in accordance with the details shown in the Contract Documents. Clean out sediment containment systems as necessary in accordance with the Contract Documents.

104-6.4.5 Sediment Barriers: Provide and install sediment barriers according to details shown in the Contract Documents or, as directed by the Engineer to protect against downstream accumulation of sediment. Sediment Barriers include, but are not limited to synthetic bales, silt fence, fiber logs and geosynthetic barriers. Reusable barriers that have had sediment deposits removed may be reinstalled on the project as approved by the Engineer.

104-6.4.6 Silt Fence:

104-6.4.6.1 General: Furnish, install, maintain, and remove silt fences, in accordance with the applicable permits, the manufacturer's directions, and the Contract Documents.

104-6.4.6.2 Materials and Installation: Use a geotextile fabric made from woven or nonwoven fabric, meeting the physical requirements of Section 985 according to those applications for erosion control.

Choose the type and size of posts and wire mesh reinforcement (if required). Do not use products which have a separate layer of plastic mesh or netting. Provide a durable and effective silt fence that controls sediment in accordance with the Contract Documents.

Erect silt fence at upland locations and at temporary locations shown in the Contract Documents or where continuous construction activities change the natural contour and drainage runoff. Do not attach silt fence to existing trees unless approved by the Engineer.

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104-6.4.6.3 Inspection and Maintenance: Inspect all silt fences in accordance with any applicable permit. If the project does not have a permit, inspect within 24 hours after each rain event and at least daily during prolonged rainfall. Immediately correct any deficiencies. In addition, make a daily review of the location of silt fences in areas where construction activities have changed the natural contour and drainage runoff to ensure that the silt fences are properly located for effectiveness. Where deficiencies exist, repair or replace silt fences in accordance with the Contract Documents or as directed by the Engineer.

Remove sediment deposits when the deposit reaches approximately 1/2 the height of the silt fence or as directed by the Engineer. Shape any remaining sediment deposits to conform with the finished grade and prepare the area for turf in accordance with Section 570.

104-6.4.7 Floating Turbidity Barriers and Staked Turbidity Barriers: Furnish, install, maintain, and remove floating turbidity barriers in accordance with the applicable permits, the manufacturer's directions, and the Contract Documents. The Contractor may need to deploy turbidity barriers around isolated areas of concern (such as, seagrass beds, coral communities) both within as well as outside the project limits. The Engineer will identify such areas. Place the barriers prior to the commencement of any work that could impact the area of concern. Ensure that the type of barrier used and the deployment and maintenance of the barrier will minimize dispersion of turbid waters from the project. The Engineer may approve alternate methods or materials.

Install and maintain turbidity barriers to avoid or minimize the degradation of the water quality of the surrounding waters and minimize damage to areas where the floating barriers are installed.

104-6.4.8 Inlet Protection System: Furnish and install inlet protection systems as shown in the Contract Documents.

104-6.4.9 Rolled Erosion Control Products (RECPs):

104-6.4.9.1 General: Install RECPs in locations where temporary protection from erosion is needed. Two common applications are described below.

1. Use RECPs composed of natural or synthetic fiber mats, plastic sheeting, or netting as protection against erosion, when directed by the Engineer, during temporary pauses in construction caused by inclement weather or other circumstances. Remove the material when construction resumes.

2. Use RECPs as erosion control blankets, at locations shown in the Plans, to facilitate plant growth while permanent grassing is being established. For the purpose described, use non-toxic, biodegradable, natural or synthetic woven fiber mats. Install erosion control blankets capable of sustaining a maximum design velocity of 6.5 ft/sec as determined from tests performed by Utah State University, Texas Transportation Institute or an independent testing laboratory approved by the Department. Submit to the Engineer, certified test reports from the manufacturer showing that the erosion control blankets meet the requirements of this Specification. Certification must be attested, by a person having legal authority to bind the manufacturing company. Also, furnish two 4 by 8 inch samples for product identification. The manufacturers test records shall be made available to the Department upon request. Leave the material in place, as installed, to biodegrade.

104-6.4.10 Chemical Treatment: Provide chemical treatment in accordance with the Contract Documents. Chemical treatment may be used to clarify turbid or sediment laden water that does not meet state water quality standards or to supplement other erosion and

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sediment control devices to aid in their performance. The contractor must provide the required toxicity testing information in accordance with the Contract Documents to the Engineer for review and acceptance prior to using any chemical treatment on the project site.

104-6.5 Removal of Temporary Erosion Control Devices: In general, remove or incorporate into the soil any temporary erosion control devices upon incorporation of the permanent erosion control devices into the project. The Engineer may direct that temporary devices be left in place.

104-7 Maintenance of Erosion and Sediment Control Devices.

104-7.1 General: Provide routine maintenance of permanent and temporary erosion and sediment control devices, at no expense to the Department, until the project is complete and accepted. If reconstruction or replacement of erosion and sediment control devices is necessary due to the Contractor's negligence or carelessness or, in the case of temporary erosion and sediment control devices, improper installation, lack of maintenance, excessive wear, design-life exceedance or failure by the Contractor to install permanent erosion control devices as scheduled, the Contractor shall repair or replace such erosion control devices at no expense to the Department. If reconstruction of permanent or temporary erosion and sediment control devices is necessary due to factors beyond the control of the Contractor, the Department will pay for replacement under the appropriate Contract pay item or items.

Inspect all erosion and sediment control devices at least once every seven calendar days and within 24 hours of the end of a storm event that is 0.50 inches or greater. Maintain all erosion and sediment control devices as required in the Stormwater Pollution Prevention Plan, the Contractor's Erosion and Sediment Control Plan, and if applicable, as specified in the State of Florida Department of Environmental Protection Generic Permit for Stormwater Discharge from Large and Small Construction Activities.

104-8 Protection During Suspension of Contract Time.

Initiate stabilization measures within seven calendar days upon suspension of construction activities. If it is necessary to suspend the construction operations for any appreciable length of time, shape the disturbed areas to facilitate stormwater runoff and construct earthen berms along the top edges of embankments to intercept stormwater runoff. Provide temporary slope drains in areas that are highly erodible to avoid pollution of surface waters, wetlands, groundwater, or property beyond the project limits. Locate slope drains at intervals of approximately 500 feet and stabilize by paving or covering with waterproof materials. Should such preventive measures fail, immediately take action as necessary to effectively prevent erosion and siltation. During suspension of operations, the Engineer may direct the Contractor to perform additional erosion and sediment control work as necessary.

104-9 Method of Measurement.

When separate items for temporary erosion control devices are included in the Contract, the quantities to be paid for will be:

1. the area, in square yards, of rolled erosion control products;
2. the length, in feet, of runoff control structures, measured along the surface of the work constructed;
3. the number of sediment containment systems constructed and accepted;
4. the number of sediment containment system cleanouts accomplished and accepted;

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5. the length, in feet, of sediment barriers;
6. the length, in feet, of floating turbidity barrier;
7. the length, in feet, of staked turbidity barrier;
8. the number of inlet protection systems, for existing inlets;
9. the area, in square yards, of chemical treatment;
10. the number of floc logs or drums of product for chemical treatment;

Upon acceptance by the Engineer, the quantity of floating turbidity barriers, sediment barriers, staked turbidity barriers, and inlet protection devices will be paid for regardless of whether materials are new, used, or relocated from a previous installation on the project. Protection of newly constructed inlets and drainage systems is incidental to their installation. No separate payment will be made for temporary erosion control devices used to protect newly constructed drainage systems.

104-10 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section, including construction and routine maintenance of temporary erosion control devices.

Any additional costs resulting from compliance with the requirements of this Section, other than construction, routine maintenance, and removal of temporary erosion control devices, will be included in the Contract unit prices for the item or items to which such costs are related. Temporary sod used as a temporary erosion control device in accordance with 104-6.4.2 will be paid for under Section 570.

Separate payment will not be made for the cost of constructing temporary earth berms along the edges of the roadways to prevent erosion during grading and subsequent operations. The Contractor shall include these costs in the Contract prices for grading items.

In case of repeated failure on the part of the Contractor to control erosion, pollution, or siltation, the Engineer reserves the right to employ outside assistance or to use the Department's own forces to provide the necessary corrective measures. Any such costs incurred, including engineering costs, will be charged to the Contractor and appropriate deductions made from the monthly progress estimate.

Payment will be made under:

Item No. 104- 1-	Artificial Coverings/ Rolled Erosion Control Products - per square yard.
Item No. 104- 6-	Slope Drains (Temporary)/ Runoff Control Structures - per foot.
Item No. 104- 7-	Sediment Basins/ Containment Systems - each.
Item No. 104- 9-	Sediment Basin/ Containment system Cleanouts - each.
Item No. 104- 10-	Sediment Barriers - per foot
Item No. 104- 11-	Floating Turbidity Barrier - per foot.
Item No. 104- 12-	Staked Turbidity Barrier - per foot.
Item No. 104- 18-	Inlet Protection System - each.
Item No. 104- 19-	Chemical Treatment - per square yard.
Item No. 104- 20-	Chemical Treatment (floc logs, drums of product) - each.

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SECTION 105
CONTRACTOR QUALITY CONTROL GENERAL REQUIREMENTS

105-1 General.

105-1.1 Quality Control Documentation:

105-1.1.1 Submission of Materials Certification and Reporting Test Results: Submit certifications prior to placement of materials. Report test results at completion of the test and meet the requirements of the applicable Specifications.

105-1.1.2 Databases: Obtain access to the Department's databases prior to testing and material placement. Database access information is available through the Department's website. Enter all required and specified documentation and test results into the Department's databases.

105-1.1.3 Worksheets: Make available to the Department, when requested, worksheets used for collecting test information. Ensure the worksheets at a minimum contain the following:

1. Project Identification Number,
2. Time and Date,
3. Laboratory Identification and Name,
4. Training Identification Numbers (TIN) and initials,
5. Record details as specified within the test method.

105-1.1.4 Earthwork Records System: Record QC test results directly into the Earthwork Records System (ERS) section of the Department's database. If authorized by the Engineer due to ERS inaccessibility in the field, collect the data in the field on Department approved forms and enter the data in the ERS section of the Department's database. Submit the original forms by uploading into the Department's database.

105-1.2 Inspections to Assure Compliance with Acceptance Criteria:

105-1.2.1 General: The Department is not obligated to make an inspection of materials at the source of supply, manufacture, or fabrication. Provide the Engineer with unrestricted entry at all times to such parts of the facilities that concern the manufacture, fabrication, or production of the ordered materials. Bear all costs incurred in determining whether the material meets the requirements of these Specifications.

105-1.2.2 Quality Control (QC) Inspection: Provide all necessary inspection to assure effective QC of the operations related to materials acceptance. This includes but is not limited to sampling and testing, production, storage, delivery, construction and placement. Ensure that the equipment used in the production and testing of the materials provides accurate and precise measurements in accordance with the applicable Specifications. Maintain a record of all inspections, including but not limited to, date of inspection, results of inspection, and any subsequent corrective actions taken. Make available to the Department the inspection records, when requested.

105-1.2.3 Notification of Placing Order: Order materials sufficiently in advance of their incorporation in the work to allow time for sampling, testing and inspection. Notify the Engineer prior to placing orders for materials.

Submit to the Engineer a fabrication schedule for all items requiring commercial inspection at least 30 days before beginning fabrication. These items include steel bridge components, moveable bridge components, pedestrian bridges, castings, forgings, structures erected either partially or completely over the travelled roadway or mounted on

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bridges as overhead traffic signs (some of these may be further classified as cantilevered, overhead trusses, or monotubes) or any other item identified as an item requiring commercial inspection in the Contract Documents.

105-2 Additional Requirements for Lump Sum Projects.

Prepare and submit to the Engineer a project-specific list of material items and quantities to be used on the project as a Job Guide Schedule in the same format as the current Sampling, Testing, and Reporting Guide 21 calendar days prior to commencement of construction. Submit up-to-date quantities for the items on the Job Guide Schedule to the Engineer with each monthly progress estimate. The Department may not authorize payment of any progress estimate not accompanied by updated Job Guide Schedule quantities. Maintain the Job Guide Schedule throughout the project including the quantity placed since the previous submittal, and total to date quantity and any additional materials placed. Do not commence work activities that require testing until the Job Guide Schedule has been reviewed and accepted by the Engineer. At final acceptance, submit a final Job Guide Schedule that includes all materials used on the project in the same format as the monthly reports.

105-3 Quality Control Program.

Certain operations require personnel with specific qualifications. Certain materials require production under an approved Quality Control (QC) Plan to ensure that these materials meet the requirements of the Contract Documents. Applicable materials include hot mix asphalt, portland cement concrete (structural), earthwork, cementitious materials, timber, steel and miscellaneous metals, galvanized metal products, prestressed and/or precast concrete products, drainage products, and fiber reinforced polymer products. For all applicable materials included in the Contract, submit a QC Plan prepared in accordance with the requirements of this Section to the Engineer. Do not incorporate any of these materials into the project prior to the Engineer's approval of the QC Plan.

Steel and Miscellaneous Metal products, including aluminum, are defined as the metal components of bridges**,** including pedestrian and moveable bridges, overhead and cantilevered sign supports, ladders and platforms, bearings, end wall grates, roadway gratings, drainage items, expansion joints, roadway decking, shear connectors, handrails, galvanized products, fencing, guardrail, light poles, high mast light poles, standard mast arm assemblies and Monotube assemblies, stay in-place forms, casing pipe, strain poles, fasteners, connectors and other hardware.

105-4 Producer Quality Control Program.

105-4.1 General: When accreditation or certification is required, make supporting documents from the two previous inspections performed by the accrediting or certifying agency available to the Department upon request.

Obtain Department approval prior to beginning production. Meet and maintain the approved Producer Quality Control Program requirements at all times. Production of these products without the Department's prior acceptance of the Producer Quality Control Program may result in rejection of the products. Continued approval will be subject to satisfactory results from Department evaluations, including the Independent Assurance program. In cases of non-compliance with the accepted Producer Quality Control Program, identify all affected material and do not incorporate or supply to the Department projects. The following conditions may result in suspension of a Producer Quality Control Program:

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1. Failure to timely supply information required.
2. Repeated failure of material to meet Standard Specification requirements.
3. Failure to take immediate corrective action relative to deficiencies in the performance of the Producer Quality Control Program.
4. Certifying materials that are not produced under an accepted Producer Quality Control Program for use on Department projects.
5. Failure to correct any deficiencies related to any requirement of the Producer Quality Control Program, having received notice from the Department, within the amount of time defined in the notice.

105-4.2 Producer Quality Control Program Requirements:

105-4.2.1 Hot Mix Asphalt, Portland Cement Concrete (Structural), Earthwork, Cementitious Materials, Timber, Steel and Miscellaneous Metals, **Galvanized Metal Products, Prestressed and/or Precast Concrete Products, Drainage Products, and Fiber Reinforced Polymer Products Quality Control Program:** Have an accepted Producer Quality Control Program, developed in accordance with this Section, during the production of materials to be used on Department projects.

105-4.2.2 Prestressed Concrete Quality Control Program: Have a current certification from a Department approved precast prestressed concrete plant certification agency and a Department accepted Producer Quality Control Plan, meeting the requirements of this Section. The list of Department approved certification agencies is available on the website of the State Materials Office (SMO).

105-4.2.3 Steel and Miscellaneous Metals Quality Control Program: Have an accepted Producer Quality Control Plan, developed in accordance with this Section and a current American Institute for Steel Construction (AISC) certification, provided that AISC certification program is available for the category of the fabrication products.

105-4.3 Submittal: Depending on the type of products, producers shall submit their proposed Producer Quality Control Programs to the SMO or to the District Materials Office, as described below:

105-4.3.1 State Materials Office (SMO): Producers of cementitious materials, steel and miscellaneous metals, galvanized metal products, aggregates, timber, flexible pipe, and fiber reinforced polymer (FRP) products must submit their proposed Producer Quality Control Program to the SMO for review and acceptance.

105-4.3.2 District Materials Office: Producers of hot mix asphalt, portland cement concrete (structural), earthwork, and precast/prestressed concrete products and must submit their proposed Producer Quality Control Program to the local District Materials Office for acceptance. Producers located outside the State must contact the SMO for address information of the District Materials Office responsible for the review of the proposed Quality Control Program.

105-4.4 Compliance with the Materials Manual:

Producers of Polymer Slurry shall meet the requirements of Section 2.4, Volume II of the Department's Materials Manual, which may be viewed at the following URL: https://www.fdot.gov/programmanagement/implemented/URLinSpecs/Section24V2.shtm.

Producers of Asphalt Emulsion shall meet the requirements of Section 3.4 Volume II of the Department's Materials Manual, which may be viewed at the following URL:

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https://www.fdot.gov/programmanagement/implemented/URLinSpecs/Section34V2.shtm.

Producers of Asphalt Binder shall meet the requirements of Section 3.5, Volume II of the Department's Materials Manual, which may be viewed at the following URL: https://www.fdot.gov/programmanagement/implemented/URLinspecs/Section35V2.shtm.

Producers of Flexible Pipe shall meet the requirements of Section 6.1, Volume II of the Department's Materials Manual, which may be viewed at the following URL: https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/Section61V2.shtm

Producers of Precast Concrete Pipe shall meet the requirements of Section 6.2, Volume II of the Department's Materials Manual, which may be viewed at the following URL: https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/Section62V2.shtm.

Producers of Precast Concrete Drainage Structures shall meet the requirements of Section 6.3, Volume II of the Department's Materials Manual, which may be viewed at the following URL: https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/Section63V2.shtm.

Producers of Precast Prestressed Concrete Products shall meet the requirements of Sections 8.1 and 8.3, Volume II of the Department's Materials Manual, which may be viewed at the following URLs: https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/Section81V2.shtm. https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/Section83V2.shtm.

Producers of Precast Prestressed Concrete Products using Self Consolidating Concrete shall meet the requirements of Section 8.4, Volume II of the Department's Materials Manual, which may be viewed at the following URL: https://www.fdot.gov/programmanagement/Implemented/URLinspecs/Section84V2.shtm

Producers of Precast/Prestressed Concrete Products using Flowing Concrete shall meet the requirements of Section 8.6, Volume II of the Department's Materials Manual, which may be viewed at the following URL: https://www.fdot.gov/programmanagement/Implemented/URLinspecs/Section86V2.shtm

Producers of Incidental Precast/Prestressed Concrete Products shall meet the requirements of Section 8.2, Volume II of the Department's Materials Manual, which may be viewed at the following URL: https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/Section82V2.shtm.

Producers of Portland Cement Concrete shall meet the requirements of Section 9.2, Volume II of the Department's Materials Manual, which may be viewed at the following URL: https://www.fdot.gov/programmanagement/Implemented/URLinspecs/Section92V2.shtm.

Producers of Paving Concrete produced by Central Mix Plants shall meet the requirements of Section 9.3, Volume II of the Department's Materials Manual, which may be viewed at the following URL: https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/Section93V2.shtm.

Specialty Engineers preparing, submitting, and implementing Mass Concrete Control Plans shall meet the requirements of Section 9.4 Volume II of the Department's Materials Manual, which may be viewed at the following URL: https://www.fdot.gov/programmanagement/Implemented/URLinspecs/Section94V2.shtm.

Producers of Structural Steel and Miscellaneous Metal Components shall meet the requirements of Sections 11.1, 11.2, 11.3, 11.4, 11.5 and 11.6 of the Department's Materials Manual, which may be viewed at the following URLs: https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/Section111V2.shtm.

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https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/Section112V2.shtm.
https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/Section113V2.shtm.
https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/Section114V2.shtm.
https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/Section115V2.shtm.
https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/Section116V2.shtm.

Producers of Fiber Reinforced Polymer Composites shall meet the requirements of Section 12-1, Volume II of the Department's Materials Manual, which may be viewed at the following URL:
https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/Section121V2.shtm.

105-4.5 Producer Quality Control (QC) Plan Review and Acceptance: The Department will respond to the producer within 21 calendar days of receipt of the proposed Producer Quality Control Program. The Department may perform evaluation activities to verify compliance with submitted documents prior to acceptance.

If the Producer Quality Control Program must be revised for any reason, including non-compliance, submit the revision to the Department. The Department will respond to the producer within seven calendar days of receipt of the revised Producer Quality Control Program.

105-4.6 Producer's Quality Control (QC) Plan: Submit detailed policies, methods and procedures to ensure the specified quality of all applicable materials and related production operations. Include other items in addition to these guidelines as necessary.

105-4.6.1 Personnel:

105-4.6.1.1 Qualifications: Submit the Training Identification Numbers (TINs) or any other information which will be traceable to the certification agency's training location and dates for all technicians performing sampling, testing and inspection for both field and laboratory tests. Submit the names of the Construction Training and Qualification Program (CTQP) certifications and other pertinent certifications held and the expiration dates for each certification for each technician. Include employed and subcontracted technicians.

105-4.6.1.2 Level of Responsibility: Identify the primary contact for the Department. Identify roles and responsibilities of various personnel involved in the QC process.

105-4.6.2 Raw Materials:

105-4.6.2.1 Source: Identify the sources of raw materials. Submit locations and plant or mine numbers when applicable.

105-4.6.2.2 Certification: Submit methods of verifying compliance of certification with the Specifications.

105-4.6.2.3 Disposition of Failing Materials: Describe the system for controlling non-conforming materials, including procedures for identification, isolation and disposition.

105-4.6.3 Storage Facilities for Raw Materials: Describe measures and methods, including bedding details, for preventing segregation, contamination and degradation.

Describe methods of identifying individual materials. Where applicable, submit a site plan showing the locations of various materials.

105-4.6.4 Production Equipment: Describe calibration frequencies, maintenance schedule and procedures for production equipment.

105-4.6.5 Plant Requirements:

105-4.6.5.1 Plant Identification: For those facilities producing materials listed in 105-3, submit the mailing address, physical address including county and X,Y (latitude

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and longitude) coordinates of the plant, telephone and fax numbers, email address, primary contact at the plant, responsible person in charge, facility number provided by the Department, owner information including parent company, vendor number, designed production capacity, and other information as required.

105-4.6.5.2 Process Control System: Describe the methods and measures established to ensure Contract compliance for the produced materials that are supplemental to the QC sampling and testing program described in the Contract Documents. These methods and measures will include, but are not limited to, inspection schedule, additional sampling and testing, maintenance schedule, etc.

105-4.6.5.3 Loading and Shipping Control: Describe the methods and measures for preventing segregation, contamination and degradation during loading and shipping operations. Describe the methods established for materials to be in compliance with the Specifications at the point of use.

105-4.6.5.4 Types of Products Generated: Describe the products the plant is approved to produce under Department guidelines.

105-4.7 Other Requirements:

105-4.7.1 Submittal of Certification: Submit certifications issued by the plant/Contractor for the applicable products approved by the Department.

105-4.7.2 Statement of Compliance: Include a statement of compliance with all quality requirements set forth by the Department in the Contract Documents and Department manuals.

105-4.7.3 Documentation Storage: Identify location of document storage to enable Department review. Include QC charts, qualification and accreditation records, inspection reports, and other pertinent supporting documents.

105-4.8 Final Manufactured Product - Plant Operations: Describe inspection schedule and methods for identifying defects and non-compliance with the Specifications. Describe corrective actions and methods to resolve them.

105-4.8.1 Storage: When storage of the produced materials is required and it is not defined in the Contract Documents, describe the methods and duration for storage. Include measures and methods for preventing segregation, contamination and degradation during storage.

105-4.8.2 Disposition of Failing Materials: When not described in the Specifications, describe the methods and measures for identifying and controlling the failing materials. Include preventive and corrective measures. Describe disposition of failing materials.

105-4.9 Testing Laboratories: Identify the laboratories performing testing. Ensure that the testing laboratories comply with the Laboratory Qualification Program requirements of this Section or other applicable requirements.

105-4.10 Department Inspection Access: Include a statement in the Quality Control Plan allowing the Department inspectors access to the production facility to perform the inspections of the production process and the products produced for the Department.

105-5 Contractor Quality Control (QC) Plan.

105-5.1 General: Submit the Contractor QC Plan in the Department's database seven days prior to beginning work on any QC material as defined in this Section. The QC Plan may be submitted as a whole or in portions for the work related to the Contract.

Update the QC Plan at least five working days prior to the implementation of any changes.

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If at any time the Work is not in compliance with the Contract Documents, the Engineer may suspend operations in accordance with 8-6.1.

105-5.2 Personnel Qualification: Submit the Training Identification Numbers for all technicians performing sampling, testing and inspection for field tests. Include employed and subcontracted technicians.

105-5.3 Production Facilities: Identify the producers of materials listed in 105-4.4 for the project. Include the Department's facility ID number as part of the identification. All producers must have accepted Producer's Quality Control Program and be listed on the Department's Production Facility Listing**.**

105-5.3.1 Structural Concrete Mix Designs: Identify the approved structural concrete mix designs for each structural concrete production facility for review and approval by the Engineer. Do not begin work on the material without the Engineer's approval. The Engineer will review and respond within five calendar days of submittal.

105-5.4 Testing Laboratories: Identify the laboratories performing testing. Ensure that the testing laboratories comply with the Laboratory Qualification Program requirements of this Section.

105-6 Contractor Certification of Compliance.

Provide the Engineer with a notarized monthly certification of compliance with the Contract Documents, to accompany each progress estimate, on a form provided by the Engineer. The Department may not authorize payment of any progress estimate not accompanied by an executed certification document.

Final payment in accordance with 9-8 will not be made until a final notarized certification summarizing all QC exceptions has been submitted.

105-7 Lab Qualification Program.

Testing laboratories participating in the Department's Acceptance Program must have current Department qualification when testing materials that are used on Department projects. In addition, they must have one of the following:

1. Current AASHTO (AAP) accreditation.
2. Inspected on a regular basis per ASTM D3740 for earthwork, ASTM D3666 for asphalt and ASTM C1077 for concrete for test methods used in the Acceptance Program, with all deficiencies corrected, and under the supervision of a Specialty Engineer.
3. Current Construction Materials Engineering Council (CMEC) program accreditation or other independent inspection program accreditation acceptable to the Engineer and equivalent to (1) or (2) above.

After meeting the criteria described above, submit a Laboratory Qualification Application to the Department. The application is available from the Department's website: https://www.fdot.gov/materials/quality/programs/laboratoryqualification/index.shtm. Obtain the Department's qualification prior to beginning testing. The Department may inspect the laboratory for compliance with the accreditation requirements prior to issuing qualification.

Meet and maintain the qualification requirements at all times. Testing without Department's qualification may result in a rejection of the test results. Continued qualifications are subject to satisfactory results from Department evaluations, including Independent Assurance evaluations. In case of suspension or disqualification, prior to resumption of testing, resolve the issues to the Department's satisfaction and obtain reinstatement of qualification. The following conditions may result in suspension of a laboratory's qualified status:

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1. Failure to timely supply required information.
2. Loss of accredited status.
3. Failure to correct deficiencies in a timely manner.
4. Unsatisfactory performance.
5. Changing the laboratory's physical location without notification to the accrediting agency and the Engineer.
6. Delays in reporting the test data in the Department's database.
7. Incomplete or inaccurate reporting.
8. Using unqualified technicians performing testing.

Should any qualified laboratory falsify records, the laboratory qualification will be subject to revocation by the Engineer. Falsification of project-related documentation will be subject to further investigation and penalty under State and Federal laws.

It is prohibited for any contract laboratory or staff to perform Contractor QC testing and any other Acceptance Program testing on the same contract.

105-8 Personnel Qualifications.

105-8.1 General: Provide qualified personnel for sampling, testing and inspection of materials and construction activities. Ensure that qualifications are maintained during the course of sampling, testing and inspection.

Construction operations that require a qualified technician must not begin until the Department verifies that the technician is on the CTQP list of qualified technicians. The CTQP lists are subject to satisfactory results from periodic Independent Assurance evaluations.

105-8.2 Quality Control (QC) Manager: Designate a QC Manager who has full authority to act as the Contractor's agent to institute any and all actions necessary to administer, implement, monitor, and as necessary, adjust quality control processes to ensure compliance with the Contract Documents. The QC Manager must speak and understand English. The QC Manager must be on-site at the project on a daily basis or always available upon four hours' notice. Ensure that the QC Manager is qualified as such through the Construction Training and Qualification Program. The QC Manager and the Superintendent must not be the same individual.

Under the direction of the QC Manager, ensure that the QC test data is entered into the Department's database on a daily basis. Use Department approved programs to generate the plots for the ERS. Maintain all QC related reports and documentation for a period of three years from final acceptance of the project. Make copies available for review by the Department upon request.

105-8.3 Temporary Traffic Control (Maintenance of Traffic) Personnel: Worksite Traffic Supervisors, flaggers, and other personnel responsible for work zone related transportation management and traffic control must obtain training and certification in accordance with the Department's Temporary Traffic Control (Maintenance of Traffic) Training Handbook located at the following URL address: https://www.fdot.gov/roadway/TTC/Default.shtm.

Worksite Traffic Supervisors (or designees) and other personnel responsible for the planning and implementation of lane closures must obtain training and certification for the Department's Lane Closure Notification System (LCNS) available at the following URL address: https://info.one.network/fdot-live-link-resources.

105-8.4 Earthwork Quality Control (QC) Personnel:

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105-8.4.1 Earthwork Level 1: Ensure the technician who samples the soil and earthwork materials from the roadway project, takes earthwork moisture and density readings, and records those data into the ERS section of the Department's database, holds a CTQP Earthwork Construction Inspection Level 1 qualification.

105-8.4.2 Earthwork Level 2: Ensure the technician responsible for determining the disposition of soil and earthwork materials on the roadway, and for interpreting and meeting Contract Document requirements holds a CTQP Earthwork Construction Inspection Level 2 qualification.

105-8.5 Asphalt Quality Control (QC) Personnel:

105-8.5.1 Plant Technicians: For asphalt plant operations, provide a QC technician, qualified as a CTQP Asphalt Plant Level 2 Technician, available at the asphalt plant at all times when producing mix for the Department. Perform all asphalt plant related testing with a CTQP Asphalt Plant Level 1 Technician. As an exception, measurements of temperature may be performed by someone under the supervision of a CTQP Plant Level 2 technician.

105-8.5.2 Paving Technicians: For paving operations (with the exception of miscellaneous or temporary asphalt), keep a qualified CTQP Asphalt Paving Level 2 Technician on the roadway at all times when placing asphalt mix for the Department, and perform all testing with a CTQP Asphalt Paving Level 1 Technician. As an exception, measurements of cross-slope, temperature, and yield (spread rate) can be performed by someone under the supervision of a CTQP Paving Level 2 Technician at the roadway.

105-8.5.3 Mix Designer: Ensure all mix designs are developed by individuals who are CTQP qualified as an Asphalt Hot Mix Designer.

105-8.5.4 Documentation: Document all QC procedures, inspection, and all test results and make them available for review by the Engineer throughout the life of the Contract. Identify in the asphalt producer's QC Plan the QC Managers and Asphalt Plant Level 2 technicians responsible for the decision to resume production after a quality control failure.

105-8.6 Concrete QC Personnel:

105-8.6.1 Concrete Field Technician - Level 1: Ensure technicians performing plastic property testing on concrete for materials acceptance at the project jobsite possess a CTQP Concrete Field Technician Level 1 qualification. Plastic property testing will include but not be limited to slump, temperature, air content, water-to-cementitious materials ratio calculation, and making and curing concrete cylinders. Duties include initial sampling and testing to confirm specification compliance prior to beginning concrete placements, ensuring timely commencement of initial curing, and providing for the transport of compressive strength samples to the designated laboratories.

105-8.6.2 Self-Consolidating Concrete (SCC) Field Technician - Level 1: Ensure technicians performing plastic property testing on self-consolidating concrete (SCC) for materials acceptance at the project jobsite possess a CTQP Self-Consolidating Concrete (SCC) Field Technician Level I qualification. Plastic property testing will include but not be limited to slump flow, rapid assessment of static segregation resistance, temperature, air content, water-to-cementitious materials ratio calculation, and making and curing SCC cylinders. Duties include initial sampling and testing to confirm specification compliance prior to beginning concrete placements, ensuring timely commencement of initial curing, and providing for the transport of compressive strength samples to the designated laboratories.

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105-8.6. 3 Concrete Field Inspector - Level 2: Ensure field inspectors responsible for the quality of concrete being placed on the following structure types are qualified CTQP Concrete Field Inspectors Level 2:

1. Moveable bridges
2. Bridges over a water opening of 1,000 feet or more
3. Bridges with a span of 190 feet or more
4. Cable supported or cable stayed bridges
5. Post-tensioned bridges
6. Steel girder or steel truss bridges
7. Multi-level roadways

With the exception of concrete traffic railing and bridge approach slab placements, a Level 2 Inspector must be present on the jobsite during all concrete placements. Prior to the placement of concrete, the inspector will inspect the element to be cast to ensure compliance with Contract Documents. A Level 2 Inspector's duties may include ensuring that concrete testing, inspection, and curing in the field are performed in accordance with the Contract Documents. The QC Inspector will inform the Verification Inspector of anticipated concrete placements and LOT sizes.

105-8.6. 4 Concrete Laboratory Technician – Level 1: Ensure technicians testing cylinders and recording concrete strength for material acceptance are qualified CTQP Concrete Laboratory Technicians Level 1. Duties include final curing, compressive strength testing, and the recording/reporting of all test data.

105-8.7 Structural Concrete Production Facility Quality Control (QC) Personnel:

Ensure that each portland cement structural concrete production facility (plant), has designated personnel including plant manager of QC, concrete mix designer, concrete batch plant operator, and testing technicians to provide QC inspections and testing.

Upon Department approval, the functions of the above positions may be performed by the same person when it can be demonstrated that the plant's operation and quality of concrete will not be detrimentally affected and personnel have the qualifications required herein.

105-8.7.1 Plant Manager of QC: Ensure that the plant manager of QC has at least three years of concrete related experience and the following training certifications:

1. CTQP Concrete Laboratory Technician - Level 1 certificate.
2. CTQP Concrete Field Technician - Level 1 certificate.
3. Concrete Batch Plant Operator certification in accordance with 105-8.7.4.

As alternatives to these certifications, the Department will accept, one of the following:

a. Prestressed Concrete Institute (PCI) Quality Control Personnel Certification Level III.

b. Precast Concrete Pipe, Box Culverts, Drainage Structures or Incidental Precast Concrete Plants Level II QC Inspector Certifications.

c. National Ready Mixed Concrete Association (NRMCA) Certified Concrete Technologist Level 2.

105-8.7.2 Concrete Mix Designer: Ensure that the concrete mix designer has the CTQP Concrete Laboratory Technician Level 2 certification. As an alternative, the Department will accept any of the following qualifications:

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1. PCI Quality Control Personnel Level III Certification, for concrete mix designs of prestressed concrete products.

2. National Ready Mix Concrete Association (NRMCA) Certified Concrete Technologist Level 3.

3. Any of the Level II QC certifications in accordance with 105-8.9.2.2.

105-8.7.3 Qualified Testing Technicians: Ensure that the testing technicians have the following certifications , as appropriate:

1. ACI Concrete Field Testing Technician Grade I, for personnel performing concrete plastic property tests and ACI Self-Consolidating Concrete Testing Technician if testing self-consolidating concrete (SCC).

2. ACI Concrete Strength Testing Technician, for personnel performing tests on hardened properties of concrete.

105-8.7.4 Concrete Batch Plant Operator: Ensure that the concrete batch plant operator has a CTQP Concrete Batch Plant Operator Certification. As an alternative, the Department will accept the following certifications:

a. Precast Concrete Structures Association (PCSA) Batch Plant Operator,

b. NRMCA Certified Concrete Technologist Level 3, or

c. NRMCA Plant Manager Certification.

For dry cast concrete pipe and dry cast drainage structures/box culverts, the Department will accept American Concrete Pipe Association (ACPA) Concrete Pipe/Precast Box Culvert Batch Plant Operator or Quality School Certification.

105-8.8 Prestressed Concrete Plant Quality Control (QC) Personnel: Obtain personnel certifications from Department accredited training providers. The list of Department approved courses and their accredited providers is available on the SMO website at the following URL:https://www.fdot.gov/materials/administration/resources/training/structural/concrete-prestressed.shtm.

Ensure each prestressed concrete plant has an onsite production manager, an onsite plant QC manager, a plant engineer, and adequate onsite QC testing personnel to provide complete QC inspections and testing.

105-8.8.1 Plant QC Manager: Ensure the plant QC manager has at least five years of related experience and the following certifications:

1. ACI Concrete Field Testing Technician Grade I certification.

2. PCI Quality Control Technician/Inspector Level III.

3. CTQP Prestressed Concrete Field Inspector.

105-8.8.2 QC Inspector/Technician: Ensure that the QC inspector/technician has the following certifications:

1. ACI Concrete Field Testing Technician Grade I.

2. PCI Quality Control Technician/Inspector Level II.

3. CTQP Prestressed Concrete Field Inspector.

105-8.8.3 QC Testing Technicians: Ensure technicians performing QC program concrete testing at the plant possess the following qualifications, as appropriate.

1. CTQP Program Concrete Field Technician - Level I, for personnel performing concrete sampling and plastic property testing on concrete.

2. CTQP Program Self-Consolidating Concrete (SCC) Field Technician – Level I, for personnel performing concrete sampling and plastic property testing on SCC.

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3. CTQP Concrete Laboratory Technician – Level I, for personnel performing compressive strength testing on concrete.

105-8.8.4 Batch Plant Operator: Ensure that the batch plant operator meets the requirement of 105-8.7.4.

105-8.9 Pipe and Precast Concrete Products Manufacturing Facilities Quality Control (QC) Personnel:

105-8.9.1 General: Obtain personnel certifications from Department accredited training providers. The list of Department approved courses and their accredited providers is available on the SMO website at the following URL: https://www.fdot.gov/materials/administration/resources/training/structural/index.shtm.

105-8.9.2 Precast Concrete Drainage Structures, Precast Concrete Box Culvert, Precast Concrete Pipe, and Incidental Precast Concrete Manufacturing Facilities Quality Control (QC) Personnel:

105-8.9.2.1 Level I Quality Control Inspectors: Ensure that the Level I Inspectors have the following certifications.

105-8.9.2.1.1 Precast Concrete Drainage Technician Level I: PCI Quality Control Technician/Inspector Level I. As an alternative, a Precast Concrete QC Personnel Level I certification in the respective work area will be accepted.

105-8.9.2.1.2 Incidental Precast Concrete Technician Level I: PCI Quality Control Technician/Inspector Level I certification. As an alternative, a Precast Concrete QC Personnel Level I certification in the respective work area will be accepted.

105-8.9.2.1.3 Precast Concrete Pipe Technician Level I: Precast Concrete Pipe Personnel Level I certification. Personnel performing compressive strength testing must possess an ACI Concrete Strength Testing Technician certification.

105-8.9.2.2 Level II Quality Control Inspectors: Ensure that Level II Inspectors have the following certifications.

105-8.9.2.2.1 Precast Concrete Drainage Technician Level II:

1. Precast Concrete Drainage Technician Level I, in accordance with 105-8.9.2.1.1.
2. PCI Quality Control Technician/Inspector Level II certification. As an alternative, a Precast Concrete Quality Control Personnel Level II certification in the respective work area will be accepted.
3. CTQP Concrete Field Technician Level 1, if the plant produces structural concrete in accordance with Section 346.

105-8.9.2.2.2 Incidental Precast Concrete Technician Level II:

1. Incidental Precast Concrete Technician Level I, in accordance with 105-8.9.2.1.2.
2. PCI Quality Control Technician/Inspector Level II. As an alternative, a Precast Concrete QC Personnel Level II certification in the respective work area will be accepted.
3. CTQP Concrete Field Technician Level 1.
4. Level II technicians who will perform quality control of incidental prestressed products must possess a CTQP Prestressed Concrete Field Inspector certification.

105-8.9.2.2.3 Precast Concrete Pipe Technician Level II:

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1. Precast Concrete Pipe Technician Level I, in accordance with 105-8.9.2.1.3.

2. Precast Concrete Pipe Personnel Certification Level II.

105-8.9.2.3 Plant Quality Control Manager: Ensure that the QC manager has a minimum of two years construction related experience in the specific work area and has the following certifications:

105-8.9.2.3.1 Precast Concrete Drainage Facilities:

Precast Concrete Drainage Technician Level II in accordance with 105-8.9.2.2.1.

105-8.9.2.3.2 Incidental Precast Concrete Facilities:

1. Incidental Precast Concrete Technician Level II in accordance with 105-8.9.2.2.2.

2. CTQP Prestressed Concrete Field Inspector, if the plant produces incidental prestressed products.

105-8.9.2.3.3 Precast Concrete Pipe Facilities:

Precast Concrete Pipe Technician Level II in accordance with 105-8.9.2.2.3.

105-8.9.2.4 Additional Requirements for Quality Control (QC) Personnel of Incidental Precast Concrete Manufacturing Facilities:

105-8.9.2.4.1 Testing Personnel: Ensure testing technicians meet the requirement of 105-8.8.3.

105-8.9.2.4.2 Batch Plant Operator: Ensure the batch plant operator meets the requirement of 105-8.7.4.

105-8.9.2.5 Additional Requirements for Quality Control (QC) Personnel of Precast Concrete Drainage Structures and Box Culverts Manufacturing Facilities:

105-8.9.2.5.1 Testing Personnel: Ensure the testing technicians meet the requirements of 105-8.7.3.

105-8.9.2.5.2 Batch Plant Operator: Ensure the batch plant operator meets the requirement of 105-8.7.4.

105-8.10 Supervisory Personnel – Post-Tensioned and Movable Bridge Structures:

105-8.10.1 General: Provide supervisory personnel meeting the qualification requirements only for the post-tensioned and movable bridge types detailed in this Article. Submit qualifications to the Engineer at the pre-construction conference. Do not begin construction until the qualifications of supervisory personnel have been approved by the Engineer.

105-8.10.2 Proof of License or Certification: Submit a copy of the Professional Engineer license current and in force issued by the state in which registration is held. The license must be for the field of engineering that the construction work involves such as Civil, Electrical or Mechanical. Under certain circumstances Florida registration may be required.

Submit a copy of the license issued by the State of Florida for tradesmen that require a license indicating that the license is in force and is current. Submit a copy of the certification issued by the International Society of Automation for each Certified Control Systems Technician.

105-8.10.3 Experience Record: Submit the following information for supervisory personnel to substantiate their experience record. The supervisor (project engineer,

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superintendent/manager or foreman) seeking approval must provide a notarized certification statement attesting to the completeness and accuracy of the information submitted. Submit the following experience information for each individual seeking approval as a supervisor:

Project owner's name and telephone number of an owner's representative, project identification number, state, city, county, highway number and feature intersected.

Detailed descriptions of each bridge construction experience and the level of supervisory authority during that experience. Report the duration in weeks, as well as begin and end dates, for each experience period.

The name, address and telephone number of an individual that can verify that the experience being reported is accurate. This individual should have been an immediate supervisor unless the supervisor cannot be contacted in which case another individual with direct knowledge of the experience is acceptable.

105-8.10.4 Concrete Post-Tensioned Segmental Box Girder Construction: Ensure the individuals filling the following positions meet the minimum requirements as follows:

105-8.10.4.1 Project Engineer-New Construction: Ensure the project engineer is a registered Professional Engineer with five years of bridge construction experience. Ensure a minimum of three years of experience is in segmental box girder construction engineering and includes a minimum of one year in segmental casting yard operations and related surveying, one year in segment erection and related surveying, including post-tensioning and grouting of longitudinal tendons and a minimum of one year as the project engineer in responsible charge of segmental box girder construction engineering. Ensure this individual is present at the site of construction, at all times while segmental box girder construction or segment erection is in progress.

105-8.10.4.2 Project Engineer-Repair and Rehabilitation: Ensure the project engineer is a registered Professional Engineer with five years of bridge construction experience. Ensure a minimum of three years of experience is in segmental box girder construction engineering and includes one year of post-tensioning and grouting of longitudinal tendons and a minimum of one year as the project engineer in responsible charge of segmental box girder rehabilitation engineering or segmental box girder new construction engineering.

105-8.10.4.3 Project Superintendent/Manager-New Construction: Ensure the project superintendent/manager has a minimum of ten years of bridge construction experience or is a registered Professional Engineer with five years of bridge construction experience. Ensure that a minimum of three years of experience is in segmental box girder construction operations and includes a minimum of one year in the casting yard operations and related surveying, one year in segment erection and related surveying including post-tensioning and grouting of longitudinal tendons and a minimum of one year as the project superintendent/manager in responsible charge of segmental box girder construction operations. Ensure this individual is present at the site of construction, at all times while segmental box girder construction or segment erection is in progress.

105-8.10.4.4 Project Superintendent/Manager-Repair and Rehabilitation: Ensure the project superintendent/manager has a minimum of five years of bridge construction experience or is a registered Professional Engineer with three years of bridge construction experience. Ensure that a minimum of two years of experience is in segmental box girder construction operations and includes a minimum of one year of experience performing post-tensioning and grouting of longitudinal tendons and a minimum of one year as the project

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superintendent/manager in responsible charge of segmental box girder rehabilitation operations or segmental box girder new construction operations.

105-8.10.4.5 Foreman-New Construction: Ensure that the foreman has a minimum of five years of bridge construction experience with two years of experience in segmental box girder operations and a minimum of one year as the foreman in responsible charge of segmental box girder new construction operations. Ensure this individual is present at the site of construction, at all times while segmental box girder construction or segment erection is in progress.

105-8.10.4.6 Foreman-Repair and Rehabilitation: Ensure the foremen has a minimum of five years of bridge construction experience with two years of experience in segmental box girder operations and a minimum of one year as the foreman in responsible charge of segmental box girder rehabilitation operations or segmental box girder new construction operations.

105-8.10.4.7 Geometry Control Engineer/Manager: Ensure that the geometry control engineer/manager for construction of cast-in-place box segments is a registered Professional Engineer with one year of experience, a non-registered Engineer with three years of experience or a registered Professional Land Surveyor with three years of experience in geometry control for casting and erection of cast-in-place box segments. Credit for experience in cast-in-place box girder geometry control will be given for experience in precast box girder geometry control but not vice versa.

Ensure that the geometry control engineer/manager for precast box segments is a registered Professional Engineer with one year of experience or non-registered with three years of experience in casting yard geometry control of concrete box segments.

The geometry control engineer/manager must be responsible for and experienced at implementing the method for establishing and maintaining geometry control for segment casting yard operations and segment erection operations and must be experienced with the use of computer programs for monitoring and adjusting theoretical segment casting curves and geometry. This individual must be experienced at establishing procedures for assuring accurate segment form setup, post-tensioning duct and rebar alignment and effective concrete placement and curing operations as well as for verifying that casting and erection field survey data has been properly gathered and recorded. Ensure this individual is present at the site of construction, at all times while cast-in-place segmental box girder construction is in progress or until casting yard operations and segment erection is complete.

105-8.10.4.8 Surveyor: Ensure that the surveyor in charge of geometry control surveying for box segment casting and/or box segment erection has a minimum of one year of bridge construction surveying experience. Ensure this individual is present at the site of construction, at all times while segmental box girder construction or segment erection is in progress.

105-8.10.5 Movable Bridge Construction: Ensure the individual filling the following positions meet the minimum requirements as follows:

105-8.10.5.1 Electrical Journeyman: Ensure the electrical journeyman holds, an active journeyman electrician's license and has at least five years' experience in industrial electrical work, or is a certified control systems technician. A certified control systems technician will not be permitted to perform electrical power work including, but not limited to, conduit and wire-way installation or power conductor connection. Ensure the electrical

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journeyman has successfully completed the installation of one similar movable bridge electrical system during the last three years.

105-8.10.5.2 Control Systems Engineer and Mechanical Systems Engineer: Ensure the control systems engineer and mechanical systems engineer are both registered Professional Engineers with a minimum of 10 years supervisory experience each in movable bridge construction. Ensure the engineers have working knowledge of the movable bridge leaf motion control techniques, mechanical equipment and arrangements specified for this project. Ensure that each engineer has been in responsible control of the design and implementation of at least three movable bridge electrical control and machinery systems within the past 10 years of which, at least one of the three bridges was within the last three years. Ensure that a minimum of one of the three bridge designs incorporated the same type of leaf motion control and machinery systems specified for this project.

105-8.10.6 Concrete Post-Tensioned Other Than Segmental Box Girder Construction: Ensure the individual filling the following positions meet the minimum requirements as follows:

105-8.10.6.1 Project Engineer: Ensure the project engineer is a registered Professional Engineer with five years of bridge construction experience. Ensure that a minimum of three years of experience is in concrete post-tensioned construction. Ensure that the three years of experience includes experience in girder erection, safe use of cranes, stabilization of girders; design of false work for temporary girder support, post-tensioning and grouting operations, and a minimum of one year as the project engineer in responsible charge of post-tensioning related engineering responsibilities.

105-8.10.6.2 Project Superintendent/Manager: Ensure the project superintendent/manager has a minimum of ten years of bridge construction experience or is a registered Professional Engineer with five years of bridge construction experience and has a minimum of three years of supervisory experience in girder erection, safe use of cranes, stabilization of girders; design of falsework for temporary girder support post-tensioning, grouting operations and a minimum of one year as the project superintendent/manager in responsible charge of post-tensioning related operations.

105-8.10.6.3 Foreman: Ensure the foremen has a minimum of five years of bridge construction experience with two years of experience in post-tensioning related operations and a minimum of one year as the foreman in responsible charge of post-tensioning related operations.

105-8.10.7 Post-Tensioning (PT) and Filler Injection Personnel Qualifications: Perform all stressing and filler injection operations in the presence of the Engineer and with personnel meeting the qualifications of this article. Coordinate and schedule all PT and filler injection activities to facilitate inspection by the Engineer.

105-8.10.7.1 Post-Tensioning: Perform all PT field operations under the direct supervision of a Level 2 CTQP Qualified PT Technician who must be present at the site of the post-tensioning work during the entire duration of the operation. For the superstructures of bridges having concrete post-tensioned box or I girder construction, provide at least two CTQP Qualified PT Technicians, Level 1 or 2, on the work crew. The supervisor of the work crew, who must be a Level 2 CTQP Qualified PT Technician, may also be a work crew member, in which case, the supervisor shall count as one of the two CTQP qualified work crew members. For PT operations other than the superstructures of post-tensioned box or I girder construction, perform all PT operations under the direct supervision of a Level 2 CTQP Qualified PT Technician who

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must be present at the site of the PT work during the entire duration of the operation. Work crew members are not required to be CTQP qualified.

105-8.10.7.2 Grouting: Perform all grouting field operations under the direct supervision of a Level 2 CTQP Qualified Grouting Technician who must be present at the site of the grouting work during the entire duration of the operation. For the superstructures of bridges having concrete post-tensioned box or I girder construction, provide at least two CTQP Qualified Grouting Technicians, Level 1 or 2, on the work crew. The supervisor of the work crew, who must be a Level 2 CTQP Qualified Grouting Technician, may also be a work crew member, in which case, the supervisor shall count as one of two CTQP qualified work crew members. For grouting operations other than the superstructures of post-tensioned box or I girder construction, perform all grouting operations under the direct supervision of a Level 2 CTQP Qualified Grouting Technician who must be present at the site of the grouting work during the entire duration of the operation. Work crew members are not required to be CTQP qualified.

Perform all vacuum grouting operations under the direct supervision of a crew foreman who has been trained and has experience in the use of vacuum grouting equipment and procedures. Submit the crew foreman's training and experience records to the Engineer for approval prior to performing any vacuum grouting operation.

105-8.10.7.3 Flexible Filler Injection: Perform all filler injection operations under the direct supervision of a filler injection foreman who has American Segmental Bridge Institute (ASBI) certification in the flexible filler process. Provide at least two CTQP Qualified Grouting Technicians with ASBI certification in the flexible filler process, one of whom must be a Level 2 CTQP Qualified Grouting Technician. Both technicians must be present at the site of the flexible filler injection work during the entire duration of the operation.

Provide a filler injection quality control (QC) inspector who has ASBI certification in the flexible filler process. The filler injection QC inspector must be present at the site of the flexible filler injection work during the entire duration of the operation.

Verifiable experience performing injection of similar flexible filler on at least two projects is acceptable in lieu of ASBI certification in the flexible filler process.

Perform all flexible filler repair operations under the direct supervision of a crew foreman who has been trained and has verifiable experience in the use of vacuum flexible filler repair equipment and procedures. Submit the crew foreman's training and experience records to the Engineer prior to performing any flexible filler operation.

105-8.10.8 Failure to Comply with Bridge Qualification Requirements: Make an immediate effort to reestablish compliance. If an immediate effort is not put forth as determined by the Engineer, payment for the bridge construction operations requiring supervisors to be qualified under this Specification will be withheld up to 60 days. Cease all bridge construction and related activities (casting yard, etc.) if compliance is not met within 60 days, regardless of how much effort is put forth. Resume bridge construction operations only after written approval from the Engineer stating that compliance is reestablished.

105-8.11 Signal Installation Inspector: Provide an inspector trained and certified by the International Municipal Signal Association (IMSA) as a traffic signal inspector to perform all signal installation inspections. Use only Department approved signal inspection report forms during the signal inspection activities. Ensure all equipment, materials, and hardware is in compliance with Department Specifications and verify that all equipment requiring certification is listed on the Department's Approved Product List (APL). Submit the completed signal inspection report forms, certified by the IMSA traffic signal inspector to the Engineer.

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The Department's approved inspection report forms are available at the following URL: http://www.fdot.gov/traffic/.

105-8.12 Structural Steel and Miscellaneous Metals Fabrication Facility Quality Control Personnel: Ensure each fabrication facility has an onsite production manager, an onsite facility manager for QC, a plant engineer, and onsite QC inspectors/technicians to provide complete QC inspections and testing.

Ensure that the facility manager for QC and QC inspectors/technicians meet the certification requirements set forth in the latest version of AASHTO/NSBA Steel Bridge Collaboration S 4.1, Steel Bridge Fabrication QC/QA Guide Specification, including the years of experience required in Table 105-1 below. The facility manager for QC must meet the requirements of Table 105-1 for every structural steel member type produced by a plant with QC being managed by the facility manager for QC. The facility manager for QC will report directly to the plant manager or plant engineer and must not be the plant production manager nor report to or be the subordinate of the plant production manager. QC inspectors/technicians must be the employees of and must report directly to the facility manager for QC.

Table 105-1
Experience Requirements for QC Inspectors/Technicians
And Facility Manager for Quality Control

Structural Steel Member Type	Minimum Years of Experience Required	
	QC Inspector/Technician	Facility Manager for QC
Rolled beam bridges	1 year	3 years
Welded plate girders (I sections, box sections, etc.)	2 years	4 years
Complex structures, such as trusses, arches, cable stayed bridges, and moveable bridges	3 years	5 years
Fracture critical (FC) members	3 years	5 years

105-8.13 Geotechnical Foundation Services Personnel For Driven Pile Foundations:

105-8.13.1 General: Provide qualified and trained personnel to perform foundation testing, inspection of the construction activities and oversight of the foundation construction operations. Ensure the personnel provided meet the registration and qualification requirements specified herein and these requirements are maintained throughout the duration of the design and construction of the project elements where these personnel are required to work.

Submit qualification statements for the dynamic testing, load testing and non-destructive testing personnel to be used on the project for acceptance by the Engineer. The Department will review these qualification statements, provide comments, or request additional information within 10 working days, excluding weekends and Department observed holidays. Do not begin Construction until the qualifications of supervisory personnel have been accepted by the Engineer. Acceptance of the personnel does not relieve the Contractor of the responsibility for obtaining the required results in the completed work.

105-8.13.2 Dynamic Testing Engineer (DTE): Provide a Dynamic Testing Engineer in responsible charge of the performance of the dynamic load testing of driven piles, evaluation, signal matching and analysis of the dynamic load test data, recommending production pile lengths (when these are to be determined based on test pile information) and

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developing the driving criteria. The DTE must be an employee of a firm pre-qualified for Type of Work 9.4.1 in accordance with the Rules of the Department of Transportation, Chapter 14-75. Production pile lengths shall be recommended, and the driving criteria shall be developed by the same engineering firm, and under the same DTE analyzing the dynamic pile testing data. The DTE must be a Professional Engineer registered in the state of Florida with responsible charge experience of geotechnical foundation construction engineering and dynamic testing of driven piles for a period of not less than three years including at least three Department bridge projects. This "responsible charge" experience shall include verifiable experience using the test methods that will be utilized on the project. The DTE must have a rank of Intermediate or higher in the PDCA/PDI Dynamic Measurement and Analysis Proficiency Test or equivalent qualification approved by the Engineer.

105-8.13.3 Dynamic Testing Operator (DTO): Provide a Dynamic Testing Operator (DTO) to perform the dynamic load testing of instrumented piles and test piles in the field. The DTO must have a rank of Intermediate or higher in the PDCA/PDI Dynamic Measurement and Analysis Proficiency Test. When EDCs are used to monitor piles and/or test piles, EDC monitoring shall be performed by an operator who has passed EDC Monitoring Certification as evidenced by a Smart Structures valid Certification Card and ID. The DTO must have experience in geotechnical foundation construction and dynamic testing of driven piles for a period of not less than two years including at least three Department bridge projects. The experience may have been obtained while working under the supervision of another qualified operator. The DTO shall work under the supervision of the DTE.

105-8.13.4 Pile Driving Inspectors: Provide qualified pile driving inspectors, working under the supervision of the DTE, to monitor and record the construction of driven pile foundations. Pile driving inspectors must possess a valid CTQP Pile Driving Inspector qualification.

105-8.13.5 Supervisory Personnel - Pile Driving: Use pile driving superintendents or foremen in responsible charge of pile driving operations, with experience in installing driven piles of similar the type, size and depth proposed for the project and for a period of not less than two years.

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SECTION 107
LITTER REMOVAL AND MOWING

107-1 Description.

Provide pickup, removal and disposal of litter within the project limits from the outside edge of travel way to the right of way line. Include the median on divided highways, from the inside edge of travel way to the inside edge of travel way. Litter includes but is not limited to, bottles, cans, paper, tires, tire pieces, lumber, vehicle parts, metal junk, and brush debris.

Mow turf or vegetation within the project limits. Turf consists of grasses planted in accordance with Section 570. Vegetation consists of planted and natural grasses, weeds, and other natural vegetation that have been previously mowed.

107-2 Operation.

107-2.1 Frequency: Begin litter removal and mowing when directed by the Engineer and continue every 30 days, unless otherwise directed by the Engineer. Continue litter removal and mowing until final acceptance in accordance with 5-11. Mow all areas to obtain a uniform height of 6 inches.

After final acceptance, perform litter removal and mowing until new turf is established in accordance with 570-4 at no cost to the Department. Maintain turf and vegetation height between 6 inches and 12 inches. Do not include seed stalk or wildflowers when measuring height.

Perform litter removal prior to and in conjunction with mowing; however, the Engineer may direct litter pickups in addition to those performed in conjunction with mowing.

Do not mow new turf until a healthy root system is established. In designated wildflower areas, avoid cutting wildflowers when in bloom and when re-seeding.

107-2.2 General: Mow shoulders and medians concurrently so that not more than one mile will be left partially mowed at the conclusion of the working day. Mow turf and vegetation on slopes or around appurtenances concurrent with the mowing operation.

In areas saturated with standing water, mow or cut to the surface of the water using hand labor or other specialized equipment when standard equipment will cause damage.

Do not remove turf or other vegetation cuttings from the right-of-way, or rake or pick up the cuttings unless the cuttings are in the traveled ways, bike lanes, or sidewalk; are obstructing drainage structures; or are the result of cleaning the equipment.

107-2.3 Limitations: Maintain traffic in accordance with Section 102. When mowing within four feet of a travel lane, operate the equipment in the same direction of traffic, unless the adjacent lane is closed to traffic due to construction operations.

Perform all work during daylight hours.

107-2.4 Disposal of Litter and Debris: During each litter removal cycle, bag and remove all litter or piles at the end of each working day. Dispose of litter in accordance with applicable local and state laws. Do not store or stockpile litter within the project limits.

107-3 Method of Measurement.

The quantity to be paid will be the project area shown in the Contract Documents, in acres, for each litter removal or mowing cycle completed and accepted. No adjustments will be made to the project area quantity.

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107-4 Basis of Payment.

Price and payment will be full compensation for all work specified in this section.

No separate payment will be made for litter removal and mowing after final acceptance.

Payment will be made under:

Item No. 107 - 1- Litter Removal - per acre.

Item No. 107 - 2- Mowing - per acre

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SECTION 108
MONITOR EXISTING STRUCTURES

108-1 Description.

Provide settlement, vibration, and groundwater monitoring in accordance with the requirements of this Section. The work required under this Section does not modify the requirements or responsibilities for preservation of existing property from damage in accordance with 7-11.1.

Evaluate the need for, design of, and provide any necessary precautionary features to protect existing structures from damage. Employ construction methods that will not produce damaging vibrations, soil movement, soil loss, or instability of existing structures.

108-2 Construction.

108-2.1 Inspection and Settlement Monitoring:

108-2.1.1 Miscellaneous Structures: When constructing foundations for miscellaneous structures such as sign, signal, lighting, or intelligent transportation system structures, inspect and document the condition of the existing structures shown in the Plans, and survey and monitor for settlement the existing structures shown in the Plans.

108-2.1.2 Structures other than Miscellaneous: When excavating or constructing retaining walls and foundations for bridges, buildings, and structures other than miscellaneous structures, inspect and document the condition of the following existing structures, and survey and monitor for settlement the following existing structures:

1. as shown in the Plans.
2. within a distance of five shaft or auger cast pile diameters, or the estimated depth of drilled shaft or auger cast pile excavation, whichever is greater, measured from the center of these foundation elements.
3. within a distance of three times the depth of any other excavations.
4. within 200 feet of sheet pile installation and extraction operations.
5. within 100 feet of steel soldier pile installation and extraction operations.
6. for projects with pile driving operations, inspect and document the condition of all structures within a distance, in feet, of pile driving operations equal to 0.25 times the square root of the impact hammer energy, in foot-pounds. Survey and monitor for settlement all structures within a distance, in feet, of pile driving operations equal to 0.5 times the square root of the impact hammer energy, in foot-pounds.

108-2.1.3 Roadway Compaction Operations: When performing embankment and asphalt compaction, inspect and document the condition of the following existing structures, and survey and monitor for settlement the following existing structures:

1. as shown in the Plans.
2. within 75 feet of vibratory compaction (in any vibratory mode) operations.

108-2.1.4 Inspection and Documentation Requirements: Inspect and document the condition of the existing structures and all existing cracks with descriptions and pictures using a qualified Specialty Engineer. Submit two reports, signed and sealed by the Specialty Engineer, documenting the condition of the structures. Submit one report before beginning the construction operations that may affect the existing structures such as but not limited to foundation construction, excavations, vibratory compaction, dewatering and retaining wall

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construction. Submit the second report documenting the condition of the structures after the construction operations are complete. Include in the reports the Specialty Engineer's assessment of any damage present, and in the event of damage, the Specialty Engineer's assessment of whether the observed damage is the result of the construction operations. Submit both reports to the Engineer. Inspecting and documenting the condition of bridges, sign, signal, lighting, and ITS structures owned by the Department is not required except when shown in the Contract Documents.

The Department will make the necessary arrangements to provide right-of-way entry to the existing structures.

108-2.1.5 Settlement Surveying and Monitoring Requirements: Obtain the Engineer's approval for the number and location of monitoring points. Survey and monitor the settlement of structures, providing +/-0.005 foot accuracy, recording elevations to 0.001 foot:

1. before beginning construction
2. daily, during the driving of any casings, piling, or sheeting,
3. daily, during compaction
4. daily, during foundation drilling
5. weekly, for two weeks after stopping pile driving
6. during excavation
7. during blasting
8. or, as directed by the Engineer

Upon either detecting movement of 0.010 feet or damage to the structure, immediately stop the construction operations affecting the structure, backfill any open excavations, notify the Engineer and submit a corrective action plan for acceptance by the Engineer. Submit settlement monitoring records to the Engineer on a weekly basis.

108-2.2 Vibration Monitoring: When shown in the Contract Documents, employ a Specialty Engineer to provide a system which will continuously monitor and record ground vibration levels near the structures shown in the Plans during the operation of any equipment causing vibrations or during blasting operations. Provide vibration monitoring equipment capable of detecting velocities of 0.01 inches per second or less. Obtain the Engineer's approval of the number and locations of the monitoring points and install the system per the Specialty Engineer's recommendations. Submit the vibration records to the Engineer within 24 hours of performing the monitoring activity.

Upon either detecting vibration levels reaching 0.5 inches per second or damage to the structure, immediately stop the source of vibrations, backfill any open excavations, notify the Engineer and submit a corrective action plan for acceptance by the Engineer.

108-2.3 Groundwater Monitoring: When shown in the Contract Documents, install a piezometer at the right-of-way line and near any existing structure that may be affected by dewatering operations, or as directed by the Engineer. Monitor the piezometer and record the groundwater elevation level each day that dewatering activities are performed and for one week after activities have ceased, or on a schedule approved by the Engineer. Notify the Engineer of any groundwater lowering near the structure of 12 inches or more.

108-3 Method of Measurement.

The quantities to be paid for will be lump sum, completed and accepted. No separate payment will be made for the design, furnishing, construction, and removal of precautionary features, such as but not limited to sheeting, shoring, or bracing, installed for protection of existing structures.

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108-4 Basis of Payment.

Price and payment will be full compensation for all work and materials specified in this Section.

Payment will be made under:

Item No. 108- 1	Monitor Existing Structures - Inspection and Settlement Monitoring - lump sum.
Item No. 108- 2	Monitor Existing Structures - Vibration Monitoring - lump sum.
Item No. 108- 3	Monitor Existing Structures - Groundwater Monitoring - lump sum.

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SECTION 110
CLEARING AND GRUBBING

110-1 Description.

Clear and grub within the areas shown in the Plans. Remove and dispose of all trees, stumps, roots and other such protruding objects, buildings, structures, appurtenances, existing flexible asphalt pavement, and other facilities necessary to prepare the area for the proposed construction. Remove and dispose of all product and debris not required to be salvaged or not required to complete the construction.

Perform miscellaneous work necessary for the complete preparation of the overall project site as specified in 110-10.

110-2 Standard Clearing and Grubbing.

110-2.1 Work Included: Completely remove and dispose of all buildings, timber, brush, trees, stumps, roots, rubbish, debris, existing flexible pavement and base, drainage structures, culverts, and pipes. Remove all other obstructions resting on or protruding through the surface of the existing ground and the surface of excavated areas.

Perform standard clearing and grubbing within the following areas:

1. All areas where excavation is to be done, including borrow pits, lateral ditches, right-of-way ditches, etc.
2. If constructing over an existing road, remove existing asphalt pavement. If shown in the Contract Documents, remove existing pavement base.
3. All areas where roadway embankments will be constructed.
4. All areas where structures will be constructed, including pipe culverts and other pipe lines.

110-2.2 Depths of Removal of Roots, Stumps, and Other Debris: In all areas where excavation is to be performed, or roadway embankments are to be constructed, remove roots and other debris to a depth of 12 inches below the ground surface. Remove roots and other debris from all excavated material to be used in the construction of roadway embankment or roadway base. Plow the surface to a depth of at least 6 inches, and remove all roots thereby exposed to a depth of at least 12 inches. Completely remove and dispose of all stumps within the roadway right-of-way.

Remove all roots, etc., protruding through or appearing on the surface of the completed excavation within the roadway area and for structures, to a depth of at least 12 inches below the finished excavation surface.

Remove or cut off all stumps, roots, etc., below the surface of the completed excavation in borrow pits, material pits, and lateral ditches.

In borrow and material pits, do not perform any clearing or grubbing within 3 feet inside the right-of-way line.

Within all other areas where standard clearing and grubbing is to be performed, remove roots and other debris projecting through or appearing on the surface of the original ground to a depth of 12 inches below the surface, but do not plow or harrow these areas.

110-2.3 Boulders: Remove any boulders encountered in the roadway excavation (other than as permitted under the provisions of 120-7.2) or found on the surface of the ground. When approved by the Engineer place boulders in neat piles inside the right of way. The Contractor

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may stockpile boulders encountered in Department-furnished borrow areas, which are not suitable for use in the embankment construction, within the borrow area.

110-2.4 Asbestos Containing Materials (ACM) Not Identified Prior to the Work: When encountering or exposing any condition indicating the presence of asbestos, cease operations immediately in the vicinity and notify the Engineer, in accordance with 110-6.5.

110-3 Selective Clearing and Grubbing.

110-3.1 General: Remove and dispose of vegetation, obstructions, etc., as shown in the Plans. Provide acceptable fill material, and grade and compact holes or voids created by the removal of the stumps. Perform all selective clearing and grubbing in accordance with ANSI A300.

No staging, storing, stockpiling, parking or dumping will be allowed in selective clearing and grubbing areas. Only mechanical equipment related to selective clearing and grubbing activities will be allowed in selective clearing and grubbing areas. Protect trees to remain from trunk, branch and root damage.

110-3.2 Protection of Plant Preservation Areas: Areas to remain natural may be designated in the Plans. No clearing and grubbing, staging, storage, stockpiling, parking or dumping is allowed in these areas. Do not bring equipment into these areas.

110-3.3 Tree Protection Barrier: Construct a tree protection barrier in accordance with Standard Plans Index 110-100 and the Plans. Maintain barrier for duration of the Contract.

110-3.4 Tree Root and Branch Pruning: When pruning cuts or root pruning to existing trees are shown in the Plans, work is to be supervised on site by an International Society of Arboriculture (ISA) Certified Arborist and performed in accordance with ANSI A300.

110-3.5 Tree Removal: Remove trees as shown in the Plans.

110-4 Protection of Property Remaining in Place.

Protect property to remain in place in accordance with 7-11.

110-5 Removal of Buildings.

110-5.1 Parts to be Removed: Completely remove all parts of the buildings, including utilities, plumbing, foundations, floors, basements, steps, connecting concrete sidewalks or other pavement, septic tanks, and any other appurtenances, by any practical manner which is not detrimental to other property and improvements.

Remove utilities to the point of connection to the utility authority's cut-in. After removing the sewer connections to the point of cut-in, construct a concrete plug at the cut-in point, as directed by the Engineer, except where the utility owners may elect to perform their own plugging. Contact the appropriate utility companies prior to removal of any part of the building to ensure disconnection of services.

Submit demolition schedule 15 working days before beginning any demolition or renovation of a building.

110-5.2 Removal by Others: Where buildings within the area to be cleared and grubbed are so specified to be removed by others, remove and dispose of any foundations, curtain walls, concrete floors, basements or other foundation parts which might be left in place after such removal of buildings by others.

110-6 Removal of Existing Bridges.

110-6.1 General: The work under this Article includes bridges, as defined in 1-3.

Remove and dispose of the materials from existing bridges. Remove

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1. those bridges and approach slabs, or portions of bridges, shown in the Plans to be removed,

2. those bridges and approach slabs, or portions of bridges, found within the limits of the area to be cleared and grubbed, and directed by the Engineer to be removed,

3. those bridges and approach slabs, or portion of bridges, which are necessary to be removed in order to complete the work, and

4. other appurtenances or obstructions which may be designated in the Contract Documents to be included as an item of payment for the work under this Article.

Submit schedule information and demolition plan for approval 15 working days before beginning any demolition or renovation of any structures.

110-6.2 Method of Removal:

110-6.2.1 General: Remove the structures in such a way so as to leave no obstructions to any proposed new bridge or to any waterways. Pull, cut off, or break off pilings to the requirements of the permit or other Contract Documents, or if not specified, not less than 2 feet below the finished graded surface. In the event that the Plans indicate channel excavation to be done by others, consider the finished graded surface as the limits of such excavation. For materials which are to remain the property of the Department or are to be salvaged for use in temporary bridges, avoid damage to such materials, and entirely remove all bolts, nails, etc. from timbers to be so salvaged. Mark structural steel members for identification as directed.

110-6.2.2 Removal of Steel Members with Hazardous Coatings: Submit to the Engineer for approval the "Contractor's Lead in Construction Compliance Program", QP2 certification from the Society for Protective Coatings (SSPC) from the firm actually removing and disposing of these steel members before any members are disturbed.

Vacuum power tool clean any coated steel member to bare metal as defined by SSPC-SP11 a minimum of 4 inches either side of any area to be heated (e.g. torch cutting, sawing, grinding, etc.) in accordance with 29 CFR 1926.354. Abrasive blasting is prohibited.

110-6.3 Partial Removal of Bridges: On concrete bridges to be partially removed and widened, remove concrete by manually or mechanically operated pavement breakers, by concrete saws, by chipping hammers, or by hydro-demolition methods. Do not use explosives. Where concrete is to be removed to neat lines, use concrete saws or hydro-demolition methods capable of providing a reasonably uniform cleavage face. If the equipment used will not provide a uniform cut without surface spalling, first score the outlines of the work with small trenches or grooves. For all demolition methods, submit for review and approval of the Engineer, a demolition plan that describes the method of removal, equipment to be used, types of rebar splices or couplers, and method of straightening or cutting rebar. In addition, for hydro-demolition, describe the method for control of water or slurry runoff and measures for safe containment of concrete fragments that are thrown out by the hydro-demolition machine.

110-6.4 Authority of U.S. Coast Guard: For bridges in navigable waters, when constructing the project under authority of a U.S. Coast Guard permit, the U.S. Coast Guard may inspect and approve the work to remove any existing bridges involved therein, prior to acceptance by the Department.

110-6.5 Asbestos Containing Materials (ACM) Not Identified Prior to the Work: When encountering or exposing any condition indicating the presence of asbestos, cease operations immediately in the vicinity and notify the Engineer.

Make every effort to minimize the disturbance of the ACM. Immediately provide provisions for the health and safety of all jobsite personnel and the public that may be exposed to

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any ACM. Provisions shall meet all applicable Federal, State, and Local Rules and Regulations regarding potentially hazardous conditions due to ACM.

The Engineer will notify the District Contamination Impact Coordinator (DCIC) who will engage the services of the Department's Contamination Assessment/Remediation Contractor (CAR). Provide access to the potential contamination area. Preliminary investigation by the CAR Contractor will determine the course of action necessary for site security and the steps necessary to resolve the contamination issue.

The CAR Contractor will perform an asbestos survey to delineate the asbestos areas, and identify any staging or holding areas that will be needed for assessment or abatement of the asbestos material.

The CAR Contractor will maintain jurisdiction over activities within areas contaminated with ACM including staging and holding areas. The CAR Contractor will be responsible for the health and safety of workers within these delineated areas. Provide continuous access to these areas for the CAR Contractor and representatives of regulatory or enforcement agencies having jurisdiction.

Coordinate with the CAR Contractor and Engineer to develop a work plan with projected completion dates for the final resolution of the contamination, in coordination with any regulatory agencies as appropriate. Use the work plan and schedule as a basis for planning the completion of all work efforts. The Engineer may grant Contract Time extensions according to the provisions of 8-7.3.2.

Cooperate with the CAR Contractor to expedite integration of the CAR Contractor's operations into the construction project. Adjustments to quantities or to Contract unit prices will be made according to work additions or reductions on the part of the Prime Contractor in accordance with 4-3.

The Engineer will inform the Prime Contractor when operations may resume in the affected area.

110-7 Removal of Existing Concrete.

Remove and dispose of existing Portland cement concrete pavement, sidewalk, slope pavement, ditch pavement, curb, and curb and gutter, etc., where shown in the Plans.

Remove all gravity walls, noise/sound walls, retaining walls, MSE walls, perimeter walls, and roadway concrete barriers, where shown in the Plans. All ancillary elements of these concrete features being removed including, but not limited to, base, leveling pads, copings, reinforcing steel or straps, footings, edgedrains, etc, are incidental and included in the cost of the removal.

110-8 Ownership of Materials.

Except as may be otherwise specified in the Contract Documents, take ownership of all buildings, structures, appurtenances, and other materials removed and dispose of them in accordance with 110-9.

110-9 Disposal of Materials.

110-9.1 General: Either stack materials designated to remain the property of the Department in neat piles within the right-of-way, load onto the Department's vehicles, or deliver to location designated in the Plans.

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Dispose of timber, stumps, brush, roots, rubbish, and other material resulting from clearing and grubbing in areas and by methods meeting the applicable requirements of all Federal, State and Local Rules and Regulations. Do not block waterways by the disposal of debris.

With the approval of the Engineer, wood chips may be evenly distributed to a depth of no more than one inch in designated areas in the Department's right-of-way.

110-9.2 Burning Debris: Where burning of such materials is permitted, perform all such burning in accordance with the applicable Federal, State and Local rules and regulations. Perform all burning at locations where trees and shrubs adjacent to the cleared area will not be harmed.

110-9.3 Timber and Crops: The Contractor may sell any merchantable timber, fruit trees, and crops that are cleared under the operations of clearing and grubbing for his own benefit, subject to the provisions of 7-1.2, which may require that the timber, fruit trees, or crops be burned at or near the site of their removal, as directed by the Engineer. The Contractor is liable for any claims which may arise pursuant to the provisions of this Subarticle.

110-9.4 Disposal of Treated Wood: Treated wood must be handled and disposed of properly during removal. Treated wood should not be cut or otherwise mechanically altered in a manner that would generate dust or particles without proper respiratory and dermal protection. The treated wood must be disposed of in at least a lined solid waste facility or through recycling/reuse. Treated wood shall not be disposed by burning or placement in a construction and demolition (C&D) debris landfill.

110-9.5 Hazardous Materials/Waste: Handle, transport, and dispose of hazardous materials/waste in accordance with all Federal, State, and Local Rules and Regulations including, but not limited to, the following:

1. SSPC Guide 7
2. Federal Water Pollution Control Act, and
3. Resource Conservation and Recover Act (RCRA).

Accept responsibility for the collection, sampling, classification, packaging, labeling, accumulation time, storage, manifesting, transportation, treatment and disposal of hazardous materials/waste, both solid and liquid. Separate all solid and liquid waste and collect all liquids used at hygiene stations and handle as hazardous materials/waste. Obtain written approval from the Engineer for all hazardous materials/waste stabilization methods before implementation.

Obtain an EPA/FDEP Hazardous Waste Identification Number (EPA/FDEP ID Number) before transporting and/or disposal of any hazardous materials/waste.

List the Department as the generator for hazardous materials/waste resulting from removal or demolition of Department materials.

Submit the following for the Engineers' approval before transporting, treatment or disposal of any hazardous materials/waste:

1. Name, address and qualifications of the transporter,
2. Name, address and qualifications of the treatment facility,
3. Proposed treatment and/or disposal of all Hazardous Materials/Waste.
4. EPA/FDEP Hazardous Waste Identification Number Application Form.
5. Manifest forms.

Transport all hazardous materials/waste in accordance with applicable Federal, State, and Local Rules and Regulations including, but not limited to, the 40 CFR 263 Standards.

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Submit all final Hazardous Materials/Waste manifest/bills of lading and certificates of disposal to the Engineer within 21 days of each shipment.

110-9.5.1 Steel Members with Hazardous Coating: Dispose of steel members with hazardous coating in one of the following manners:

1. Deliver the steel members and other hazardous waste to a licensed recycling or treatment facility capable of processing steel members with hazardous coating.

2. Deliver the steel members with hazardous coating to a site designated by the Engineer for use as an offshore artificial reef. Deliver any other hazardous materials/waste to a licensed hazardous materials/waste recycling treatment facility.

Dismantle and/or cut steel members to meet the required dimensions of the recycling facility, treatment facility or offshore artificial reef agency.

All compensation for the cost of removal and disposal of hazardous materials/waste will be included in the Cost of Removal of Existing Structures.

110-9.5.2 Certification of Compliance: Submit certification of Compliance from the firm actually removing and disposing of the hazardous materials/waste stipulating, the hazardous materials/waste has been handled, transported and disposed of in accordance with this Specification. The Certification of Compliance shall be attested to by a person having legal authority to bind the company.

Maintain all records required by this Specification and ensure these records are available to the Department upon request.

110-10 Miscellaneous Operations.

110-10.1 Water Wells Required to be Plugged: Fill or plug all water wells within the right-of-way, including areas of borrow pits and lateral ditches, that are not to remain in service, in accordance with applicable Federal, State, and Local Rules and Regulations.

Cut off the casing of cased wells at least 12 inches below the existing surface or 12 inches below the elevation of the finished graded surface, whichever is lower. Water wells, as referred to herein, are defined either as artesian or non-artesian, as follows:

1. An artesian well is an artificial hole in the ground from which water supplies may be obtained and which penetrates any water-bearing rock, the water in which is raised to the surface by natural flow or which rises to an elevation above the top of the water-bearing bed. Artesian wells are further defined to include all holes drilled as a source of water that penetrate any water-bearing beds that are a part of the artesian water system of Florida, as determined by representatives of the applicable Water Management District.

2. A non-artesian (water-table) well is a well in which the source of water is an unconfined aquifer. The water in a non-artesian well does not rise above the source bed.

110-10.2 Leveling Terrain: Within the areas between the limits of construction and the outer limits of clearing and grubbing, fill all holes and other depressions, and cut down all mounds and ridges. Make the area of a sufficient uniform contour so that the Department's subsequent mowing and cutting operations are not hindered by irregularity of terrain. Perform this work regardless of whether the irregularities were the result of construction operations or existed originally.

110-10.3 Mailboxes: When the Contract Documents require furnishing and installing mailboxes, permit each owner to remove the existing mailbox. Work with the Local Postmaster to develop a method of temporary mail service for the period between removal and installation of the new mailboxes. Install the mailboxes in accordance with the Standard Plans.

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110-11 Method of Measurement.

110-11.1 Clearing and Grubbing: The quantity to be paid for will be the lump sum quantity.

110-11.2 Selective Clearing and Grubbing: The quantity to be paid will be the plan quantity area in acres designated for Selective Clearing and Grubbing. The quantity to be paid for Tree Protection Barrier will be the linear foot measurement as shown in the Plans. Tree Root, Branch Pruning, and Tree Removal will be paid per each tree. Tree Removal per each will not be used where Clearing and Grubbing or Selective Clearing and Grubbing per acre is used.

110-11.3 Removal of Existing Bridges: The quantity to be paid for will be the lump sum quantity or quantities for the specific structures, or portions of structures to be removed.

110-11.4 Removal of Existing Concrete:

The quantity to be paid for will be the number of square yards of existing concrete elements, acceptably removed and disposed of, as specified. The quantity will be determined by actual measurement along the surface of the element before its removal. Measurements for appurtenances which have irregular surface configurations, such as curb and gutter, steps, and ditch pavement, will be the area as projected to an approximate horizontal plane. Where the removal of pavement areas is necessary only for the construction of box culverts, pipe culverts, storm sewers, inlets, manholes, etc., these areas will not be included in the measurements.

Area measurements for walls will be based on exposed vertical face measurements times the horizontal length of the wall.

110-11.5 Plugging Water Wells: The quantity to be paid for will be the number of water wells plugged, for each type of well (artesian or non-artesian).

110-11.6 Mailboxes: The quantity to be paid for will be the number of mailboxes acceptably furnished and installed.

110-11.7 Delivery of Salvageable Material to the Department The quantity to be paid for will be the Lump Sum quantity for delivery of salvageable materials to the Department, as indicated in the Plans.

110-11.8 General: In each case, except as provided below, where no item of separate payment for such work is included in the proposal, all costs of such work will be included in the various scheduled items in the Contract, or under specific items as specified herein below or elsewhere in the Contract.

110-12 Basis of Payment.

110-12.1 Clearing and Grubbing:

110-12.1.1 Lump Sum Payment: Price and payment will be full compensation for all clearing and grubbing required for the roadway right-of-way and for lateral ditches, channel changes, or other outfall areas, and any other clearing and grubbing indicated, or required for the construction of the entire project, including all necessary hauling, furnishing equipment, equipment operation, furnishing any areas required for disposal of debris, leveling of terrain and the landscaping work of trimming, etc.

Where construction easements are specified in the Plans and the limits of clearing and grubbing for such easements are dependent upon the final construction requirements, no adjustment will be made in the lump sum price and payment, either over or under, for variations from the limits of the easement defined in the Plans.

110-12.1.2 When No Direct Payment is Provided: When no item for clearing and grubbing is included in the proposal, the Contractor shall include the cost of any work of clearing and grubbing which is necessary for the proper construction of the project in the

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Contract price for the structure or other item of work for which such clearing and grubbing is required. The Contractor shall include the cost of all clearing and grubbing which might be necessary in pits or areas from which base material is obtained in the Contract price for the base in which such material is used. The clearing and grubbing of areas for obtaining stabilizing materials, where required only for the purpose of obtaining materials for stabilizing, will not be paid for separately.

110-12.2 Selective Clearing and Grubbing: Price and payment will be full compensation for all selective clearing and grubbing, including all necessary hauling, furnishing equipment, Certified Arborist, equipment operation, furnishing any areas required for disposal of debris, leveling of terrain, root pruning and tree protection.

110-12.3 Removal of Existing Bridges: Price and payment will be full compensation for all work of removal and disposal of the designated bridges.

When direct payment for the removal of existing bridges is not provided in the proposal, the Contractor shall include the cost of removing all bridges in the Contract price for clearing and grubbing or, if no item of clearing and grubbing is included, in the compensation for the other items covering the new bridge being constructed.

110-12.4 Removal of Existing Concrete: Price and payment will be full compensation for performing and completing all the work of removal and satisfactory disposal.

When no separate item for this work is included, the Contractor shall include the costs of this work in the Contract price for the item of clearing and grubbing or for the pipe or other structure for which the concrete removal is required.

110-12.5 Plugging Water Wells: Price and payment will be full compensation for each type of well acceptably plugged.

If a water well requiring plugging is encountered and the Contract contains no price for plugging wells of that specific type, the plugging of such well will be paid for as unforeseeable work.

110-12.6 Mailboxes: Price and payment will be full compensation for all work and materials required, including supports and numbers.

110-12.7 Delivery of Salvageable Material to the Department: Price and payment will be full compensation for all work required for delivery of the materials to the Department.

110-12.8 Payment Items: Payment will be made under:

Item No. 110- 1-	Clearing and Grubbing - lump sum.
Item No. 110- 2-	Selective Clearing and Grubbing Area - acre.
Item No. 110- 3-	Removal of Existing Bridges - lump sum.
Item No. 110- 4-	Removal of Existing Concrete - per square yard.
Item No. 110- 5-	Plugging Water Wells (Artesian) - each.
Item No. 110- 6-	Plugging Water Wells (Non-Artesian) - each.
Item No. 110- 7-	Mailbox (Furnish and Install) - each.
Item No. 110- 21	Tree Protection Barrier - per linear foot.
Item No. 110- 22	Tree Root and Branch Pruning - per each tree.
Item No. 110- 23	Tree Removal - per each tree.
Item No. 110- 86-	Delivery of Salvageable Material to FDOT - lump sum.

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SECTION 120
EXCAVATION AND EMBANKMENT

120-1 Description.

120-1.1 General: Excavate and construct embankments as required for the roadway, ditches, channel changes and borrow material. Use suitable excavated material or authorized borrow to prepare subgrades and foundations. Construct embankments in accordance with Standard Plans, Index 120-001. Compact and dress excavated areas and embankments.

Meet the requirements of Section 110 for excavation of material for clearing and grubbing and Section 125 for excavation and backfilling of structures and pipe. Material displaced by the storm sewer or drainage structure system is not included in the earthwork quantities shown in the Contract Documents.

The existing surface may be a combination of the following:

1. The original unpaved ground line;
2. The bottom of the existing pavement;
3. The bottom of existing features removed by clearing and grubbing;
4. The bottom of the existing base, if the base is to be removed.

The finished graded surface includes the completed grades of side slopes, unpaved shoulders, and the bottom of the base for flexible or rigid pavement.

120-1.2 Unidentified Areas of Contamination: When encountering or exposing any abnormal condition indicating the presence of contaminated materials, cease operations immediately in the vicinity and notify the Engineer. The presence of tanks or barrels; discolored earth, metal, wood, ground water, etc.; visible fumes; abnormal odors; excessively hot earth; smoke; or other conditions that appear abnormal may indicate the presence of contaminated materials and must be treated with extreme caution.

Make every effort to minimize the spread of contamination into uncontaminated areas. Immediately provide for the health and safety of all workers at the job site and make provisions necessary for the health and safety of the public that may be exposed to any potentially hazardous conditions. Ensure provisions adhere to all applicable laws, rules or regulations covering potentially hazardous conditions and will be in a manner commensurate with the gravity of the conditions.

The Engineer will notify the District Contamination Impact Coordinator (DCIC) who will coordinate selecting and tasking the Department's Contamination Assessment/Remediation Contractor (CAR). Provide access to the potentially contaminated area. Preliminary investigation by the CAR Contractor will determine the course of action necessary for site security and the steps necessary under applicable laws, rules, and regulations for additional assessment and/or remediation work to resolve the contamination issue.

The CAR Contractor will delineate the contamination areas, any staging or holding area required; and, in cooperation with the Prime Contractor and Engineer, develop a work plan that will provide the CAR Contractor's operations schedule with projected completion dates for the final resolution of the contamination issue.

The CAR Contractor will maintain jurisdiction over activities inside any outlined contaminated areas and any associated staging holding areas. The CAR Contractor will be responsible for the health and safety of workers within the delineated areas. Provide continuous

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access to these areas for the CAR Contractor and representatives of regulatory or enforcement agencies having jurisdiction.

Both Contractors will use the schedule as a basis for planning the completion of both work efforts. The Engineer may grant the Contract Time extensions according to the provisions of 8-7.3.2.

Cooperate with the CAR Contractor to expedite integration of the CAR Contractor's operations into the construction project. The Prime Contractor is not expected to engage in routine construction activities, such as excavating, grading, or any type of soil manipulation, or any construction processes required if handling of contaminated soil, surface water or ground water is involved. All routine construction activities requiring the handling of contaminated soil, surface water or groundwater will be by the CAR Contractor. Adjustments to quantities or to Contract unit prices will be made according to work additions or reductions on the part of the Prime Contractor in accordance with 4-3.

The Engineer will direct the Prime Contractor when operations may resume in the affected area.

120-2 Classifications of Excavation.

120-2.1 General: The Department may classify excavation specified under this Section for payment as any of the following: regular excavation, subsoil excavation, lateral ditch excavation, and channel excavation.

If the proposal does not show subsoil excavation or lateral ditch excavation as separate items of payment, include such excavation under the item of regular excavation.

If the proposal shows lateral ditch excavation as a separate item of payment, but does not show channel excavation as a separate item of payment, include such excavation under the item of lateral ditch excavation. Otherwise, include channel excavation under the item of regular excavation.

120-2.2 Regular Excavation: Regular excavation includes roadway excavation and borrow excavation, as defined below for each.

120-2.2.1 Roadway Excavation: Roadway excavation consists of the excavation and the utilization or disposal of all materials necessary for the construction of the roadway, ditches, channel changes, etc., except for removal of existing pavement as defined in Section 110.

120-2.2.2 Borrow Excavation: Borrow excavation consists of the excavation and utilization of material from authorized borrow pits, including only material that is suitable for the construction of roadway embankments or of other embankments covered by the Contract.

A Cost Savings Initiative Proposal (CSIP) submittal based on using borrow material from within the project limits will not be considered.

120-2.3 Subsoil Excavation: Subsoil excavation consists of the excavation and disposal of muck, clay, rock, or any other material that is unsuitable in its original position and that is excavated below the existing surface. For pond and ditches that identify the placement of a blanket material, the existing surface is template as the bottom of the blanket material. Subsoil excavation also consists of the excavation of all suitable material within the above limits as necessary to excavate the unsuitable material. Consider the limits of subsoil excavation indicated in the Plans as being particularly variable, in accordance with the field conditions actually encountered.

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The quantity of material required to replace the excavated material and to raise the elevation of the roadway to the bottom of the template will be paid for under embankment or borrow excavation (Truck Measure).

120-2.4 Lateral Ditch Excavation: Lateral ditch excavation consists of all excavation of inlet and outlet ditches to structures and roadway, changes in channels of streams, and ditches parallel to the roadway right-of-way. Dress lateral ditches to the grade and finished graded surface shown in the Plans.

120-2.5 Channel Excavation: Channel excavation consists of the excavation and satisfactory disposal of all materials from within the limits of the channel as shown in the Plans.

120-3 Preliminary Soils Investigations.

When the Plans contain the results of a soil survey, do not assume such data is a guarantee of the depth, extent, or character of material present.

120-4 Removal of Unsuitable Materials and Existing Roads.

120-4.1 Subsoil Excavation: Where muck, rock, clay, or other material within the limits of the roadway is unsuitable in its original position, excavate such material to the depths shown in the Plans as the removal limits or as indicated by the Engineer, and backfill with suitable material. Where the removal of plastic soils is required, meet a construction tolerance, of plus or minus 0.2 foot in depth and plus or minus 6 inches (each side) in width.

120-4.2 Construction over Existing Old Road: Where a new roadway is to be constructed over an old one, completely remove the existing flexible and Portland cement concrete pavement for the entire limits of the width and depth in accordance with Section 110. Compact disturbed material in accordance with Section 120 or 160, whichever material applies. If indicated in the Plans, remove the existing base in accordance with Section 110.

120-5 Disposal of Surplus and Unsuitable Material.

120-5.1 Ownership of Excavated Materials: Dispose of surplus and excavated materials as shown in the Plans or, if the Plans do not indicate the method of disposal, take ownership of the materials and dispose of them outside the right-of-way.

120-5.2 Disposal of Muck on Side Slopes: As an exception to the provisions of 120-5.1, when approved by the Engineer, in rural undeveloped areas, the Contractor may place muck (A-8 material) on the slopes, or store it alongside the roadway, provided there is a clear distance of at least 6 feet between the roadway grading limits and the muck, and the Contractor dresses the muck to present a neat appearance. In addition, the Contractor may also dispose of this material by placing it on the slopes in developed areas where, in the opinion of the Engineer, this will result in an aesthetically pleasing appearance and will have no detrimental effect on the adjacent developments. Where the Engineer permits the disposal of muck or other unsuitable material inside the right-of-way limits, do not place such material in a manner which will impede the inflow or outfall of any channel or side ditches. The Engineer will determine the limits adjacent to channels within which such materials may be disposed.

120-5.3 Disposal of Paving Materials: Unless otherwise noted, take ownership of paving materials, such as paving brick, asphalt block, concrete slab, sidewalk, curb and gutter, etc., excavated in the removal of existing pavements, and dispose of them outside the right-of-way. If the materials are to remain the property of the Department, place them in neat piles as directed. Existing base materials that are removed may be incorporated in the stabilized portion

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of the subgrade in accordance with Section 160. If the construction sequence allows, incorporate all existing base material into the project as allowed by the Contract Documents.

120-5.4 Disposal Areas: Where the Contract Documents require disposal of excavated materials outside the right-of-way, and the disposal area is not indicated in the Contract Documents, furnish the disposal area without additional compensation.

Provide areas for disposal of removed paving materials out of sight of the project and at least 300 feet from the nearest roadway right-of-way line of any State maintained road. If the materials are buried, disregard the 300-foot limitation.

120-6 Borrow.

120-6.1 Materials for Borrow: Do not open borrow pits until the Engineer has approved their location.

Prior to the purchase or use of any borrow pit materials, provide the Engineer with a written certification of borrow pit compliance meeting the requirements of Section 337.0262, Florida Statutes.

Do not provide borrow materials that are polluted as defined in Chapter 376 of the Florida Statutes (oil of any kind and in any form, gasoline, pesticides, ammonia, chlorine, and derivatives thereof, excluding liquefied petroleum gas) in concentrations above any local, State, or Federal standards.

Prior to placing any borrow material that is the product of soil incineration, provide the Engineer with a copy of the Certificate of Materials Recycling and Post Burn Analysis showing that the material is below all allowable pollutant concentrations.

120-6.2 Furnishing of Borrow Areas: To obtain the Engineer's approval to use an off-site construction activity area that involves excavation such as a borrow pit or local aggregate pit, request in writing, a review for -cultural resources involvement. Send the request to the Division of Historical Resources (DHR), Department of State, State Historic Preservation Officer, Tallahassee, FL. As a minimum, include in the request the Project Identification Number, the County, a description of the property with Township, Range, Section, etc., the dimensions of the area to be affected, and a location map. Do not start any work at the off-site construction activity area prior to receiving clearance from the DHR that no additional research is warranted.

For certain locations, the DHR will require a Cultural Resources Assessment (CRA) Survey before approval can be granted. When this is required, secure professional archaeological services to complete an historical and archaeological survey report. Submit the report to the DHR and to the Department. The Engineer will determine final approval or rejection of off-site construction activity areas based on input from the DHR.

Before receiving approval or before use of borrow areas, obtain written clearance from the Engineer concerning compliance with the Federal Endangered Species Act and other Wildlife Regulations as specified in 7-1.4 and Section 4(f) of the USDOT Act as specified in 7-1.8.

The Department will adjust Contract Time in accordance with 8-7 for any suspension of operations required to comply with this Article. The Department will not accept any monetary claims due to delays or loss of off-site construction activity areas.

Except where the Plans specifically call for the use of a particular borrow or dredging area, the Contractor may substitute borrow or dredging areas of his own choosing provided the Engineer determines the materials from such areas meet the Department's standards and other requirements for stability for use in the particular sections of the work in which it is to be placed, and the Contractor absorbs any increase in hauling or other costs. Stake the corners of

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the proposed borrow area and provide the necessary equipment along with an operator in order for the Engineer to investigate the borrow area. The Engineer will determine test locations, collect samples, and perform tests to investigate the proposed borrow area based on soil strata and required soil properties. The Engineer will approve use of materials from the proposed area based on test results and project requirements. Final acceptance of materials will be based on Point of Use Test as described in 6-1.2.4.

Before using any borrow material from any substitute areas, obtain the Engineer's approval, in writing, for the use of the particular areas, and, where applicable, ensure that the Engineer has surveyed the surface. Upon such written approval by the Engineer, consider the substitute areas as designated borrow areas.

When furnishing the dredging or borrow areas, supply the Department with evidence that the necessary permits, rights, or waivers for the use of such areas have been secured.

Do not excavate any part of a Contractor furnished borrow area which is less than 300 feet from the right-of-way of the project or any State Road until the Engineer has approved a plan for landscaping and restoring the disturbed area. Perform this landscaping and land restoration at no expense to the Department, prior to final acceptance of the project. Do not provide a borrow area closer than 25 feet to the right-of-way of any state road. In Department furnished borrow pits, do not excavate material within 5 feet of adjacent property lines.

Upon completion of excavation, neatly shape, dress, grass, vegetate, landscape, and drain all exposed areas including haul roads, as necessary so as not to present an objectionable appearance.

Meet the requirements of Section 104 when furnishing borrow areas, regardless of location.

120-6.3 Borrow Material for Shoulder Build-up: When indicated in the Plans, furnish borrow material with a specific minimum bearing value, for building up of existing shoulders. Blend materials as necessary to achieve this specified minimum bearing value prior to placing the materials on the shoulders. Take samples of this borrow material at the pit or blended stockpile. Include all costs of providing a material with the required bearing value in the Contract unit price for borrow material.

120-6.4 Haul Routes for Borrow Pits: Provide and maintain, at no expense to the Department, all necessary roads for hauling the borrow material. Where borrow area haul roads or trails are used by others, do not cause such roads or trails to deteriorate in condition.

Arrange for the use of all non-public haul routes crossing the property of any railroad. Incur any expense for the use of such haul routes. Establish haul routes which will direct construction vehicles away from developed areas when feasible, and keep noise from hauling operations to a minimum. Advise the Engineer in writing of all proposed haul routes.

120-6.5 Authorization for Use of Borrow: When the item of borrow excavation is included in the Contract, use borrow only when sufficient quantities of suitable material are not available from roadway and drainage excavation, to properly construct the embankment, subgrade, and shoulders, and to complete the backfilling of structures. Do not use borrow material until so ordered by the Engineer, and then only use material from approved borrow pits.

120-7 Materials for Embankment.

120-7.1 Use of Materials Excavated from the Roadway and Appurtenances: Assume responsibility for determining the suitability of excavated material for use on the project in

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accordance with the applicable Contract Documents. Consider the sequence of work and maintenance of traffic phasing in the determination of the availability of this material.

120-7.2 General Requirements for Embankment Materials: Construct embankments of acceptable material including reclaimed asphalt pavement (RAP), recycled concrete aggregate (RCA) and Portland cement concrete rubble, but containing no muck, stumps, roots, brush, vegetable matter, rubbish, reinforcement bar or other material that does not compact into a suitable and enduring roadbed. Do not use RAP or RCA in the top 3 feet of slopes and shoulders that are to be grassed or have other type of vegetation established. Do not use RAP or RCA in stormwater management facility fill slopes or permitted wetland impact areas.

Remove all waste material designated as undesirable. Use material in embankment construction in accordance with Plans or as the Engineer directs.

Complete the embankment using maximum particle sizes (in any dimension) as follows:

1. In top 12 inches: 3-1/2 inches (in any dimension).
2. 12 to 24 inches: 6 inches (in any dimension).
3. In the depth below 24 inches: not to exceed 12 inches (in any dimension) or the compacted thickness of the layer being placed, whichever is less.

Spread all material so that the larger particles are separated from each other to minimize voids between them during compaction. Compact around these rocks in accordance with 120-9.2.

When and where approved by the Engineer, the Contractor may place larger rocks (not to exceed 18 inches in any dimension) outside the 1:2 slope and at least 4 feet or more below the bottom of the base. Compact around these rocks to a firmness equal to that of the supporting soil. Construct grassed embankment areas in accordance with 120-9.2.5. Where constructing embankments adjacent to bridge end bents or abutments, do not place rock larger than 3-1/2 inches in diameter within 3 feet of the location of any end-bent piling.

120-7.3 Materials Used at Pipes, Culverts, etc.: Construct embankments over and around pipes, culverts, and bridge foundations with selected materials.

120-8 Embankment Construction.

120-8.1 General: Construct embankments in sections of not less than 300 feet in length or for the full length of the embankment. Do not construct another LOT over an untested LOT without the Engineer's approval in writing.

For construction of mainline pavement lanes, turn lanes, ramps, parking lots, concrete box culverts and retaining wall systems, a LOT is defined as a single lift of finished embankment not to exceed 500 feet.

For construction of shoulder-only areas, shared use paths, and sidewalks areas, a LOT is defined as a single lift of finished embankment not to exceed 2000 feet.

Isolated compaction operations will be considered as separate LOTs. For multiple phase construction, a LOT shall not extend beyond the limits of the phase.

120-8.2 Dry Fill Method:

120-8.2.1 General: Construct embankments to meet the compaction requirements in 120-9 and in accordance with the acceptance program requirements in 120-10.

As far as practicable, distribute traffic over the work during the construction of embankments so as to cover the maximum area of the surface of each layer.

Construct embankment using the dry fill method whenever normal dewatering equipment and methods can accomplish the needed dewatering.

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120-8.2.1.1 Maximum Compacted Lift Thickness Requirements:
Construct the embankment in successive layers with lifts up to a maximum listed in Table 120-1 below based on the embankment material classification group.

Table 120-1			
Group	AASHTO Soil Class	Maximum Lift Thickness	Thick Lift Control Test Section Requirements
1	A-3	12 inches	Not Needed
	A-2-4 (No. 200 Sieve ≤ 15%)		
2	A-1	6 inches without Control Test Section	Maximum of 12 inches per 120-8.2.1.2
	A-2-4 (No. 200 Sieve > 15%)		
	A-2-5, A-2-6, A-2-7, A-4, A-5, A-6		
	A-7 (Liquid Limit < 50)		

120-8.2.1.2 Thick Lift Requirements: For embankment materials classified as Group 2 in Table 120-1 above, the option to perform thick lift construction in successive layers of not more than 12 inches compacted thickness may be used after meeting the following requirements:

1. Notify the Engineer and obtain approval in writing prior to beginning construction of a test section. Demonstrate the possession and control of compacting equipment sufficient to achieve density required by 120-10.2 for the full depth of a thicker lift.
2. Construct a test section of the length of one full LOT of not less than 500 feet.
3. Perform five Quality Control (QC) tests at random locations within the test section.
   a. All five QC tests and a Department Verification test must meet the density required by 120-10.2.
   b. Identify the test section with the compaction effort and soil classification in the Department's Earthwork Records System (ERS).
4. Obtain Engineer's approval in writing for the compaction effort after completing a successful test section.

In case of a change in compaction effort or soil classification, failing QC test or when the QC tests cannot be verified, construct a new test section. The Contractor may elect to place material in 6 inches compacted thickness at any time. Construct all layers approximately parallel to the centerline profile of the road.

The Engineer reserves the right to terminate the Contractor's use of thick lift construction. Whenever the Engineer determines that the Contractor is not achieving satisfactory results, revert to the 6-inch compacted lifts.

120-8.2.1.3 Equipment and Methods: Provide normal dewatering equipment including, but not limited to, surface pumps, sump pumps and trenching/digging machinery. Provide normal dewatering methods including, but not limited to, constructing shallow surface drainage trenches/ditches, using sand blankets, sumps and siphons.

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When normal dewatering does not adequately remove the water, the Engineer may require the embankment material to be placed in the water or on low swampy ground in accordance with 120-9.2.3.

120-8.2.2 Placing in Unstable Areas: When depositing fill material in water, or on low swampy ground that will not support the weight of hauling equipment, construct the embankment by dumping successive loads in a uniformly distributed layer of a thickness not greater than necessary to support the hauling equipment while placing subsequent layers. Once sufficient material has been placed so that the hauling equipment can be supported, construct the remaining portion of the embankment in layers in accordance with the applicable provisions of 120-9.2.2.

120-8.2.3 Placing on Steep Slopes: When constructing an embankment on a hillside sloping more than 20 degrees from the horizontal, before starting the fill, deeply plow or cut steps into the surface of the existing slope on which the embankment is to be placed.

120-8.2.4 Placing Outside the Standard Minimum Slope: The standard minimum slope is defined as the plane described by a one (vertical) to two (horizontal) slope downward from the roadway shoulder point or the gutter line, in accordance with Standard Plans, Index 120-001 and 120-002. Where material that is unsuitable for normal embankment construction is to be used in the embankment outside the standard minimum slope, place such material in layers of not more than 18 inches in thickness, measured loose. The Contractor may also place material which is suitable for normal embankment, outside such standard minimum slope, in 18 inch layers. Maintain a constant thickness for suitable material placed within and outside the standard minimum slope, unless placing in a separate operation.

120-8.3 Hydraulic Method:

120-8.3.1 Method of Placing: When the hydraulic method is used, as far as practicable, place all dredged material in its final position in the embankment by such method. Place and compact any dredged material that is reworked or moved and placed in its final position by any other method, as specified in 120-9.2. Baffles or any other form of construction may be used if the slopes of the embankments are not steeper than indicated in the Plans. Remove all timber used for temporary bulkheads or baffles from the embankment, and fill and thoroughly compact all voids. When placing fill on submerged land, construct dikes prior to beginning of dredging, and maintain the dikes throughout the dredging operation.

120-8.3.2 Excess Material: Do not use any excess material placed outside the prescribed slopes or below the normal high-water table to raise the fill areas. Remove only the portion of this material required for dressing the slopes.

120-8.3.3 Protection of Openings in Embankment: Maintain openings in the embankments at the bridge sites. Remove any material which invades these openings or existing channels without additional compensation to provide the same existing channel depth as before the construction of the embankment. Do not excavate or dredge any material within 200 feet of the toe of the proposed embankment.

120-8.4 Reclaimed Asphalt Pavement (RAP) Method:

120-8.4.1 General: Use only RAP material stored at facilities with an approved Florida Department of Environmental Protection Stormwater permit or transferred directly from a milling project to the Department project. Certify the source if RAP material is from an identifiable Department project. Do not use RAP material in the following areas: construction areas that are below the seasonal high groundwater table elevation; MSE Wall backfill; underneath MSE Walls or the top 6 inches of embankment.

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Prior to placement, submit documentation to the Engineer for his approval, outlining the proposed location of the RAP material.

120-8.4.2 Soil and RAP Mixture: Place the RAP material at the location and spread uniformly, using approved methods to obtain a maximum layer thickness of 4 inches. Mix this 4-inch maximum layer of RAP with a loose soil layer 8 to 10 inches thick. After mixing, meet all embankment utilization requirements of Standard Plans, Index 120-001 for the location used. The total RAP and other embankment material shall not exceed 12 inches per lift after mixing and compaction if the Contractor can demonstrate that the density of the mixture can be achieved. Perform mixing using rotary tillers or other equipment meeting the approval of the Engineer. The Engineer will determine the order in which to spread the two materials. Mix both materials to the full depth. Ensure that the finished layer will have the thickness and shape required by the typical section. Demonstrate the feasibility of this construction method by successfully completing a 500-foot long test section.

120-8.4.3 Alternate Soil and RAP Layer Construction: Construct soil in 6-inch to 12-inch compacted lifts and RAP in alternate layers with 6-inch maximum compacted lifts. Use soil with a minimum LBR value of 40 to prevent failure during compaction of the overlying RAP layer. Demonstrate the feasibility of this construction method by successfully completing a 500-foot long test section.

120-9 Compaction Requirements.

120-9.1 Moisture Content: Compact the materials at a moisture content such that the specified density can be attained. If necessary to attain the specified density, add water to the material, or lower the moisture content by manipulating the material or allowing it to dry, as is appropriate.

120-9.2 Compaction of Embankments:

120-9.2.1 General: Uniformly compact each layer, using equipment that will achieve the required density, and as compaction operations progress, shape and manipulate each layer as necessary to ensure uniform density throughout the embankment.

120-9.2.2 Compaction Over Unstable Foundations: Where the embankment material is deposited in water or on low swampy ground, and in a layer thicker than 12 inches (as provided in 120-8.2.2), compact the top 6 inches (compacted thickness) of such layer to the density as specified in 120-10.2.

120-9.2.3 Compaction Where Plastic Material Has Been Removed: Where unsuitable material is removed and the remaining surface is of the A-4, A-5, A-6, or A-7 Soil Groups (see AASHTO M 145), as determined by the Engineer, compact the surface of the excavated area by rolling with a sheepsfoot roller exerting a compression of at least 250 psi on the tamper feet, for the full width of the roadbed (subgrade and shoulders). Perform rolling before beginning any backfill and continue until the roller feet do not penetrate the surface more than 1 inch. Do not perform such rolling where the remaining surface is below the normal water table and covered with water. Vary the procedure and equipment required for this operation at the discretion of the Engineer.

120-9.2.4 Compaction of Grassed Shoulder Areas: For the upper 6-inch layer of all shoulders which are to be grassed, since no specific density is required, compact only to the extent needed for planting.

120-9.2.5 Compaction of Grassed Embankment Areas: Do not compact the outer layers of any embankments where plant growth will be established. Leave this layer in a loose condition to a minimum depth of 6 inches for the subsequent seeding or planting

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operations. Do not place RAP or RAP blended material within the top 12 inches of areas to be grassed.

120-9.3 Compaction for Pipes, Culverts, etc.: Compact the backfill of trenches to the densities specified for embankment or subgrade, as applicable, and in accordance with the requirements of 125-9.2.

Thoroughly compact embankments over and around pipes, culverts, and bridges in a manner which will not place undue stress on the structures, and in accordance with the requirements of 125-9.2.

120-9.4 Compaction of Subgrade: If the Plans do not provide for stabilizing, compact the subgrade in both cuts and fills, to the density specified in 120-10.2. For cut areas, determine Standard Proctor Maximum Density in accordance with FM 1-T099 at a frequency of one per mile or when there is a change in soil type, whichever occurs first. For undisturbed soils, do not apply density requirements where constructing paved shoulders 5 feet or less in width.

Where trenches for widening strips are not of sufficient width to permit the use of standard compaction equipment, perform compaction using vibratory rollers, trench rollers, or other type compaction equipment approved by the Engineer.

Maintain the required density until the base or pavement is placed on the subgrade.

120-10 Acceptance Program.

120-10.1 General Requirements:

120-10.1.1 Equipment Comparison: Before initial production, perform an initial three-way density gauge comparison with Verification and Independent Assurance (IA) gauges to validate QC and Verification gauges. When comparing the wet density between two density gauges, three sets of calculations must be performed (IA to QC, IA to Verification, and QC to Verification) within the same test hole and same test depth. Ensure that the difference between any two wet densities does not exceed the tolerances listed in Table 120-2. Repair, calibrate, or replace any gauge that does not compare favorably with the IA gauge.

Table 120-2

Condition	Comparison Type	Manufacturer	Tolerance
Condition 1: When both gauges in the comparison are Nuclear Density Gauges (NDG)	NDG to NDG	Same Manufacturer	2 lb/ft^3
	NDG to NDG	Different Manufacturer	3 lb/ft^3
Condition 2: When one of the gauges in the comparison is a Low-Activity Nuclear Density Gauge (L-NDG)	L-NDG to L-NDG	Same Manufacturer	2 lb/ft^3
	L-NDG to L-NDG	Different Manufacturer	3 lb/ft^3
	NDG to L-NDG	Same/Different Manufacturer	

Ensure the equipment intended to determine the moisture content of soils by Speedy moisture tester in accordance with FM 5-507 has been calibrated and visually inspected by the Engineer.

To validate additional nuclear density gauges, perform a two-way comparison analysis between the QC nuclear gauge and the Verification nuclear gauge any time a nuclear gauge is first brought to the project or returns from annual calibration/repair. At least one of the nuclear gauges in the two-way comparison analysis must have been previously

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validated in a comparison. Repair or replace any QC gauge that does not compare favorably with a validated Verification gauge at any time during the remainder of the project. Calibrate all gauges annually.

120-10.1.2 Initial Production LOT: Before construction of any production LOT, prepare a 500-foot initial control section consisting of one full LOT. Notify the Engineer in writing at least 24 hours prior to production of the initial control section. Perform all QC tests required in 120-10.1.4 with the Engineer present. Do not begin constructing another LOT until successfully completing the initial production LOT.

If the QC test result fails the density requirements of 120-10.2, correct the areas of non-compliance. The QC and Verification tests will then be repeated.

120-10.1.3 Density over 105%: When a QC computed dry density results in a value greater than 105% of the applicable Proctor maximum dry density, the Engineer will perform an Independent Verification (IV) density test within 5 feet. If the IV density results in a value greater than 105%, the Engineer will investigate the compaction methods, examine the applicable Standard Proctor Maximum Density and material description. The Engineer may collect and test an IV Standard Proctor Maximum Density sample for acceptance in accordance with the criteria of 120-10.2.

120-10.1.4 Quality Control (QC) Tests:

120-10.1.4.1 Standard Proctor Maximum Density Determination: Determine the QC standard Proctor maximum density and optimum moisture content by sampling and testing the material in accordance with the specified test method listed in 120-10.2.

120-10.1.4.2 Density Testing Requirements: Ensure compliance to the requirements of 120-10.2 by Nuclear Density testing in accordance with FM 1-T310. Determine the in-place moisture content for each density test in accordance with FM 1-T310, FM 5-507 (Speedy Moisture), or ASTM D-4643 (Microwave Oven), whichever is applicable.

120-10.1.4.3 Soil Classification: Perform soil classification tests on the sample collected in 120-10.1.4.1, in accordance with AASHTO T88, T89, T90, and FM 1-T267. Classify soils in accordance with AASHTO M145 in order to determine compliance with embankment utilization requirements as specified in Standard Plans, Index 120-001.

120-10.1.5 Department Verification: The Engineer will conduct Verification tests in order to accept all materials and work associated with 120-10.1.4. The Engineer will verify the QC results if they meet the Verification Comparison Criteria, otherwise the Engineer will implement Resolution procedures.

The Engineer will select test locations, including Station, Offset, and Lift, using a random number generator, based on the LOTs under consideration. Each Verification test evaluates all work represented by the QC testing completed in those LOTs.

In addition to the Verification testing, the Engineer may perform additional Independent Verification (IV) testing. The Engineer will evaluate and act upon the IV test results in the same manner as Verification test results.

When the project requires less than four QC tests per material type, the Engineer reserves the right to accept the materials and work through visual inspection.

120-10.1.6 Reduced Testing Frequency: Obtain the Engineer's written approval for the option to reduce density testing frequency to one test every two LOTs if Resolution testing was not required for 12 consecutive verified LOTs, or if Resolution testing was required, but the QC test data was upheld and all substantiating tests are recorded in the ERS.

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Generate random numbers based on the two LOTs under consideration. When QC test frequency is reduced to one every two LOTs, obtain the Engineer's approval to place more than one LOT over an untested LOT. Assure similar compaction efforts for the untested LOTs. If the Verification test fails, and QC test data is not upheld by Resolution testing, the QC testing will revert to the original frequency of one QC test per LOT. Do not apply reduced testing frequency in construction of shoulder-only areas, shared use paths, sidewalks, and first and last lift.

120-10.1.7 Payment for Resolution Tests: If the Resolution laboratory results compare favorably with the QC results, the Department will pay for Resolution testing. No additional compensation, either monetary or time, will be made for the impacts of any such testing.

If the Resolution laboratory results do not compare favorably with the QC results, the costs of the Resolution testing will be deducted from monthly estimates. No additional time will be granted for the impacts of any such testing.

120-10.2 Acceptance Criteria: Obtain a minimum QC density of 100% of the standard Proctor maximum density as determined by FM 1-T099, with the following exceptions: embankment constructed by the hydraulic method as specified in 120-8.3; material placed outside the standard minimum slope as specified in 120-8.2.4 except when a structure is supported on existing embankment; and other areas specifically excluded herein.

120-10.3 Additional Requirements:

120-10.3.1 Frequency: Conduct QC sampling and testing at a minimum frequency listed in Table 120-3 below. The Engineer will perform Verification sampling and tests at a minimum frequency listed in Table 120-3 below.

Table 120-3

Test Name	Quality Control	Verification	Verification of Shoulder-Only Areas, Shared Use Paths, and Sidewalks
Standard Proctor Maximum Density	One per soil type	One per soil type	One per soil type
Density	One per LOT	One per four LOTS and for wet conditions, the first lift not affected by water	One per two LOTs
Soil Classification and Organic Content	One per Standard Proctor Maximum Density	One per Standard Proctor Maximum Density	One per Standard Proctor Maximum Density

120-10.3.2 Test Selection and Reporting: Determine test locations including stations and offsets, using the random number generator approved by the Engineer. Record data directly in the ERS section of the Department's database. Do not use notepads or worksheets to record data for later transfer to the ERS. Notify the Engineer upon successful completion of QC testing on each LOT prior to placing another lift on top.

120-10.4 Verification Comparison Criteria and Resolution Procedures:

120-10.4.1 Standard Proctor Maximum Density Determination: The Engineer will verify the QC results if the results compare within 4.5 lb/ft^3 of the Verification test result.

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Otherwise, the Engineer will take one additional sample of material from the soil type in question. The State Materials Office (SMO) or an AASHTO accredited laboratory designated by the SMO will perform Resolution testing. The material will be sampled and tested in accordance with FM 1-T099.

The Engineer will compare the Resolution test results with the QC test results. If all Resolution test results are within 4.5 lb/ft^3 of the corresponding QC test results, the Engineer will use the QC test results for material acceptance purposes for each LOT with that soil type. If the Resolution test result is not within 4.5 lb/ft^3 of the Contractor's QC test, the Verification test result will be used for material acceptance purposes.

120-10.4.2 Density Testing: When a Verification or IV density test fails the acceptance criteria, perform an equipment comparison analysis using the same test hole and same test depth in accordance with 120-10.1.1. If the equipment compares favorably, then retest the site within a 5-foot radius of the failing Verification's test. Otherwise, repair, calibrate, or replace density gauge in accordance with 120-10.1.1.

If the QC retest meets the acceptance criteria, the Engineer will accept those LOTs in question. Otherwise, rework and retest the LOT. The Engineer will perform new verification testing. Record the equipment comparison data and the QC test results in the ERS section of the Department's database.

120-10.4.3 Soil Classification: The Engineer will verify the QC test results if the Verification and the QC test results both match the soil utilization symbol listed in Standard Plans, Index 120-001. Otherwise, the Engineer will test the sample retained for Resolution testing. The SMO or an AASHTO accredited laboratory designated by the SMO will perform the Resolution testing. The material will be sampled and tested in accordance with AASHTO T 88, T 89, and T 90, and classified in accordance with AASHTO M 145.

The Engineer will compare the Resolution test results with the QC test results. If the Resolution test matches the QC soil utilization symbol, the Engineer will use the QC soil utilization symbol for material acceptance purposes. If the Resolution test result does not match the Contractor's QC soil utilization symbol, the Verification test results will be used for material acceptance purposes.

120-10.4.4 Organic Content: The Engineer will verify the QC test results if the Verification test results satisfy the organic content test criteria in Standard Plans, Index 120-001. Otherwise, the Engineer will test the sample retained for Resolution testing. The SMO or an AASHTO accredited laboratory designated by the SMO will perform Resolution testing. The material will be sampled and tested in accordance with FM 1-T 267. If the Resolution test results satisfy the required criteria, material of that soil type will be verified and accepted. If the Resolution test results do not meet the required criteria, reject the material and reconstruct with acceptable material.

120-10.5 Disposition of Defective Materials: Assume responsibility for removing and replacing all defective material, as defined in Section 6.

Alternately, submit an Engineering Analysis Scope in accordance with 6-4 to determine the disposition of the material.

120-11 Maintenance and Protection of Work.

While construction is in progress, maintain adequate drainage for the roadbed at all times. Maintain a shoulder at least 3 feet wide adjacent to all pavement or base construction in order to provide support for the edges.

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Maintain all earthwork construction throughout the life of the Contract and take all reasonable precautions to prevent loss of material from the roadway due to the action of wind or water. Repair, at no expense to the Department except as otherwise provided herein, any slides, washouts, settlement, subsidence, or other mishap which may occur prior to final acceptance of the work. Perform maintenance and protection of earthwork construction in accordance with Section 104.

Maintain all channels excavated as a part of the Contract work against natural shoaling or other encroachments to the lines and grades, shown in the Plans, until final acceptance of the project.

120-12 Construction.

120-12.1 Construction Tolerances: Shape the surface of the earthwork to conform to the lines and grades as shown in the Plans. In final shaping of the surface of earthwork, maintain a tolerance of 0.3 foot above or below the finished graded surface with the following exceptions:

1. Shape the surface of shoulders to within 0.1 foot of the finished graded surface shown in the Plans.
2. Shape the earthwork to match adjacent pavement, curb, sidewalk, structures, etc.
3. Shape the bottom of conveyance ditches so that the ditch impounds no water.
4. When the work does not include construction of base or pavement, shape the entire roadbed (shoulder point to shoulder point) to within 0.1 foot above or below the Plan finished graded surface.
5. When the work includes permitted linear stormwater management facilities, shape the swales and ditch blocks to within 0.1 foot of the finished graded surface shown in the Plans.

Ensure that the shoulder lines do not vary horizontally more than 0.3 foot from the true lines shown in the Plans.

120-12.2 Operations Adjacent to Pavement: Carefully dress areas adjacent to pavement areas to avoid damage to such pavement. Complete grassing of shoulder areas prior to placing the final wearing course. Do not manipulate any embankment material on a pavement surface.

When shoulder dressing is underway adjacent to a pavement lane being used to maintain traffic, exercise extreme care to avoid interference with the safe movement of traffic.

120-13 Method of Measurement.

120-13.1 General: When payment for excavation is on a volumetric basis, the quantity to be paid for will be the volume, in cubic yards. The material will be measured in its original position by field survey or by photogrammetric means as designated by the Engineer, unless otherwise specified under the provisions for individual items.

Where subsoil excavation extends outside the lines shown in the Plans or authorized by the Engineer including allowable tolerances, and the space is backfilled with material obtained in additional authorized roadway or borrow excavation, the net fill, plus shrinkage allowance, will be excluded from the quantity of roadway excavation or borrow excavation to be paid for, as applicable.

The quantity of all material washed, blown, or placed beyond the limits of the finished graded surface will be determined by the Engineer and will be excluded from the quantity of roadway excavation or borrow excavation to be paid for, as applicable.

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Subsoil excavation that extends outside the lines shown in the Plans or authorized by the Engineer including allowable tolerances will be excluded from the quantity to be paid for as subsoil excavation.

120-13.2 Roadway Excavation: The measurement will include only the net volume of material excavated between the original ground line or finished graded surface of an existing roadbed, as applicable, and the finished surface of new pavement, except that the measurement will also include all unavoidable slides which may occur in connection with excavation classified as roadway excavation.

The pay quantity will be the plan quantity provided that the excavation was accomplished in substantial compliance with the plan dimensions and subject to the provisions of 9-3.2 and 9-3.4. On designated 3-R Projects, regular excavation will be paid for at the Contract lump sum price provided that the excavation was accomplished in substantial compliance with the plan dimension.

120-13.3 Borrow Excavation: Measurement will be made on a loose volume basis, measured in trucks or other hauling equipment at the point of dumping on the road. If measurement is made in vehicles, level the material to facilitate accurate measurement.

Unsuitable material excavated from borrow pits where truck measurement is provided for and from any borrow pits furnished by the Contractor, will not be included in the quantity of excavation to be paid for.

120-13.4 Lateral Ditch Excavation: The measurement will include only material excavated within the lines and grades indicated in the Plans or as directed by the Engineer. The measurement will include the full length shown in the Plans or directed by the Engineer and acceptably completed. Excavation included for payment under Section 125 will not be included in this measurement.

The pay quantity will be the plan quantity provided that the excavation was accomplished in substantial compliance with the plan dimensions and subject to the provisions of 9-3.2 and 9-3.4.

120-13.5 Channel Excavation: The measurement will include only material excavated within the lines and grades indicated in the Plans or in accordance with authorized Plan changes. The measurement will include the full length shown in the Plans including any authorized changes thereto.

If shoaling occurs subsequent to excavation of a channel and the Engineer authorized the shoaled material to remain in place, the volume of any such material remaining within the limits of channel excavation shown in the Plans will be excluded from the measured quantity of channel excavation.

120-13.6 Subsoil Excavation: The measurement will include only material excavated within the lines and grades indicated in the Plans (including the tolerance permitted therefore) or as directed by the Engineer.

When no item for subsoil excavation is shown in the Contract but subsoil excavation is subsequently determined to be necessary, such unanticipated subsoil excavation will be paid for as provided in Article 4-4.

120-13.7 Embankment: The quantity will be at the plan quantity. Where payment for embankment is not to be included in the payment for the excavation and is to be paid for on a cubic yard basis for the item of embankment, the measurement will include material placed within the limits of the existing surface, to the finished graded surface as shown in the Plans, Standard Plans Index 120-001, or directed by the Engineer. Where embankment is constructed

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over an existing road, the embankment measurement will include only the material actually placed up to the finished graded surface. If there are authorized changes in plan dimensions or if errors in plan quantities are detected, plan quantity will be adjusted as provided in 9-3.2.

Any overrun or underrun of plan quantity for subsoil excavation which results in a corresponding increase or decrease in embankment will be considered as an authorized plan change for adjustment purposes as defined in 9-3.2.2.

No payment will be made for embankment material used to replace unsuitable material excavated beyond the lines and grades shown in the Plans or ordered by the Engineer.

In no case will payment be made for material allowed to run out of the embankment on a flatter slope than indicated on the Plans. The Contractor shall make his own estimate on the volume of material actually required to obtain the pay section.

120-14 Basis of Payment.

120-14.1 General: Prices and payments for the various work items included in this Section will be full compensation for all work described herein, including excavating, dredging, pumping, hauling, placing, and compacting; dressing the surface of the earthwork; maintaining and protecting the complete earthwork.

The Department will not allow extra compensation for any reworking of materials. The Department will compensate for the cost of grassing or other permanent erosion control measures directed by the Engineer as provided in the Contract.

120-14.2 Excavation:

120-14.2.1 Items of Payment: When no classification of material is indicated in the Plans, and bids are taken only on regular excavation, the total quantity of all excavation specified under this Section will be paid for at the Contract unit price for regular excavation.

When separate classifications of excavation are shown in the proposal, the quantities of each of the various classes of materials so shown will be paid for at the Contract unit prices per cubic yard for regular excavation, lateral ditch excavation, subsoil excavation, and channel excavation, as applicable, and any of such classifications not so shown will be included under the item of regular excavation (except that if there is a classification for lateral ditch excavation shown and there is no classification for channel excavation, any channel excavation will be included under the item of lateral ditch excavation). As an exception on designated projects, regular excavation will be paid for at the Contract lump sum price.

120-14.2.2 Basic Work Included in Payments: Prices and payments will be full compensation for all work described under this Section, except for any excavation, or embankment which is specified to be included for payment under other items. Such prices and payments will include hauling; any reworking that may be necessary to accomplish final disposal as shown in the Plans; the dressing of shoulders, ditches and slopes; removal of trash, vegetation, etc., from the previously graded roadway where no item for clearing and grubbing is shown in the Plans; and compacting as required.

120-14.2.3 Additional Depth of Subsoil Excavation: Where subsoil excavation is made to a depth of 0 to 5 feet below the depth shown in the Plans, such excavation will be paid for at the unit price bid.

Where subsoil excavation is made to a depth greater than 5 feet, and up to 15 feet, deeper than the depth shown in the Plans, such excavation will be paid for at the unit price bid plus 25% of such unit price. Additional extra depth, more than 15 feet below such plan depth, will be considered as a change in the character of the work and will be paid for as unforeseeable work.

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Where no subsoil excavation is shown in a particular location on the original Plans, payment for extra depth of subsoil will begin 5 feet below the lowest elevation on the finished graded surface.

120-14.2.4 Borrow Excavation: When the item of borrow excavation is included in the Contract, price and payment will also include the cost of furnishing the borrow areas and any necessary clearing and grubbing thereof, the removal of unsuitable material that it is necessary to excavate in order to obtain suitable borrow material, and also the costs incurred in complying with the provisions of 120-6.3.

120-14.2.5 Materials Excluded from Payment for the Excavation: No payment for excavation will be made for any excavation covered for payment under the item of embankment.

No payment will be made for the excavation of any materials which is used for purposes other than those shown in the Plans or designated by the Engineer. No payment will be made for materials excavated outside the lines and grades given by the Engineer, unless specifically authorized by the Engineer. As an exception, in operations of roadway excavation, all slides and falls of insecure masses of material beyond the regular slopes that are not due to lack of precaution on the part of the Contractor, will be paid for at the Contract unit price for the material involved. The removal of slides and falls of material classified as lateral ditch excavation or as subsoil excavation will not be paid for separately, but will be included in the Contract unit price for the pay quantity of these materials, measured as provided in 120-14.

120-14.3 Embankment:

120-14.3.1 General: Price and payment will be full compensation for all work specified in this Section, including all material for constructing the embankment, all excavating, dredging, pumping, placing and compacting of material for constructing the embankment complete, dressing of the surface of the roadway, maintenance and protection of the completed earthwork, and the removal of rubbish, vegetation, etc., from the roadway where no clearing and grubbing of the area is specified in the Plans. Also, such price and payment, in each case, will specifically include all costs of any roadway, lateral ditch, or channel excavation, unless such excavation is specifically shown to be paid for separately, regardless of whether the materials are utilized in the embankment.

120-14.3.2 Excluded Material: No payment will be made for the removal of muck or overburden from the dredging or borrow areas. No payment will be made for embankment material used to replace muck or other unsuitable material excavated beyond the lines and grades shown in the Plans or ordered by the Engineer.

120-14.3.3 Clearing and Grubbing: No payment will be made for any clearing and grubbing of the borrow or dredging areas. Where no clearing and grubbing of such areas is specified in the Plans, the cost of any necessary clearing and grubbing will be included in the Contract unit or lump sum price for Embankment.

120-14.3.4 Cost of Permits, Rights, and Waivers: Where the Contractor provides borrow or dredging areas of his own choosing, the cost of securing the necessary permits, rights or waivers will be included in the Contract price for embankment.

120-14.4 Payment Items: Payment will be made under:

Item No. 120-	1-	Regular Excavation - per cubic yard.
Item No. 120-	2-	Borrow Excavation - per cubic yard.
Item No. 120-	3-	Lateral Ditch Excavation - per cubic yard.

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Item No. 120- 4-	Subsoil Excavation - per cubic yard.
Item No. 120- 5-	Channel Excavation - per cubic yard.
Item No. 120- 6-	Embankment - per cubic yard.
Item No. 120- 71-	Regular Excavation (3-R Projects) - lump sum.

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SECTION 121
FLOWABLE FILL

121-1 Description.

Furnish and place flowable fill as an alternative to compacted soil as approved by the Engineer. Applications for conventional flowable fill include beddings; encasements; closures for tanks and pipes; and general backfill for trenches, embankments and walls. Applications for cellular concrete flowable fill include beddings; encasements; closures for tanks and pipes; and general backfill for embankments and walls.

121-2 Materials.

Meet the following requirements:

Fine Aggregate[1]	Section 902
Portland Cement	Section 921
Water	Section 923
Admixtures[2]	Section 924
Ground Tire Rubber (GTR)[3]	Section 919
Supplementary Cementitious Materials	Section 929
Preformed Foam	ASTM C869

1. Any clean fine aggregate with 100% passing a 3/8-inch mesh sieve and not more than 15% passing a No. 200 sieve may be used.

2. High air generators or foaming agents may be used in lieu of conventional air entraining admixtures and shall be added at jobsite and mixed in accordance with the manufacturer's recommendation. GTR may reduce the amount of high air generators or foaming agents used.

3. GTR may replace up to 20% of the fine aggregate.

121-3 Mix Design.

Conventional flowable fill is a mixture of portland cement, coal ash, fine aggregate, admixture and water. Flowable fill contains a low cementitious content for reduced strength development. Cellular concrete flowable fill is a low density concrete made with cement, water and preformed foam to form a hardened closed cell foam material. Cellular concrete flowable fill may also contain fine aggregate, supplementary cementitious materials and admixtures.

Submit mix designs to the Engineer for approval. Table 121-1 below has suggested mix guides for excavatable, non-excavatable and cellular concrete flowable fill:

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Table 121-1			
	Excavatable	Non-Excavatable	Cellular Concrete
Cement	75-100 lb/yd^3	75-150 lb/yd^3	Min 150 lb/yd^3
Supplementary Cementitious Materials	None	150-600 lb/yd^3	Optional
Water	*	*	*
Air**	5-35%	5-15%	****
28 Day Compressive Strength**	Maximum 100 psi	Minimum 125 psi	Minimum 80 psi
Unit Weight **	90-110 lb/ft^3	100-125 lb/ft^3	20-80 lb/ft^3
Fine Aggregate	***	***	Optional

*Mix designs shall produce a consistency that will result in a flowable self-leveling product at time of placement.
**The requirements for percent air, compressive strength and unit weight are for laboratory designs only and are not intended for jobsite acceptance requirements.
***Fine Aggregate shall be proportioned to yield 1 yd^3.
****In cellular concrete, preformed foam shall be proportioned at the job site to yield 1 yd^3 in accordance with the design requirements.

121-4 Production and Placing.

Use flowable fill manufactured at a production facility that meets the requirements of 347-3. Deliver flowable fill using concrete construction equipment. Revolution counter are waived. Place flowable fill by chute, pumping or other methods approved by the Engineer. Tremie flowable fill through water. Cellular concrete flowable fill may not be placed within three feet of the bottom elevation for roadway base courses.

121-5 Construction Requirements.

Use straps, soil anchors or other approved means of restraint to ensure correct alignment when flowable fill is used as backfill for pipe or where flotation or misalignment may occur.

Protect flowable fill from freezing for a period of 36 hours after placement.

Place flowable fill to the designated fill line without vibration or other means of compaction. Do not place flowable fill during inclement weather, e.g. rain or ambient temperatures below 40ºF. Take all necessary precautions to prevent any damages caused by the hydraulic pressure of the fill during placement prior to hardening. Provide the means to confine the material within the designated space.

121-6 Acceptance.

Acceptance of flowable fill will be based on the following documentation and a minimum temperature of flowable fill at the point of delivery of 50ºF.

Submit a delivery ticket to the Engineer for each load of flowable fill delivered to the worksite. Ensure that each ticket contains the following information:

1. Project designation,
2. Date,
3. Time,
4. Class and quantity of flowable fill,
5. Actual batch proportions,
6. Free moisture content of aggregates,
7. Quantity of water withheld.

Leave the fill undisturbed until the material obtains sufficient strength. Sufficient strength is 35 psi penetration resistance as measured using a hand held penetrometer in

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accordance with ASTM C403. Provide a hand held penetrometer to measure the penetration resistance of the hardened flowable fill.

121-7 Basis of Payment.

When the item of flowable fill is included in the Contract, payment will be made at the Contract unit price per cubic yard. Such price and payment will include all cost of the mixture, in place and accepted, determined as specified above. No measurement and payment will be made for material placed outside the neat line limits or outside the adjusted limits, or for unused or wasted material.

Payment will be made under:

Item No. 121- 70- Flowable Fill - per cubic yard.

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SECTION 125
EXCAVATION FOR STRUCTURES AND PIPE

125-1 Description.

Excavate for box culverts, pipes, retaining walls, headwalls for pipes and drains, catch basins, drop inlets, manholes, and similar structures. Construct and remove cofferdams, sheeting, bracing, etc.; pump or otherwise dewater foundations; remove and dispose of any existing structures or portions of structures not covered by other items in the Contract, including foundations, abutments, piers, wings, and all other materials, obstructions, etc., found necessary to clear the site for the proposed work; backfill, dispose of surplus material, and perform final cleaning, as may be necessary for the proper execution of the work. This Section does not include excavation for bases or pavements, curbs, curb and gutter, valley gutter, ditch pavement, or rubble gutter.

125-1.1 Trench Excavation Safety System and Shoring, Special (Trench Excavation): When performing trench excavation in excess of 5 feet in depth, comply with the Occupational Safety and Health Administration's (OSHA) trench safety standards, 29 CFR 1926, Subpart P, and all subsequent revisions or updates adopted by the Department of Labor and Employment Security. Ensure that trench boxes are wide enough to accommodate compaction and density testing.

Submission of bid and subsequent execution of the Contract will serve as certification that all trench excavation in excess of 5 feet in depth will be in compliance with Section 553.62, Florida Statutes.

Consider all available geotechnical information when designing the trench excavation safety system.

Consider these and any more stringent trench safety standards as minimum Contract requirements.

125-2 Classification.

Consider all materials excavated as unclassified and as excavation regardless of the material encountered.

125-3 Cofferdams.

125-3.1 Construction:

125-3.1.1 Methods: Construct all foundations by open excavation, and shore, brace, or protect the foundation openings with cofferdams. Provide cofferdams or cribs for foundation construction below the bottom of the footings. Provide sufficient clearance in the cofferdam interiors to permit construction of forms and inspection of their exteriors, and for pumping equipment.

125-3.1.2 Protection of Concrete: Construct cofferdams to protect green concrete against damage from a sudden rising of the water and to prevent damage by erosion. Do not leave timber or bracing in cofferdams or cribs that extend into the substructure masonry except where permitted in writing by the Engineer.

125-3.1.3 Placing in the Dry: For placing footings in the dry, the Engineer may require cofferdam sheeting to be driven to an elevation 6 feet below the elevation of the bottom of the footings and require sufficient pumping equipment to dewater and maintain the cofferdam in a comparatively dry condition.

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125-3.1.4 Working Drawings: For substructure work, submit drawings showing the proposed method of cofferdam construction and other details left to choice or not fully shown in the Plans. Obtain the Engineer's approval of the type and clearance of cofferdams, insofar as such details affect the character of the finished work. For other details of design that do not affect the character of the finished work, assume responsibility for the successful construction of the work. Retain a Professional Engineer, registered in the State of Florida, to prepare the above construction drawing, and keep a signed and sealed copy on hand at the site at all times.

125-3.2 Removal: Unless otherwise provided, remove cofferdams or cribs, with all sheeting and bracing, after completion of the substructure without disturbing or marring the finished masonry.

125-4 Excavation.

125-4.1 Requirements for all Excavation: Perform all excavation to foundation materials, satisfactory to the Engineer, regardless of the elevation shown in the Plans. Remove rock, boulders or other hard lumpy or unyielding material to a depth of 12 inches below the bottom of pipes and box culverts elevations. Remove muck or other soft material to the depth indicated in the Plans or as directed by the Engineer.

125-4.2 Earth Excavation:

125-4.2.1 Foundation Material other than the Rock: When masonry is to rest on an excavated surface other than rock, take special care to avoid disturbing the bottom of the excavation, and do not remove the final foundation material to grade until just before placing the masonry. In case the foundation material is soft or mucky, the Engineer may require excavation to a greater depth and to backfill to grade with approved material.

125-4.2.2 Foundation Piles: Where foundation piles are used, complete the excavation of each pit before driving the piles. After the driving is completed, remove all loose and displaced material, leaving a smooth, solid, and level bed to receive the masonry.

125-4.2.3 Removal of Obstructions: Remove boulders, logs, or any unforeseen obstacles encountered in excavating. Compensation will be in accordance with the requirements of 4-3.

125-4.3 Rock Excavation: Clean all rock and other hard foundation material, remove all loose material, and cut all rock to a firm surface. Either level, step vertically and horizontally, or serrate the rock, as may be directed by the Engineer. Clean out all seams, and fill them with concrete or mortar.

125-4.4 Pipe Trench Excavation: Excavate trenches for pipes to the elevation of the bottom of the pipe and to a width sufficient to provide adequate working room. Remove soil not meeting the classification specified as suitable backfill material in 125-8.3.2.2, to a depth of 4 inches below the bottom of the pipe elevation. Where the soils permit, ensure that the trench sides are vertical up to at least the mid-point of the pipe.

For pipe lines placed above the existing surface, place and compact the embankment, prior to excavation of the trench, to an elevation at least 2 feet above the top of the pipe and to a width equal to four pipe diameters, and then excavate the trench to the required grade.

For pipe trenches utilizing trench boxes, ensure that the trench box used is of sufficient width to permit thorough tamping of bedding material under and around the pipes as specified in 125-8.1.6.

Do not disturb the installed pipe and its embedment when moving trench boxes. Move the trench box carefully to avoid excavated wall displacement or damage. As the trench

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box is moved, fill any voids left by the trench box and continuously place and compact the backfill material adjacent to and all along the side of the trench box walls to fill any voids created by the trench box.

125-5 Preservation of Channel.

125-5.1 General: Unless shown in the Plans, do not excavate outside of caissons, cribs, cofferdams, or sheet piling, and do not disturb the natural stream bed adjacent to the structure. If excavating or dredging at the site of the structure before sinking caissons, cribs, or cofferdams, complete the foundation and backfill all such excavations to the existing surface or other required elevation, with material satisfactory to the Engineer.

125-5.2 Removal of Excavated Materials: Do not allow materials that are deposited adjacent to the stream area to infiltrate the water areas. Leave the stream in its original condition.

125-6 Disposal of Surplus.

Use suitable excavated materials for backfilling over or around the structure. Dispose of unsuitable materials. Meet the disposal requirements pertaining to water pollution contained in Section 104 and in 7-1.1.

125-7 Pumping.

Pump from the interior of any foundation enclosure in such manner as to preclude the possibility of any portion of the concrete materials being carried away. Do not pump while placing concrete, or for a period of at least 24 hours thereafter, unless using a suitable pump separated from the concrete work by a watertight wall.

125-8 Backfilling.

125-8.1 General Requirements for Structures and Pipe:

125-8.1.1 General: Backfill in the dry whenever normal dewatering equipment and methods can accomplish the needed dewatering. A LOT is defined as one lift of backfill material placement, not to exceed 500 feet in length or a single run of pipe connecting two successive structures, whichever is less. Backfill for structures and pipe compacted in one operation will be considered as one LOT within the cover zone. Backfill around structures compacted separately from the pipe will be considered as separate LOTs. Backfill on each side of the pipe for the first lift will be considered a separate LOT. Backfill on opposite sides of the pipe for the remaining lifts will be considered separate LOTs, unless the same compactive effort is applied. Same compactive effort is defined as the same type of equipment (make and model) making the same number of passes on both sides of the pipe. For multiple phase backfill, a LOT shall not extend beyond the limits of the phase.

When placing backfill within trench box each lift of backfill is considered a LOT. Placement of backfill within trench box limits will be considered a complete operation before trench box is moved for next backfill operation. When the trench box is moved for next backfill operation this will start new LOTs for each lift. Follow the density testing frequency in 125-9.3.1.

125-8.1.2 Equipment and Methods: Provide normal dewatering equipment including, but not limited to, surface pumps, sump pumps, wellpoints and header pipe and trenching/digging machinery. Provide normal dewatering methods including, but not limited to, constructing shallow surface drainage trenches/ditches, using sand blankets, perforated pipe drains, sumps and siphons.

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125-8.1.3 Backfill Materials: Backfill to the existing surface or subgrade surface of openings made for structures, with a sufficient allowance for settlement. The Engineer may require that the material used for this backfill be obtained from a source entirely apart from the structure. Use only material accepted by the Engineer. Maintain a clearance of at least 1 foot of clean select soil between recycled concrete aggregate (RCA) and aluminum or metalized drainage pipe.

Do not allow heavy construction equipment to cross over culvert or storm sewer pipes until placing and compacting backfill material to the finished graded surface or to an elevation at least 4 feet above the crown of the pipe.

125-8.1.4 Use of A-7 Material: In the backfilling of trenches, A-7 material may be used from a point 12 inches above the top of the pipe up to the elevation shown in the Standard Plans as the elevation for undercutting of A-7 material.

125-8.1.5 Time of Placing Backfill: Do not place backfill against any masonry or concrete abutment, wingwall, or culvert until the Engineer has given permission to do so, and in no case until the masonry or concrete has been in place seven days or until the specified 28 day compressive strength occurs.

125-8.1.6 Placement and Compaction: Place the material in horizontal layers not exceeding 6 inches compacted thickness, in depth above water level, behind abutments, wingwalls and end bents or end rest piers, under the haunches of the pipes and around box culverts and all structures including pipe culverts. When the backfill material is deposited in water, compact as specified in 125-8.2.5 and 125-8.3.4.

125-8.1.6.1 Thick Lift Requirements: The Contractor may elect to place material in thicker lifts of no more than 12 inches compacted thickness above the Soil Envelope if the embankment material is classified as Group 1 in the table below. If the embankment material is classified as Group 2 in the table below and the Contractor chooses to place material in thicker lifts of no more than 12 inches compacted thickness above the soil envelope then the Contractor must demonstrate with a successful test section that density can be achieved. Thick lift around structures is only allowed above the soil envelope of the connecting pipe. Notify the Engineer in writing prior to beginning construction of a test section. Construct a test section of the length of one LOT. Perform five quality control (QC) tests at random locations within the test section. All five tests must meet the density required by 125-9.2 and be verified by the Department. Identify the test section with the compaction effort and soil classification in the Earthwork Records System (ERS) section of the Department's database. In case of a change in compaction effort or soil classification, construct a new test section. When a QC test fails the requirements of 125-9.2 or when the QC tests cannot be verified, construct a new test section. The Contractor may elect to place material in 6 inches compacted thickness at any time.

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Table 125-1					
Group	AASHTO Soil Class	Maximum Lift Thickness		Thick Lift Control Test Section Requirements	
		Within Cover Zone	Above Soil Envelope	Within Cover Zone	Above Soil Envelope
1	A-3 A-2-4 (No. 200 Sieve ≤ 15%)	6 inches	12 inches	N/A	Not Needed
2	A-1 A-2-4 (No. 200 Sieve > 15%) A-2-5, A-2-6, A-2-7, A-4, A-5, A-6 A-7 (Liquid Limit < 50)	6 inches without control test section		N/A	Maximum of 12 inches per 120-8.2.1.2

125-8.2 Additional Requirements for Structures Other than Pipe:

125-8.2.1 Density: Where the backfill material is deposited in water, obtain a 12 inch layer of comparatively dry material, thoroughly compacted by tamping, before verifying the layer and density requirements. Meet the requirements of 125-9.2.

125-8.2.2 Box Culverts: For box culverts over which pavement is to be constructed, compact around the structure to an elevation not less than 12 inches above the top of the structure, using rapid-striking mechanical tampers.

125-8.2.3 Other Limited Areas: Compact in other limited areas using mechanical tampers or approved hand tampers, until the cover over the structure is at least 12 inches thick. When hand tampers are used, deposit the materials in layers not more than 4 inches thick using hand tampers suitable for this purpose with a face area of not more than 100 square inches. Take special precautions to prevent any wedging action against the masonry, and step or terrace the slope bounding the excavation for abutments and wingwalls if required by the Engineer.

125-8.2.4 Culverts and Piers: Backfill around culverts and piers on both sides simultaneously to approximately the same elevation.

125-8.2.5 Compaction Under Wet Conditions: Where wet conditions do not permit the use of mechanical tampers, compact using hand tampers. Use only A-3 material for the hand tamped portions of the backfill. When the backfill has reached an elevation and condition such as to make the use of the mechanical tampers practical, perform mechanical tamping in such manner and to such extent as to transfer the compaction force into the sections previously tamped by hand.

125-8.3 Additional Requirements for Pipe Greater than 12 Inches Inside Diameter:

125-8.3.1 General: Trenches for pipe may have up to four zones that must be backfilled.

Lowest Zone: The lowest zone is backfilled for deep undercuts up to within 4 inches of the bottom of the pipe.

Bedding Zone: The zone above the lowest zone is the bedding zone. Usually it will be the backfill which is the 4 inches of soil below the bottom of the pipe. When rock or other hard material has been removed to place the pipe, the bedding zone will be the 12 inches of soil below the bottom of the pipe.

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Cover Zone: The next zone is backfill that is placed after the pipe has been laid and will be called the cover zone. This zone extends to 12 inches above the top of the pipe. The cover zone and the bedding zone are considered the Soil Envelope for the pipe.

Top Zone: The top zone extends from 12 inches above the top of the pipe to the base or final grade.

125-8.3.2 Material:

125-8.3.2.1 Lowest Zone: Backfill areas undercut below the bedding zone of a pipe with coarse sand, or other suitable granular material, obtained from the grading operations on the project, or a commercial material if no suitable material is available.

125-8.3.2.2 Soil Envelope: In both the bedding zone and the cover zone of the pipe, backfill with materials classified as A-1, A-2, or A-3. Material classified as A-4 may be used if the pipe is concrete pipe.

125-8.3.2.3 Top Zone: Backfill the area of the trench above the soil envelope of the pipe with materials allowed on Standard Plans, Index 120-001.

125-8.3.3 Compaction:

125-8.3.3.1 Lowest Zone: Compact the soil in the lowest zone to approximately match the density of the soil in which the trench was cut.

125-8.3.3.2 Bedding Zone: If the trench was not undercut below the bottom of the pipe, loosen the soil in the bottom of the trench immediately below the approximate middle third of the outside diameter of the pipe.

If the trench was undercut, place the bedding material and leave it in a loose condition below the middle third of the outside diameter of the pipe. Compact the outer portions to meet the density requirements of the acceptance criteria. Place the material in lifts no greater than 6 inches (compacted thickness).

125-8.3.3.3 Cover Zone: Before placing the cover zone material, lay pipe according to Section 430. Excavate for pipe bells before laying pipe. Place the material in 6 inch layers (compacted thickness), evenly deposited on both sides of the pipe, and compact with mechanical tampers suitable for this purpose. Hand tamp material below the pipe haunch that cannot be reached by mechanical tampers. Meet the requirements of in 125-9.2.

125-8.3.3.4 Top Zone: Place the material in layers not to exceed 12 inches in compacted thickness. Meet the requirements of the density acceptance criteria.

125-8.3.4 Backfill Under Wet Conditions: Where wet conditions are such that dewatering by normal pumping methods would not be effective, the procedure outlined below may be used when specifically authorized by the Engineer in writing. The Department will pay for any select material which is not available from the grading as Unforeseeable Work. The Department will not pay for select material that might be used by the Contractor for his own convenience instead of dewatering.

The Department will permit the use of granular material below the elevation at which mechanical tampers would be effective, but only material classified as A-3. Place and compact the material using timbers or hand tampers until the backfill reaches an elevation such that its moisture content will permit the use of mechanical tampers. When the backfill has reached such elevation, use normally acceptable backfill material. Compact the material using mechanical tampers in such manner and to such extent as to transfer the compacting force into the material previously tamped by hand.

The Department will permit the use of coarse aggregate below the elevation at which mechanical tampers would be effective. Use coarse aggregate as specified in

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Section 901 for Aggregate Size Number 89, 8, 78, 7, 68, 6, or 57. Place the coarse aggregate such that it will be stable and firm. Fully wrap the aggregate with a layer of Type D-4 filter fabric, as specified in Section 985. Do not place coarse aggregate within 4 feet of the ends of the trench or ditch. Use normally accepted backfill material at the ends.

125-9 Acceptance Program.

125-9.1 General Requirements: Meet the requirements of 120-10, except replace the requirements of 120-10.1.6 with 125-9.1.1, 120-10.2 with 125-9.2, and 120-10.3 with 125-9.3.

125-9.1.1 Reduced Testing Frequency: Obtain the Engineer's approval in writing for the option to reduce density testing frequency to one test every two LOTs or one every four LOTs for trench box operations if the following requirements are met:

1. Resolution testing was not required for six consecutive verified LOTs.
2. Resolution testing was required for any of the six consecutive verified LOTs, but QC test data was upheld.

Identify the substantiating tests in the ERS section of the Department's database and notify the Engineer in writing prior to starting reduced frequency of testing. Generate random numbers for selecting test locations for the LOTs under consideration. When QC test frequency is reduced, obtain the Engineer's approval in writing to place more than one LOT over an untested LOT. Do not apply reduced testing frequency for the first and last lift of pipe. Assure similar compaction efforts for the untested sections. If the Verification test fails, and QC test data is not upheld by Resolution testing the QC testing will revert to the original frequency.

125-9.2 Acceptance Criteria:

125-9.2.1 Density: Obtain a minimum QC density in any LOT of 100% of the Standard Proctor maximum density as determined by FM 1-T099 or the requirements of 125-8.3.3.1 when applicable. When the cover height below the bottom of base under asphalt pavement, below concrete pavement, or below unpaved ground, exceeds 15 inches, compact the pipe backfill in the cover zone to a density of at least 95% of the Standard Proctor maximum density as determined by FM 1-T099.

For density requirements around drainage structures, obtain a minimum QC density in any LOT of 100% of the Standard Proctor maximum density as determined by FM 1-T099 for a distance of one pipe diameter but not less than 3 feet from the outside face of the structure.

125-9.2.2 Exceptions to Structures and Pipe Density Requirements: Compact the backfill to a firmness approximately equal to that of the soil next to the pipe trench in locations outside the plane described by a one (vertical) to two (horizontal) slope downward from the roadway shoulder point or the gutter line in accordance with Standard Plans, Index 120-001 or 120-002. Apply 125-9.2.1 when compacting side-drain pipe backfill under driveways serving a property that is not a single residential lot.

125-9.3 Additional Requirements:

125-9.3.1 Frequency: Conduct Standard Proctor maximum density sampling and testing at a minimum frequency of one test per soil type. The summary of tests and frequency is shown in Table 125-2 below.

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Table 125-2		
Test Name	Quality Control	Verification
Standard Proctor Maximum Density	One per soil type	One per soil type
Density	One per LOT	One per four consecutive LOTs and for wet conditions, the first lift not affected by water
Soil Classification and Organic Content	One per Standard Proctor Maximum density	One per Standard Proctor Maximum density

125-10 Verification Comparison Criteria and Resolution Procedures.

Meet the requirements of 120-10.4.

125-11 Site Restoration.

Wherever the existing site is disturbed solely for the purpose of constructing or removing box culverts, pipes, inlets, manholes, etc., completely replace and restore the site to the Engineer's satisfaction, without additional compensation.

125-12 Cleaning Up.

Upon completion of the work, leave the structure and all adjacent areas in a neat and presentable condition, clear up all temporary structures, rubbish and surplus materials and leave the space under the structure unobstructed and in such shape that drift will not collect nor scour or be induced. Pile all material from existing structures that have been removed neatly on the bank, unless otherwise directed by the Engineer. Pull false work piling unless the Engineer permits it to be cut or broken off in which case it will be cut or broken off at least 2 feet below the finished grade or stream bed.

125-13 Method of Measurement.

No separate measurement or payment will be made for work under this Section.

125-14 Basis of Payment.

Payment for excavation of bridge structures will be made under Section 120. Payment for excavation of drainage system items will be incidental to those items.

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SECTION 145
GEOSYNTHETIC REINFORCEMENT

145-1 Description.

This Section specifies the construction requirements for geosynthetic used in geosynthetic reinforced soil slopes, geosynthetic reinforced foundations over soft soils, and geosynthetic reinforced embankment. Furnish and place geosynthetic and any associated facing material or drainage blankets.

145-2 Responsibility.

Construct the geosynthetic reinforced feature, including materials, method, and installation based on information provided in the Contract Documents and the geosynthetic supplier's recommendations. Submit shop drawings in accordance with Section 5 showing the details and distribution of the selected geosynthetic that meet the design shown in the Plans. Alternate designs optimizing the selected geosynthetic materials must be in accordance with Chapter 263 of the FDOT Design Manual.

145-3 Materials.

145-3.1 Geosynthetic Materials: Use geosynthetic materials meeting the requirements of Section 985 and listed on the Approved Product List (APL). Ensure the geosynthetic materials received at the job site are in unopened shipping packages and the packages are clearly labeled with the manufacturer's name, product name, style number, roll dimension and LOT number, otherwise, the Engineer will reject the material. Store geosynthetic materials in accordance with the manufacturer's instructions ensuring to protect the geosynthetic material from physical damage, debris, and temperatures greater than 140° F. Prevent mud, fluid concrete, asphalt, or other deleterious materials from coming in contact with the geosynthetic materials that could impact the performance of the geosynthetic material. Replace geosynthetic materials with defects, tears, punctures, flaws, deterioration, or other damage at no additional cost to the Department.

145-3.2 Geosynthetic Reinforced Soil Slopes:

145-3.2.1 Backfill Materials: Use only free draining backfill material in the reinforced fill volume as shown in the Plans meeting the following gradation limits as determined in accordance with AASHTO T 27 and FM 1-T011:

Table 145-1

Sieve Size	Percent Passing
3-1/2 inches	100
3/4 inch	70 to 100
No. 4	30 to 100
No. 40	15 to 100
No. 100	5 to 65
No. 200	0 to 15

Do not use backfill material containing more than an average of 2.0% by weight of organic material, as determined by FM 1-T267 and by averaging the test results for three randomly selected, representative samples from each stratum or stockpile of a particular material.

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Consider the stratum or stockpile unsuitable for construction of the reinforced fill volume if an individual test value exceeds 3.0%.

Use backfill material with a maximum plasticity index of 6 as determined by AASHTO T 90, and a maximum liquid limit of 15 as determined by AASHTO T 89. Use backfill material with a pH between 5.0 and 10.0 as determined by FM 5-550. For polyester geosynthetic reinforcement, use backfill material with a pH between 5.0 and 9.0.Do not use soil cement or lime stabilized backfill unless approved by the Engineer.

145-3.2.2 Slope Face Treatment: For reinforced soil slopes, provide slope face material, if applicable, as shown in the Plans and listed on the APL.

145-3.3 Geosynthetic Reinforced Foundations Over Soft Soils: Use backfill material meeting the requirements of Section 120, all Contract Documents, and any other applicable specification requirements. Meet the pH criteria specified in 145-3.2.1 as determined by FM 5-550.

145-3.4 Geosynthetic Reinforced Embankment: Use backfill material meeting the requirements of Section 120 for Embankment, Section 160 for Stabilization, Section 200 for Rock Base, and Section 204 for Graded Aggregate Base, all Contract Documents, and any other applicable specification requirements. Meet the pH criteria specified in 145-3.2.1 as determined by FM 5-550.

145-4 Construction Requirements.

145-4.1 General: Obtain from the geosynthetic supplier, technical instructions, guidance in preconstruction activities, and on-site technical assistance during construction. Submit a copy of any instructions provided by the supplier to the Engineer prior to beginning installation.

145-4.2 Geosynthetic Reinforced Soil Slopes:

145-4.2.1 Foundation Preparation: Excavate to the limits shown in the Contract Documents. Remove all existing vegetation and all unsuitable foundation materials. Prepare the foundation in accordance with Section 110 and 120, except as noted herein.

Proof-roll the graded area with a vibratory roller weighing a minimum of 8 tons or a sheepsfoot roller, where appropriate, exerting a compression of at least 250 psi on the tamper foot for at least five passes in the presence of the Engineer or as directed by the Engineer. Remove and replace any soft or loose foundation subsoils that are incapable of sustaining the required proof rolling. Excavate to suitable foundation materials, satisfactory to the Engineer, regardless of the elevation shown in the Plans. Remove all loose and disintegrated rock or thin strata.

Ensure the proof-rolled ground surfaces are uniform, smooth, and free of abrupt changes in slope, debris, and irregularities that might damage the reinforcement. Promptly repair and restore to their original condition any areas outside the limits of disturbance shown in the Plans which are damaged as part of this work at no expense to the Department. Make every possible effort to avoid such damage.

145-4.2.2 Geosynthetic Placement: Place the geosynthetic at the proper elevation, location and orientation as shown in the Plans. In general, place the geosynthetic used for slope stabilization such that its primary direction of tensile strength is perpendicular to the plan face of the slope. Pull the geosynthetic material tight and secure it as necessary to lay flat against the soil prior to fill placement.

Place adjacent rolls of geosynthetic to maintain 100% horizontal coverage at the face of the slope. When placing geosynthetic for curved embankments, do not allow less than 50% horizontal coverage or an unreinforced horizontal spacing greater than 3 feet at the end

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of the reinforcement farthest from the face of the slope. Do not allow vertical spacing of the geosynthetic layers to exceed the spacing shown in the shop drawings.

Do not make any splices or seams in the primary direction of tensile strength in the geosynthetic without approval of the Engineer. When splices in the primary direction are approved, make splices full width of the geosynthetic strip by using a similar material with similar strength. Use a splice mechanism that allows a minimum of 95% load transfer from piece to piece of geosynthetic. Make only one splice per length of geosynthetic. Do not place splices within 6 feet of the slope face, within 6 feet below top of slope, or horizontally adjacent to another splice.

Place only that amount of geosynthetic material, including facing and drainage material, which will be covered in a single days' production.

Do not operate equipment directly on the geosynthetic. Operate equipment such that no turning movements occur on the areas where geosynthetic is in place with less than 12 inches of fill cover. Fill and compact ruts of more than 3 inches in depth as they develop. Replace or repair any rejected geosynthetic at no additional cost to the Department.

145-4.2.3 Backfill Placement: Perform work in accordance with an approved QC Plan meeting the requirements of 105-3. A LOT is defined as a single lift of finished embankment not to exceed 500 feet in length. Maintain uniform moisture content of the backfill material prior to and during compaction throughout each layer of material. Use backfill material having a placement moisture content within 2% on the dry side of optimum. Do not place wet backfill with moisture content greater than optimum in the fill. Spread backfill material over the geosynthetic in the direction of geosynthetic overlaps. Do not stockpile backfill materials on the installed geosynthetic. Avoid construction procedures or equipment which, in the opinion of the Engineer, will cause excessive mudwaving.

Uniformly compact each layer, using equipment that will achieve the required density. Compact the backfill using either smooth wheel or rubber tire rollers. Do not use sheepsfoot, grid rollers, or other types of equipment employing a foot. At the end of each day's operation, slope the backfill surface to permit runoff of rainwater away from the slope face, or provide some other positive drainage. Do not exceed the maximum allowable lift thickness in Section 120.

145-4.2.4 Repairs: Repair geosynthetic damaged during or after installation only after the supplier establishes that the interior and exterior stability is not affected and after obtaining the Engineer's approval. Make such repairs as follows:

Remove all backfill material from the damaged area of the reinforcement geosynthetic plus an additional 4 feet in all directions beyond the limits of damage. Place a patch consisting of the same material as the reinforcement geosynthetic over the damaged area in accordance with the supplier's recommendation. Overlap the undamaged reinforcement geosynthetic with the patch a minimum of 3 feet in all directions. Then replace and compact backfill material in accordance with 145-4.2.3.

145-4.2.5 Slope Face Treatment: Place the slope face treatment at the elevation and location shown in the Plans and are listed on the APL, if applicable.

145-4.3 Geosynthetic Reinforced Foundations Over Soft Soils: This subsection specifies requirements for geosynthetic used to improve embankment stability by strengthening and increasing the embankment stiffness.

145-4.3.1 Preparation: For some applications involving reinforcement of soft in situ soils, the Engineer may require that some vegetation be left in place. If directed in the Plans

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or by the Engineer, cut trees to within 6 inches of the existing surface, and leave the stumps in place. Remove fallen trunks, limbs, etc. greater than 3 inches in diameter.

145-4.3.2 Backfill Placement: Use materials meeting the requirements of 145-3.3. Perform work in accordance with an approved QC Plan meeting the requirements of 105-3 and Section 120 for Embankment, all Contract Documents, and any other applicable specification requirements.

145-4.3.3 Geosynthetic Placement: Meet the requirements of 145-4.2.2 except as noted herein. Position and orient the geosynthetic over prepared surfaces with the machine direction perpendicular to the embankment alignment. Place a geotextile filter of a type recommended by the designer of the geosynthetic system under the reinforcement geosynthetic.

Cut and overlap geosynthetic as necessary to accommodate curves. Overlaps shall be a minimum of 3 feet, unless specified otherwise in the Contract Documents for a particular application. Make any overlaps in geosynthetic in the same direction that embankment will be spread. Ensure geosynthetic sections do not separate at overlaps during construction. Pull the geosynthetic material tight by hand to a tension that removes all slack and wrinkles or as recommended by the supplier. To reduce overlaps, the geosynthetic material may be sewn together in accordance with the supplier's recommendations. Sew the seams with thread meeting the chemical requirements and minimum seam strength requirements for the application.

145-4.3.4 Repairs: Meet the requirements of 145-4.2.4.

145-4.4 Geosynthetic Reinforced Embankment: This subsection specifies requirements for geosynthetic used to provide structural support of traffic loads over the life of the pavement. This reinforcement application involves a relatively shallow flexible pavement substructure (embankment/subgrade/base profile) that is constructed over unsuitable soils that are at or near the ground surface.

145-4.4.1 Preparation: Remove all existing vegetation and all unsuitable foundation materials as shown in the Plans. Prepare the foundation in accordance with Section 110 and 120 or to the limits shown in the Contract Documents.

145-4.4.2 Backfill Placement: Use materials meeting the requirements of 145-3.4. Perform work in accordance with an approved QC Plan meeting the requirements of 105-3, Section 120 for Embankment, Section 160 for Stabilization, Section 200 for Rock Base, and Section 204 for Graded Aggregate Base, all Contract Documents, and any other applicable specification requirements. Spread backfill material over the reinforcement geosynthetic in the direction of the geosynthetic overlaps. Place the first lift of backfill materials over the reinforcement geosynthetic to a minimum thickness of 4 inches. Place backfill material in a manner to avoid any damage or disturbance to the geosynthetic reinforcement material

145-4.4.3 Geosynthetic Placement: Meet the requirements of 145-4.3.3.

145-4.4.3 Repairs: Meet the requirements of 145-4.2.4.

145-5 Certification.

For geosynthetic materials, submit to the Engineer the product label with the manufacturer's name, product name, style number, roll dimension and LOT number at least fourteen days prior to placement. In addition, provide two 8-inch by 10-inch samples of geosynthetic materials for product identification to the Engineer. The acceptance of the geosynthetic material is subject to the approval of the State Materials Office (SMO).

For backfill materials, submit to the Engineer a signed and sealed certification by a Professional Engineer registered in the State of Florida, that the pH meets the requirements of 145-3.

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145-6 Acceptance Program.

145-6.1 General Requirements:

145-6.1.1 Equipment Comparison: Meet the requirements of 120-10.1.1.

145-6.1.2 Initial Production LOT: Meet the requirements of 120-10.1.2 except as modified herein.

145-6.1.3 Density over 105%: Meet the requirements of 120-10.1.3 except as modified herein.

145-6.2 Quality Control Tests:

145-6.2.1 Geosynthetic Reinforced Soil Slopes:

145-6.2.1.1 Maximum Density Determination: Collect enough material to split and create three separate samples. Determine test locations, including stations and offsets, using the Random Number generator approved by the Department. Retain the Verification and Resolution samples for the Department until the Engineer accepts the LOTs represented by the samples. Determine modified Proctor maximum density and optimum moisture content by sampling and testing the material in accordance FM 1-T 180.

When compacting A-3 or A-2-4 materials to meet the optional acceptance criteria in 145-6.2.1.4, determine the maximum density in accordance with FM 1-T099.

145-6.2.1.2 Soil Classification and Organic Content Testing: Perform soil classification tests on the sample collected in 145-6.2.1.1, in accordance with AASHTO T 27 and FM 1-T011, AASHTO T89, AASHTO T90, and FM 1-T267. Classify the soil in accordance with AASHTO M145 to determine compliance with soil utilization requirements as specified in Standard Plans, Index 120-001. Meet the testing parameters set forth in 145-3.2.1.

145-6.2.1.3 pH Testing: Perform pH testing in accordance with FM 5-550 and meet the pH test criteria set forth in 145-3.2.1.

145-6.2.1.4 Density Testing Requirements: Meet the requirements of 120-10.1.4.2 except as modified herein. For select backfill, obtain a density in each LOT of at least 95% of the maximum density as determined by FM 1-T180.

Alternatively, for A-3 and A-2-4 backfill materials, obtain a minimum density of 100% of the standard Proctor maximum dry density as determined by FM 1-T099.

The combined width from both reinforced fill volume and retained fill material may be considered the same LOT if both volumes comprise the same material and both are compacted with the same procedure, lift thickness, equipment, and compacting effort.

145-6.2.1.5 Frequency: Conduct sampling and testing at a minimum frequency listed in the table below. The Engineer will perform verification sampling and tests at a minimum frequency listed in the table below.

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Table 145-2		
Test Name	Quality Control (QC)	Verification
Maximum Density	One per soil type	One per soil type
Density	One per LOT	One per four LOTs
Soil Classification, Gradation, LL & PI	One per soil type	One per soil type
Organic Content	One per soil type	One per soil type
pH	One per soil type	One per soil type

145-6.2.1.6 Test Selection and Reporting: Determine test locations including stations and offsets, using the random number generator approved by the Engineer. Do not use notepads or worksheets to record data for later transfer into the Earthwork Records System (ERS) section of the Department's database. Notify the Engineer upon successful completion of QC testing on each LOT.

145-6.2.2 Geosynthetic Reinforced Foundation Over Soft Soils: Meet the acceptance criteria for backfill and compaction requirements for embankment material in accordance with Section 120, all Contract Documents, and any other applicable specification requirements. In addition to the requirements of the applicable earthwork material, test for pH in accordance with FM 5-550 and meet the pH test criteria set forth in 145-3.2.1.

145-6.2.3 Geosynthetic Reinforced Embankment: Meet the acceptance criteria for backfill and compaction requirements for embankment material in accordance with Section 120, Stabilization requirements in accordance with 160, Rock Base requirements in accordance with Section 200, Graded Aggregate Base requirements in accordance with Section 204, all Contract Documents, and any other applicable specification requirements. In addition to the requirements of the applicable earthwork material, test for pH in accordance with FM 5-550 and meet the pH test criteria set forth in 145-3.2.1.

145-6.3 Department Verification: Meet the requirements of 120-10.1.5 except that the Engineer will conduct Verification tests to accept all materials and work associated with 145-6.2.

145-6.4 Payment for Resolution Tests: Meet the requirements of 120-10.1.7.

145-7 Verification Comparison Criteria and Resolution Procedures.

145-7.1 Geosynthetic Reinforced Soil Slopes:

145-7.1.1 Maximum Density Determination: The Engineer will verify the QC test results in accordance with the procedures specified in 120-10.4.1 except replace FM 1-T099 with FM 1-T180. If the Contractor selects the optional acceptance criteria, the Engineer will verify the QC test results of FM 1-T099 in accordance with 120-10.4.1.

145-7.1.2 Density Testing: Meet the requirements of 120-10.4.2.

145-7.1.3 Soil Classification, Organic Content, and pH Testing: The Engineer will verify the QC test results if the verification test results meet the limits set forth in 145-3.2.1 for gradation (AASHTO T27 and FM 1-T011), liquid limit (AASHTO T89), plasticity index (AASHTO T90), organic content (FM 1-T267), and pH (FM 5-550) testing. Otherwise, the Engineer will test the sample retained in 145-6.2.1.1. The State Materials Office (SMO) or an AASHTO accredited laboratory designated by the SMO will perform resolution testing.

If the resolution test result satisfies the required gradation limits, liquid limit, plasticity index, organic content, and pH, then the LOTs will be verified. If the resolution test

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results do not verify QC test results, then reconstruct the LOTs with acceptable material. The Engineer will perform new verification testing post reconstructing the LOTs.

145-7.2 Geosynthetic Reinforced Foundations Over Soft Soils: Meet the verification comparison criteria and resolution procedure for embankment material in accordance with Section 120. In addition, the Engineer will verify the QC tests results if the verification test results meet the limits set forth in 145-3.2.1 for pH in accordance with FM 5-550. Otherwise, the Engineer will follow the resolution procedures specified in 145-7.1.3.

145-7.3 Geosynthetic Reinforced Embankment: Meet the verification comparison criteria and resolution procedure for embankment material in accordance with Section 120, Stabilization requirements in accordance with 160, Rock Base requirements in accordance with Section 200, and Graded Aggregate Base with Section 204. In addition, the Engineer will verify the QC tests results if the verification test results meet the limits set forth in 145-3.2.1 for pH in accordance with FM 5-550. Otherwise, the Engineer will follow the resolution procedures specified in 145-7.1.3.

145-8 Method of Measurement.

145-8.1 Geosynthetic Reinforced Soil Slopes: The quantity to be paid for will be the plan quantity area, in square feet, of the projected vertical height of the slope face, measured from the top of slope to the finished graded surface at the toe of slope and from the beginning to end limits as shown in the Plans, regardless of the length or number of layers of geosynthetic within the reinforced volume and including any reinforcement required below the toe of slope elevation.

145-8.2 Geosynthetic Reinforced Foundations Over Soft Soils: The quantity to be paid for will be the plan quantity area, in square yards, of the embankment to be reinforced as shown in the Plans, regardless of the length or number of layers of geosynthetic within the reinforced soil volume, and including any reinforcement required below the original ground elevation.

145-8.3 Geosynthetic Reinforced Embankment: Meet the requirements of 145-8.2.

145-9 Basis of Payment.

145-9.1 Geosynthetic Reinforced Soil Slopes: Price and payment will be full compensation for all work, materials, and services specified in this Section, including geosynthetic materials, drainage materials, installation, testing, and required submittals. The cost and placement of all backfill material will be included in the pay quantity for embankment or borrow excavation, as applicable.

145-9.2 Geosynthetic Reinforced Foundations Over Soft Soils: Price and payment will be full compensation for all work, materials, and services specified in this Section, including geosynthetic materials, geotextile filter materials, facing materials, drainage materials, installation, testing, and required submittals. The cost and placement of all backfill will be included in the pay quantity for embankment or borrow excavation, as applicable.

145-9.3 Geosynthetic Reinforced Embankment: Meet the requirements of 145-9.2

145-9.4 Payment Items: Payment will be made under:

Item No. 145- 1-	Geosynthetic Reinforced Soil Slopes - per square foot.
Item No. 145- 2-	Geosynthetic Reinforced Foundations over Soft Soils - per square yard.
Item No. 145- 3-	Geosynthetic Reinforced Embankment - per square yard.

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SECTION 160
STABILIZING

160-1 Description.

Stabilize designated portions of the roadbed to provide a firm and unyielding subgrade, having the required bearing value specified in the Plans.

160-2 Materials.

160-2.1 Commercial Material: Meet the requirements of Section 914-2.1.

160-2.2 Local Material: Submit test results to the Engineer at least 14 days prior to the stabilization operation.

160-2.2.1 Local Stabilizing Material: Sample and test material from each source and meet the requirements of Section 914. The Engineer will verify the Quality Control (QC) test results meet the requirements of Section 914. If the QC and Verification results do not compare, the Engineer will take one additional sample of material from the source in question and the State Materials Office (SMO) or an AASHTO accredited laboratory designated by the SMO will perform Resolution testing. If the Resolution test results satisfy the required criteria, material from that source will be verified and accepted. If the Resolution test results do not meet the required criteria, reject the material.

160-2.2.2 Reclaimed Asphalt Pavement (RAP): Obtain the Engineer's approval in writing for the option to use 100% RAP material. Material must be milled and stockpiled without blending or contaminating with any other material.

160-2.2.3 Reclaimed Asphalt Pavement (RAP) Blended Material: RAP blended material is defined as material meeting the requirements of 914-1 and 914-2.2 except for the limits for organic content. If the RAP blended material meets the requirements of 914-1 and 914-2, then the blended material will be classified as local stabilizing material. Provide test results to the Engineer and obtain their approval in writing before using RAP blended material. The Engineer will verify that the QC test results meet the acceptance criteria, otherwise the Engineer will perform Resolution testing procedures specified in 160-2.2.1.

160-2.3 Existing Base: Obtain the Engineer's approval in writing before using existing base. When the material from an existing base is used as all, or a portion, of the stabilizing additives, no further testing is required unless directed by the Engineer.

160-2.4 Granular Subbase: The Engineer may allow, at no additional cost to the Department, the substitution of 6 inches of granular subbase meeting the requirements of 290-2 and 290-3, only when 12 inches of Type B stabilization requiring a Limerock Bearing Ratio (LBR) value of 40 is specified in accordance with Standard Plans, Index 120-001.

160-3 Construction Methods.

160-3.1 General: Prior to the beginning of stabilizing operations, construct the area to be stabilized to an elevation such that, upon completion of stabilizing operations, the completed stabilized subgrade will conform to the lines and grades shown in the Plans. Prior to spreading any additive stabilizing material, bring the surface of the roadbed to a plane approximately parallel to the plane of the finished graded surface shown in the Plans.

Construct mainline pavement lanes, turn lanes, ramps, parking lots, concrete box culverts, retaining wall systems, shoulder-only areas, sidewalk, and shared use path areas meeting the requirements of 120-8.1, except replace "embankment" with "subgrade".

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Isolated mixing operations will be considered as separate LOTs. Curb pads and shoulders compacted separately shall be considered separate LOTs. Isolated compaction operations will be considered as separate LOTs. For multiple phase construction, a LOT shall not extend beyond the limits of the phase.

160-3.2 Application and Acceptance of Stabilizing Material: After completing the roadbed grading operations, determine the type and quantity (if any) of stabilizing material necessary for compliance with the bearing value requirements. Before using any Fossil Fuel Combustion Products (FFCPs), submit documentation, at the preconstruction meeting or no later than 30 days prior to delivery of FFCP's to the project, signed and sealed by the Specialty Engineer that these materials meet the requirements of 403.7047 F.S. Notify the Engineer of the approximate quantity to be added before spreading. When additive stabilizing materials are required, spread the material uniformly over the area to be stabilized.

The Engineer may perform Independent Verification (IV) sampling and testing if variability in the stabilizing material is observed during inspection after spreading on the roadway. If the IV test results do not meet the requirements of Section 914, then remove and replace the failing LOTs with acceptable material. The Engineer reserves the right to reject stabilizing material that contains excessive deleterious substances.

160-3.3 Mixing: Perform mixing using rotary tillers, a plant or other equipment meeting the approval of the Engineer. The subgrade may be mixed in one course if the equipment and method of construction provides the uniformity, particle size limitation, compaction and other desired results of 160-4. Thoroughly mix the area to be stabilized throughout the entire depth and width of the stabilizing limits.

Perform the mixing operations, as specified, (either in place or in a plant) regardless of whether the existing soil, or any select soils placed within the limits of the stabilized sections, have the required bearing value without the addition of stabilizing materials.

160-3.4 Mixed Material Requirements: At the completion of the mixing, ensure the gradation of the material within the limits of the area being stabilized is such that 97% will pass a 3-1/2 inch sieve. Break down or remove from the stabilized area materials, including clay lumps or lumps made of clay-size particles (any particle size 2 microns or less), not meeting the gradation requirements. After mixing, remove any existing lumps of clay or clay-sized particles greater than one inch that do not meet the requirements of 160-3.2 or this Section from the stabilized area. The final product must meet the acceptance requirements of 160-4.

160-3.4.1 Classification and Bearing Value: Meet the soil utilization and bearing value requirements for the subgrade in accordance with 160-4.

160-3.4.2 Compaction: After completing the mixing operations and satisfying the requirements for bearing value, uniformity, and particle size, compact the materials at a moisture content permitting the specified compaction in 160-4.2.3. If the moisture content of the material is improper for attaining the specified density, either add water or allow the material to dry until reaching the proper moisture content for the specified compaction.

160-3.4.3 Finish Grading: Shape the completed stabilized subgrade to conform with the finished graded surface shown in the Plans. Check the subgrade using elevation stakes or other means approved by the Engineer.

160-3.4.4 Condition of Completed Subgrade: After completing the stabilizing and compacting operations, ensure that the subgrade is firm and substantially unyielding to the extent that it will support construction equipment and will have the bearing value required by the Plans.

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Remove all soft and yielding material, and any other portions of the subgrade which will not compact readily, and replace it with suitable material so that the whole subgrade is brought to line and grade, with proper allowance for subsequent compaction.

160-3.4.5 Maintenance of Completed Subgrade: After completing the subgrade as specified above, maintain it free from ruts, depressions, and any damage resulting from the hauling or handling of materials, equipment, tools, etc. The Contractor is responsible for maintaining the required density until the subsequent base or pavement is in place including any repairs, replacement, etc., of curb and gutter, sidewalk, etc., which might become necessary in order to recompact the subgrade in the event of underwash or other damage occurring to the previously compacted subgrade. Perform any such recompaction at no expense to the Department. Construct and maintain ditches and drains along the completed subgrade section.

160-4 Acceptance Program for Mixed Materials.

160-4.1 General Requirements:

160-4.1.1 Initial Equipment Comparison: Meet the requirements of 120-10.1.1.

160-4.1.2 Initial Production LOT: Meet the requirements of 120-10.1.2.

160-4.1.3 Density over 105%: Meet the requirements of 120-10.1.3.

160-4.1.4 Quality Control Tests:

160-4.1.4.1 Modified Proctor Maximum Density Determination: Collect enough material to split and create three separate samples. Determine test locations, including stations and offsets, using the Random Number generator approved by the Department. Retain the Verification and Resolution samples for the Department until the Engineer accepts the LOTs represented by the samples. Determine modified Proctor maximum density and optimum moisture content by sampling and testing the material in accordance FM 1-T 180.

160-4.1.4.2 Density Testing Requirements: Meet the requirements of 120-10.1.4.2.

160-4.1.4.3 Bearing Value Requirements: Test the stabilized subgrade sample collected in 160-4.1.4.1 to determine the LBR in accordance with FM 5-515. Within the entire limits of the width and depth of the areas to be stabilized, obtain the required minimum bearing value at the frequency in 160-4.4.1. For any area where the bearing value obtained is deficient from the value indicated in the Plans, in excess of the tolerances established herein, spread and mix additional stabilizing material in accordance with 160-3.3. Perform this reprocessing for the full width of the roadway being stabilized and longitudinally for a distance of 50 feet beyond the limits of the area in which the bearing value is deficient.

Determine the quantity of additional stabilizing material to be used in reprocessing.

160-4.1.4.3.1 Under-tolerances in Bearing Value Requirements: The under-tolerances are allowed for the following specified Bearing Values:

Table 160-1

Specified Bearing Value	Under-tolerance
LBR 40	5.0
LBR 35	4.0
LBR 30 (and under)	2.5

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160-4.1.4.3.2 Unsoaked LBR Requirements: If unsoaked LBR is desired, submit request for approval to the Engineer. Upon approval by the Engineer to consider the use of unsoaked LBR, randomly sample and test from three locations in the initial LOT for both soaked and unsoaked LBR in accordance with FM 5-515. Ensure all of the tests achieves the LBR value shown in the table below. Continue testing unsoaked LBR at the frequency shown in 160-4.4.1. Discontinue unsoaked LBR testing if any unsatisfactory QC LBR test result is obtained or resolution determines an unsatisfactory LBR.

The following unsoaked bearing value requirement is based on tests performed on samples obtained after completing mixing operations:

Table 160-2		
Specified Bearing Value	Unsoaked Bearing Value Required	Under-tolerance
LBR 40	LBR 43	0.0

160-4.1.4.4 Soil Classification and Organic Content Testing: Perform soil classification tests on the sample collected in 160-4.1.4.1, in accordance with AASHTO T88, AASHTO T89, AASHTO T90, and FM 1-T 267. The Engineer may waive the soil classification and organic content testing requirements for existing base or granular subbase materials. Classify soils in accordance with AASHTO M145 to determine compliance with soil utilization requirements as specified in Standard Plans, Index 120-001. If the stabilizing material used is 100% RAP or RAP blended material, then replace FM 1-T 267 with FM 5-563 (excluding gradation analysis). The following testing requirements must be met.

Table 160-3	
Test Method	Criteria
AASHTO M145	Soil Symbol = S
FM 1-T 267	Average of 3 Organic Content ≤ 2.5%
	Individual Organic Content Result ≤ 4.0%
AASHTO T89	Liquid Limit ≤ 30
AASHTO T90	Plastic Index ≤ 8
FM 5-563*	Asphalt Content ≤ 4.0%
* Replace FM 1-T 267 with FM 5-563 (excluding gradation analysis) for 100% RAP or RAP blended material	

160-4.1.5 Department Verification: Meet the requirements of 120-10.1.5 except the Engineer will conduct the Verification tests in order to accept all materials and work associated with 160-4.1.4.

160-4.1.6 Reduced Testing Frequency: Meet the requirements of 120-10.1.6.

160-4.1.7 Payment for Resolution Tests: Meet the requirements of 120-10.1.7.

160-4.2 Mixing Depth Requirements: Report depth requirements in the Earthwork Records System (ERS) section of the Department's database measured to the nearest 0.25 inch. The difference between the individual measured depth thickness on the roadway and the plan target thickness must not exceed 2 inches. The difference between the LOT average (average of

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the three individual measured depth thickness) and the plan target thickness must not exceed 1 inch. No undertolerance of mixing depth is allowed.

As an exception to the above mixing requirements, where the subgrade is of rock, the Engineer may waive the mixing operations (and the work of stabilizing), and the Department will not pay for stabilization for such sections of the roadway.

Meet the required Plan mixing-depths by measuring from the proposed final grade line. Determine test locations, including stations and offsets, using the Random Number generator approved by the Department. Notify the Engineer a minimum of 24 hours before checking mixing depths. Record results on Department approved forms.

160-4.3 Density Acceptance Criteria:

160-4.3.1 General: Within the entire limits of the width and depth of the areas to be stabilized, other than as provided in 160-4.3.2, obtain a minimum density at any location of 98% of the Modified Proctor maximum density as determined by FM 1-T 180.

160-4.3.2 Exceptions to Density Requirements: The Contractor need not obtain the minimum density specified in 160-4.3.1 in the upper 6 inches of areas to be grassed under the same Contract. Compact these areas to a reasonably firm condition as directed by the Engineer.

160-4.4 Additional Requirements:

160-4.4.1 Frequency: Conduct QC sampling and testing at a minimum frequency listed in the table below. The Engineer will perform Verification sampling and tests at a minimum frequency listed in the table below.

Table 160-4

Test Name	Quality Control	Verification	Verification for Shoulder-Only, Shared Use Path and Sidewalk Construction
Modified Proctor Maximum Density	One per two consecutive LOTs	One per eight consecutive LOTs	One per four LOTs
LBR			
Gradation, LL/PI, and Soil Classification			
Organic Content			
Asphalt Content*			
Density	One per LOT	One per four LOTs	One per two LOTs
Stabilizing Mixing Depth	Three per 500 feet	Witness QC	Witness QC

*Replace organic content with asphalt content for 100% RAP or RAP blended material only.

160-4.5 Verification Comparison Criteria and Resolution Procedures:

160-4.5.1 Bearing Value: The Engineer will collect a sample at a location other than the location where the sample was collected in 160-4.1.4.1, and test the stabilized subgrade for determination of the LBR in accordance with FM 5-515. The Engineer will select test locations, including stations and offsets, using a Random Number generator, based on the LOTs under consideration.

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160-4.5.1.1 Unsoaked LBR: The Engineer will sample and test the initial LOT for one soaked and one unsoaked LBR if consideration of the unsoaked LBR has been approved.

160-4.5.1.2 Resolution Procedure: If the Department's Verification test meets the requirements of 160-4.1.4.3, the Engineer will accept the corresponding LOTs. Otherwise, the Engineer will collect an additional sample in the same LOT the Verification sample was obtained. SMO or an AASHTO accredited laboratory designated by SMO will perform Resolution testing on the additional sample. The material will be sampled and tested in accordance with FM 5-515.

If the resolution testing results meet the requirements of 160-4.1.4.3, then the Engineer will accept the LOTs in question. Otherwise reprocess the corresponding LOTs in accordance with 160-3 and retest in accordance with 160-4.1.4.3.

160-4.5.2 Modified Proctor Maximum Density Determination: The Engineer will randomly select one of the retained split samples referenced in 160-4.1.4.1. The Engineer will compare the Verification test results to the corresponding Quality Control (QC) test results. If the test result is within 4.5 lb/ft^3 of the QC test result, the LOTs will be verified. Otherwise, the Engineer will collect the Resolution split sample corresponding to the Verification sample tested. The State Materials Office or an AASHTO accredited laboratory designated by the State Materials Office will perform Resolution testing. The material will be sampled and tested in accordance with FM 1-T 180.

The Engineer will compare the Resolution Test (RT) results with the QC test results. If the RT result is within 4.5 lb/ft^3 of the corresponding QC test result, the Engineer will use the QC test results for material acceptance purposes for each corresponding pair of LOTs. If the RT result is not within 4.5 lb/ft^3 of the corresponding QC test, the Engineer will collect and test the remaining Verification split samples for the LOTs in question. Verification test results will be used for material acceptance purposes for the remaining LOTs in question.

160-4.5.3 Density Testing: Meet the requirement of 120-10.4.2

160-4.5.4 Soil Classification: Meet the requirements of 120-10.4.3 with the exception that the limits will be in accordance with 160-4.1.4.4.

160-4.5.5 Organic Content: Meet the requirements of 120-10.4.4 with the exception that the limits will be in accordance with 160-4.1.4.4.

160-4.5.6 Asphalt Content: If the material used to stabilize is 100% RAP or RAP blended material, meet the requirement of 120-10.4.4, except replace FM 1-T 267 with FM 5-563 (exclude gradation analysis) and meet the limits of 160-4.1.4.4.

160-4.5.7 Mixing Depth: The Engineer will witness the Contractor's mixing depth checks to ensure compliance with 160-4.2. The Engineer will select test locations, including stations and offsets, using a Random Number generator. The Department will witness the mixing depth checks.

1. If the depth checks meet the requirements of 160-4.2, the Engineer will accept that 500-foot section.

2. If the depth checks confirm shallow depth, re-mix the 500-foot section to an appropriate depth and re-measure in accordance with 160-4.2. The Engineer will repeat the witness process.

3. If the depth checks confirm extra deep mixing, conduct an additional QC density test after compaction for the bottom 12 inches of the subgrade for that 500-foot

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section in addition to a QC density test for the top 12 inches. The additional density test must meet the requirements of 160-4.3.

160-4.6 Disposition of Defective Materials: Meet the requirements of 120-10.5.

160-5 Method of Measurement.

The quantity to be paid for will be the plan quantity, in square yards, completed and accepted.

160-6 Basis of Payment.

Price and payment will constitute full compensation for all work and materials specified in this Section, including furnishing, spreading and mixing of all stabilizing material required and any reprocessing of stabilization areas necessary to attain the specified bearing value. The Department will make full payment for any areas where the existing subgrade materials meet the design bearing value requirements without the addition of stabilizing additives, as well as areas where the Contractor may elect to place select high-bearing materials from other sources within the limits of the stabilizing.

If the item of borrow excavation is included in the Contract, any stabilizing materials obtained from designated borrow areas will be included in the pay quantity for borrow excavation.

Payment will be made under:

Item No. 160- 4- Stabilization - per square yard.

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SECTION 175
CRACKING AND RESEATING EXISTING CONCRETE PAVEMENT

175-1 Description.

Perform controlled cracking of concrete pavement and reseating of the cracked slabs, by rolling, tamping, etc., on the underlying subgrade to provide a firm base for asphalt concrete surfacing.

175-2 Equipment.

175-2.1 For Cracking: Provide pneumatic or gravity-type breakers, or other specifically approved equipment that ensures controlled cracking to the size and extent of uniformity, etc., specified. Control the fall of gravity-type breakers by leads so that the fall will be straight and vertical. Use hammers for both pneumatic and gravity-type breakers of a type that will crack the concrete cleanly and not punch or unnecessarily shatter the concrete.

175-2.2 For Reseating Provide vibratory compacting equipment or traffic rollers. Use traffic rollers that weigh at least 15 tons.

175-3 Construction Requirements.

175-3.1 Protection of New Construction and Adjacent Structures: Perform cracking and reseating work prior to beginning all new construction which this work might endanger or disturb. Perform cracking and reseating in a manner that will not damage any existing structures which are to remain, and repair any damage to such structures that this work causes by this work at no expense to the Department.

175-3.2 Cracking and Seating: For the cracked slabs, make clean fractures, as near vertical as practicable. Do not punch the pieces into the subgrade, but firmly seat them thereon, to as uniform a contour as is practicable.

175-3.3 Special Requirements for Asphalt-Surfaced Pavement: Where the existing concrete pavement is covered with an asphalt surface, remove the asphalt surfacing (after the cracking operation) on test areas approximately 10 by 10 feet, at locations selected by the Engineer, in order to determine if the required results are being obtained in the cracking operations. Prepare at least one such test area for each day's operation, and prepare additional areas if deemed necessary by the Engineer.

175-3.4 Dimensions of Slabs: Ensure that the cracked slabs have no dimension greater than 3 feet. In the event that the required results in the cracking are not being obtained, adjust the spacing of blows or the height of drop of the blows as necessary to obtain the required results with the equipment being used.

175-4 Method of Measurement.

The quantity to be paid for will be the plan quantity, in square yards, of existing concrete pavement acceptably cracked and reseated on the subgrade.

175-5 Basis of Payment.

Price and payment will be full compensation for performing and completing all work specified in this Section.

Payment will be made under:

Item No. 175- 1- Reseating Concrete Pavement - per square yard.

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SECTION 200
ROCK BASE

200-1 Description.

Construct a base composed of base rock. Do not use recycled concrete aggregate (RCA) base on interstate roadways.

200-2 Materials.

200-2.1 General: Meet the requirements of Section 911for the particular type of base to be constructed. The Contractor may use more than one source of base rock on a single Contract provided that a single source is used throughout the entire width and depth of a section of base. Obtain approval from the Engineer before placing material from more than one source. Place material to ensure total thickness single source integrity at any station location of the base. Intermittent placement or "blending" of sources is not permitted. Base rock may be referred to hereinafter as "rock".

The reuse of existing base may be considered provided it meets the requirements of this Section. Submit as a Cost Savings Initiative Proposal in accordance with Section 4.

200-2.2 Existing Rock: Meet the following requirements for use of existing rock on the same project:

1. Notify the Engineer in writing prior to excavating existing rock. Do not mill any existing rock from the roadway.
2. Submit a process control plan, herein referred to as "Plan" consisting of the following:
    a. Locations where existing rock will be removed from the roadway.
    b. Locations where existing rock will be used for new construction.
    c. Method of excavation, transport, and placement to ensure excavated rock will be kept separate from other approved stockpiles. Excavation methods that may result in damage to the rock rendering it unfit to be used as base will not be approved.
    d. Proposed measures to prevent contamination and segregation.
    e. Proposed locations and methods for constructing stockpiles for sampling and testing.
    f. Method for sampling and reporting test results.
3. The Engineer will coordinate the review of the "Plan" with the District Materials Office.
4. Upon the Engineer's review of the "Plan", build a preliminary stockpile, not to exceed 1,000 cubic yards.
5. Collect and test a minimum of three samples from the preliminary stockpile. Once the stockpile has been sampled, do not add any additional material to the stockpile. Determine compliance with 200-2.1, with the exception of carbonate contents. Reject any stockpile if the Limerock Bearing Ratio (LBR) is less than 100. Engineer will sample and test the preliminary stockpile to verify compliance with this Section.
6. If all test results meet the requirements of this Section, the Engineer will notify the Contractor in writing of the approved status of the preliminary stockpile based on the analysis of test data performed by the District Materials Office.

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7. If the use of existing rock is approved, continue to produce additional stockpiles not exceeding 1,000 cubic yards. Ensure the rock meets the requirements of this Section by sampling and testing each new stockpile at a minimum frequency of one sample per 400 cubic yards. Once a stockpile has been sampled, do not add additional material to that stockpile. The District Materials Office may also perform sampling and testing. Materials will be accepted if test results meet the requirements of this Section.

8. After 10 consecutive quality control (QC) LBR test results meet the requirements of the Section and no individual LBR test is less than 120, the sampling and testing frequency may be reduced to a minimum frequency of one sample per 800 cubic yards for each stockpile. Notify the Engineer in writing prior to reducing testing frequency. If any QC LBR test result falls below 120 or a stockpile is rejected, revert to original sampling frequency of one sample per 400 cubic yards.

9. Construct a new preliminary stockpile if there is a change in material, conditions not addressed in the "Plan" are encountered, or if production varies from the approved "Plan".

200-3 Equipment.

Use mechanical rock spreaders, equipped with a device that strikes off the rock uniformly to laying thickness, capable of producing even distribution. For crossovers, intersections and ramp areas; roadway widths of 20 feet or less; the main roadway area when forms are used and any other areas where the use of a mechanical spreader is not practicable; the Contractor may spread the rock using bulldozers or blade graders.

200-4 Transporting Rock.

Transport the rock to its point of use, over rock previously placed, if practicable, and dump it on the end of the preceding spread. Hauling and dumping on the subgrade will be permitted only when, in the Engineer's opinion, these operations will not be detrimental to the subgrade.

200-5 Spreading Rock.

200-5.1 Method of Spreading: Spread the rock uniformly. Remove all segregated areas of fine or coarse rock and replace them with properly graded rock.

200-5.2 Number of Courses: When the specified compacted thickness of the base is greater than 6 inches, construct the base in multiple courses of equal thickness. Individual courses shall not be less than 3 inches. The thickness of the first course may be increased to bear the weight of the construction equipment without disturbing the subgrade.

If, through field tests, the Contractor can demonstrate that the compaction equipment can achieve density for the full depth of a thicker lift, and if approved by the Engineer, the base may be constructed in successive courses of not more than 8 inches compacted thickness. The Engineer's approval of thick lift compaction will be based on results of a successful test section constructed using the Contractor's specified compaction effort. Notify the Engineer prior to beginning construction of a test section. Construct a test section of the length of one full LOT. Perform two sets of QC density tests per source at random locations within the test section. Each set will include five density tests. One set will include the entire lift thickness and the second set a dig down test of the bottom 6 inches at the same location where the thick lift test was taken.

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All QC tests and a Department Verification test must meet the density required by 200-7.2.1. Identify the test section with the compaction effort and thickness in the Earthwork Records System (ERS) portion of the Department's database. Remove the materials above the bottom 6 inches, at no expense to the Department. After completion of a successful test section, the minimum density required on the thicker lift from thereon will be the average of the five density test results obtained on the thick lift.

Maintain the exposed surface as close to "undisturbed" as possible; no further compaction will be permitted during the test preparation. If unable to achieve the required density, remove and replace or repair the test section to comply with the specifications at no additional expense to the Department. The Contractor may elect to place material in 6 inches compacted thickness at any time.

Once approved, a change in the source of base material will require the construction of a new test section. Do not change the compaction effort once the test section is approved. The Engineer will periodically verify the density of the bottom 6 inches during thick lift operations.

The Engineer may terminate the use of thick lift construction and instruct the Contractor to revert to the 6 inches maximum lift thickness if the Contractor fails to achieve satisfactory results or meet applicable specifications.

200-5.3 Rock Base for Shoulder Pavement: Unless otherwise permitted, complete all rock base shoulder construction at any particular location before placing the final course of pavement on the traveled roadway. When dumping material for the construction of a rock base on the shoulders, do not allow material capable of scarring or contaminating the pavement surface on the adjacent pavement. Immediately sweep off any rock material that is deposited on the surface course.

200-6 Compacting and Finishing Base.

200-6.1 General: Construct mainline pavement lanes, turn lanes, ramps, parking lots, concrete box culverts and retaining wall systems meeting the requirements of 120-8.1, except replace "embankment" with "base".

Construct shoulder-only areas, shared use paths, and sidewalks. Meet the requirements of 120-8.1 except replace "embankment" with "base" meeting the acceptance criteria of 200-7.2. Shoulders compacted separately shall be considered separate LOTs.

200-6.1.1 Single Course Base: After spreading, scarify the entire surface, then shape the base to produce the required grade and cross slope, free of scabs and laminations, after compaction.

200-6.1.2 Multiple Course Base: Clean the first course of foreign material, then blade and bring it to a surface cross slope approximately parallel to the finished base. Before spreading any material for the upper courses, allow the Engineer to make density tests for the lower courses to determine that the required compaction has been obtained. After spreading the material for the top course, scarify finish and shape its surface to produce the required grade and cross slope, free of scabs and laminations, after compaction.

200-6.2 Moisture Content: When the material does not have the proper moisture content to ensure the required density, wet or dry it as required. When adding water, uniformly mix it in to the full depth of the course that is being compacted. During wetting or drying operations, manipulate, as a unit, the entire width and depth of the course that is being compacted.

200-6.3 Thickness Requirements: Within the entire limits of the length and width of the finished base, meet the specified plan thickness in accordance with the requirements of 200-7.3.1.2.

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200-6.4 Correction of Defects:

200-6.4.1 Contamination of Base Material: If, at any time, the subgrade material becomes mixed with the base course material, dig out and remove the mixture, and reshape and compact the subgrade. Then replace the materials removed with clean base material, and shape and compact as specified above. Perform this work at no expense to the Department.

200-6.4.2 Cracks and Checks: If cracks or checks appear in the base, either before or after priming, which, in the opinion of the Engineer, would impair the structural efficiency of the base, remove the cracks or checks by rescarifying, reshaping, adding base material where necessary, and recompacting.

200-6.5 Compaction of Widening Strips: Where base construction consists of widening strips and the trench width is not sufficient to permit use of standard base compaction equipment, compact the base using vibratory compactors, trench rollers or other special equipment which will achieve the density requirements specified herein.

When multiple course base construction is required, compact each course prior to spreading material for the overlaying course.

200-7 Acceptance Program.

200-7.1 General Requirements: Meet the requirements of 120-10, except exclude the requirements of 120-10.1.4.3, 120-10.3.1, 120-10.4.3, and 120-10.4.4. Use 200-7.3.1.1 instead of 120-10.1.4.1, 200-7.2 instead of 120-10.2, and 200-7.4.1 instead of 120-10.4.1.

200-7.2 Acceptance Criteria:

200-7.2.1 Density: Within the entire limits of the width and depth of the base, obtain a minimum density in any LOT of 98% of modified Proctor maximum density as determined by FM 1-T180 or the Pit Proctor when using the Pit Proctor option. For shoulder only areas and shared use paths, obtain a minimum density of 95% of the modified Proctor maximum density as determined by FM 1-T180 or the Pit Proctor when using the Pit Proctor option.

200-7.2.2 Frequency: Conduct QC sampling and testing at a minimum frequency listed in the table below. The Engineer will perform Verification sampling and tests at a minimum frequency listed in the table below.

Table 200-1
Mainline Pavement Lanes, Turn Lanes, Ramps, Parking Lots, Concrete Box Culverts and Retaining Wall Systems

Test Name	Quality Control	Verification
Modified Proctor Maximum Density	One per eight consecutive LOTs	One per 16 consecutive LOTs
Density	One per LOT	One per four LOTs
Roadway Surface and Cross Slope	One per LOT	One per two LOTs
Roadway Thickness	Three per LOT	Witness

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Table 200-2 Shoulder-Only, Shared Use Path and Sidewalk Construction		
Test Name	Quality Control	Verification
Modified Proctor Maximum Density	One per two LOTs	One per four LOTs
Density	One per LOT	One per two LOTs
Surface and Cross Slope	One per LOT	One per two LOTs
Thickness	Three per 1000 consecutive feet	Witness

200-7.2.3 Pit Proctor: In lieu of Modified Proctor Maximum Density testing at the roadway, notify the Engineer in writing that the Contractor option to use the Pit Proctor supplied by the Department will be used. The Modified Proctor maximum density frequency requirements of 200-7.2.2 shall not apply. The Department will determine the Pit Proctor from statistical analysis of the base rock Modified Proctor maximum density at Department approved mines. For posting of Mines and Pit Proctors for each calendar quarter refer to the Pit Proctor Quarterly report located at the following URL: https://www.fdot.gov/materials/laboratory/geotechnical/aggregates/pitproctor/index.shtm. Use the current posted Pit Proctor value in lieu of the Modified Proctor maximum density required by 200-7.2.1. Use the current posted Pit Proctor value for density acceptance during the quarter corresponding to the posting. Notify the Engineer in writing if returning to the provisions of 200-7.2 and 200-7.2.2 but do not re-elect to use the Pit Proctor until the start of the next calendar quarter.

200-7.3 Additional Requirements:

200-7.3.1 Quality Control Testing:

200-7.3.1.1 Modified Proctor Maximum Density Requirement: Collect enough material to split and create three separate samples and retain two for the Engineer's Verification and Resolution testing until the Engineer accepts the 16 LOTs represented by the samples.

200-7.3.1.2 Thickness and Surface Testing Requirements: Notify the Engineer a minimum of 24 hours before checking base depths and surface checking. Determine test locations including Stations and Offsets, using the Random Number generator approved by the Department. Do not perform depth and surface checks until the Engineer is present to witness. Enter test results into the Department's database. Perform thickness check on the finished base or granular subbase component of a composite base. Provide traffic control, coring/boring equipment, and an operator for the coring/boring equipment. Traffic control is to be provided in accordance with the standard maintenance of traffic requirements of the Contract.

The thickness is considered deficient, if the measured depth is over 1/2 inch less than the specified thickness. Correct all deficient areas of the completed base by scarifying and adding additional base material. As an exception, if authorized by the Department, such areas may be left in place without correction and with no payment.

Check the finished surface of the base course using a Global Navigation Satellite System enabled Automated Machine Guidance technology in accordance with Section 5. Alternately, the finished surface of the base course can be verified using stringline method with stakes or with a template cut to the required crown and with a 15-foot straightedge laid parallel to the centerline of the road. Correct all irregularities greater than ¼-

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inch to the satisfaction of the Engineer by scarifying and removing or adding rock as required, and recompact the entire area as specified hereinbefore.

200-7.3.1.2.1 Thickness and Surface Reduced Testing Frequency: When no Resolution testing is required for 12 consecutive verified LOTs, or if required, the QC test data was upheld, reduce the QC surface and/or thickness checks to one half the minimum requirements as stated in 200-7.2.2 (e.g., reduce frequency from ten per LOT to ten per two LOTs) by identifying the substantiating tests and notifying the Engineer in writing prior to starting reduced frequency of testing. If the Verification test fails, and QC test data is not upheld by Resolution testing the QC testing will revert to the original frequency of 200-7.2.2. The results of the Independent Verification testing will not affect the frequency of the QC testing. Do not apply reduced testing frequency in construction of shoulder-only areas, shared use paths, and sidewalks.

200-7.3.1.3 Cross Slope: Construct base surface course to conform to the lines and grades shown in the Plans. Furnish a level with a minimum length of 4 feet with a digital slope measuring device approved by the Engineer for control of the cross slope. Make this level available at the jobsite at all times during base construction operations.

Measure the cross slope of the base surface by placing the measuring device perpendicular to the roadway centerline. Report the cross slope to the nearest 0.1%. Record all the measurements and submit to the Engineer for documentation. Measure the cross slope at a minimum frequency of one measurement per LOT to ensure the cross slope is uniform and in compliance with the design cross slope. When the difference between the measured cross slope and the design cross slope exceeds ±0.2% for travel lanes including turn lanes or ±0.5% for shoulders, make all corrections to bring the cross slope to acceptable range by scarifying and removing or adding rock as required, and recompact the entire area as specified hereinbefore.

200-7.3.1.4 Elevation Data Collection: Within curb-and-gutter and widening areas, record the elevation of finished surface of base course every 500 feet by measuring the elevation of base adjacent to curb and gutter, as well as at each lane edge location. Provide the elevation measurements to the Engineer.

200-7.3.2 Department Verification Tests:

200-7.3.2.1 Maximum Density: The Engineer will randomly select one of the remaining two split samples and test in accordance with FM 1-T180.

200-7.3.2.2 Thickness and Surface Testing Requirements: The Department will witness the base depth and surface checks to ensure compliance with 200-7.3.1.2. If the QC test results are not deficient as defined in 200-7.3.1.2, the LOT or 500-foot section will be accepted. If the QC test results are deficient, resolve deficiencies in accordance with 200-7.3.1.2. Repeat acceptance testing. Provide traffic control, coring/boring equipment, and an operator for the coring/boring equipment.

200-7.3.2.3 Cross Slope: The Engineer will take cross slope measurements at random locations at a frequency of one per two LOTs.

200-7.4 Verification Comparison Criteria and Resolution Procedures:

200-7.4.1 Modified Proctor Maximum Density: The Engineer will compare the Verification test results of 200-7.3.2.1 to the corresponding QC test results. If the test result is within 4.5 lb/ft^3 of the QC test result, the LOTs will be verified. Otherwise, the Engineer will collect the Resolution split sample corresponding to the Verification sample tested. The State Materials Office or an AASHTO accredited laboratory designated by the State Materials Office

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will perform Resolution testing. The material will be sampled and tested in accordance with FM 1-T180.

The Engineer will compare the Resolution Test results with the QC test results. If the Resolution Test result is within 4.5 lb/ft^3 of the corresponding QC test result, the Engineer will use the QC test results for material acceptance purposes for each corresponding set of LOTs. If the Resolution test result is not within 4.5 lb/ft^3 of the corresponding QC test, the Engineer will collect the remaining Verification split sample for testing. Verification Test results will be used for material acceptance purposes for the LOTs in question**.**

200-7.4.2 Pit Proctor: When using the Pit Proctor option, the Engineer will select a random location to sample and test at the minimum frequency in the table below, to obtain an Independent Verification (IV) maximum density as determined by FM 1-T180. The Engineer will collect enough material to split and hold a sample for Resolution testing.

Table 200-3		
Test Name	Mainline Pavement Lanes, Turn Lanes, Ramps, Parking Lots, Concrete Box Culverts and Retaining Wall Systems	Shoulder-Only, Shared Use Path and Sidewalk Construction
IV Modified Proctor Maximum Density	One per 16 consecutive LOTs	One per 4 consecutive LOTs

The Engineer will compare the IV results with the Pit Proctor. If the IV result is lower than or equal to the Pit Proctor plus 4.5 pcf, keep the option to use the Pit Proctor. If the IV result is more than 4.5 pcf higher than the Pit Proctor the Engineer will test the Resolution sample and compare the Resolution result with the Pit Proctor. If the Resolution result is lower than or equal to the Pit Proctor plus 4.5 pcf, keep the option to use the Pit Proctor. Otherwise return to the provisions of 200-7.2.2, 200-7.3.1.1, 200-7.3.2.1, and 200-7.4.1.

200-7.4.3 Density: When a Verification or Independent Verification density test does not meet the requirements of 200-7.2.1 (Acceptance Criteria), meet the resolution requirements of 120-10.4.2.

200-7.4.4 Surface Testing Requirements: Resolve deficiencies in accordance with 200-7.3.1.2.

200-7.4.5 Cross Slope: The Engineer will verify the Contractor's cross slope measurements if the average cross slope of ten random measurements does not exceed the allowable tolerance from the design cross slope (±0.2% for travel lanes including turn lanes and ±0.5% for shoulders). Otherwise reprocess the LOTs in question by making corrections in accordance with 200-7.3.1.3 to bring the cross slope to acceptable range. A recheck of the cross slope will be made following any corrections or additional work performed on the base surface. This process will be repeated until the base cross slope meets the requirements of this specification.

The Engineer may waive the corrections specified above at no reduction in payment if the following conditions are met:

1. the deficiencies are sufficiently separated so as not to affect the overall ride quality, traffic safety, and surface drainage characteristics of the pavement.

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2. the Contractor agrees to use asphalt to fill in areas where the earthwork is low at no additional cost to the Department when the overall project amount is greater than the 10% allowed in Sections 234, 334, 337, and 339.

For intersections, tapers, crossovers, transitions at beginning and end of project and similar areas, adjust the cross slope to match the actual site conditions or as directed by the Engineer.

200-8 Priming and Maintaining.

200-8.1 Priming: Apply the prime coat only when the base meets the specified density requirements and when the moisture content in the top half of the base does not exceed the optimum moisture of the base material. At the time of priming, ensure that the base is firm, unyielding and in such condition that no undue distortion will occur. Ensure the prime coat adheres to the base course.

200-8.2 Maintaining: Maintain the true crown and template, with no rutting or other distortion, while applying the surface course.

200-9 Calculations for Average Thickness of Base.

For bases that are not mixed in place, the Engineer will determine the average thickness from the measurements specified in 200-10.1, calculated as follows:

1. When the measured thickness is more than 1/2 inch greater than the design thickness shown on the typical section in the Plans, it will be considered as the design thickness plus 1/2 inch.

2. Average thickness will be calculated per typical section for the entire job as a unit.

3. Any areas of base left in place with no payment will not be included in the calculations.

4. Where it is not possible through borings to distinguish the base materials from the underlying materials, the thickness of the base used in the measurement will be the design thickness.

200-10 Method of Measurement.

200-10.1 General: The quantity to be paid for will be the plan quantity, adjusted as specified below.

200-10.2 Authorized Normal Thickness Base: The surface area of authorized normal thickness base to be adjusted will be the plan quantity as specified above, omitting any areas not allowed for payment under the provisions of 200-6.3 and omitting areas which are to be included for payment under 200-10.3. The adjustment shall be made by adding or deducting, as appropriate, the area of base represented by the difference between the calculated average thickness, determined as provided in 200-9, and the specified normal thickness, converted to equivalent square yards of normal thickness base.

200-10.3 Authorized Variable Thickness Base: Where the base is constructed to a compacted thickness other than the normal thickness as shown on the typical section in the Plans, as specified in the Plans or ordered by the Engineer for providing additional depths at culverts or bridges, or for providing transitions to connecting pavements, the volume of such authorized variable thickness compacted base will be calculated from authorized lines and grades, or by other methods selected by the Engineer, converted to equivalent square yards of normal thickness base for payment.

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200-11 Basis of Payment.

Price and payment will be full compensation for all the work specified in this Section, including dust abatement, correcting all defective surface and deficient thickness, removing cracks and checks as provided in 200-6.4.2, the prime coat application as directed in 300-8, and the additional rock required for crack elimination.

Payment shall be made under:

Item No. 285- 7- Optional Base - per square yard.

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SECTION 204
GRADED AGGREGATE BASE

204-1 Description.

Construct a base course composed of graded aggregate.

204-2 Materials.

Use graded aggregate material, produced from Department approved sources, which yields a satisfactory mixture meeting all the requirements of these Specifications after it has been crushed and processed as a part of the mining operations.

The Contractor may furnish the material in two sizes of such gradation that, when combined in a central mix plant pugmill, the resultant mixture meets the required specifications.

Use graded aggregate base material of uniform quality throughout, substantially free from vegetable matter, shale, lumps and clay balls, and having a Limerock Bearing Ratio value of not less than 100. Use material retained on the No. 10 sieve composed of aggregate meeting the following requirements:

Soundness Loss, Sodium, Sulfate: AASHTO T104 ..... 15%

Percent Wear: AASHTO T 96 (Grading A)

Group 1 Aggregates 45%

Group 2 Aggregates 65%

Group 1: This group of aggregates is composed of limestone, marble, or dolomite.

Group 2: This group of aggregates is composed of granite, gneiss, or quartzite.

Use graded aggregate base material meeting the following gradation:

Table 204-1

Sieve Size	Percent by Weight Passing
2 inch	100
1-1/2 inch	95 to 100
3/4 inch	65 to 90
3/8 inch	45 to 75
No. 4	35 to 60
No. 10	25 to 45
No. 50	5 to 25
No. 200	0 to 10

For Group 1 aggregates, ensure that the fraction passing the No. 40 sieve has a Plasticity Index (AASHTO T 90) of not more than 4.0 and a Liquid Limit (AASHTO T 89) of not more than 25, and contains not more than 67% of the weight passing the No. 200 sieve.

For Group 2 aggregates, ensure that the material passing the No. 10 sieve has a sand equivalent (AASHTO T 176) value of not less than 28.

The Contractor may use graded aggregate of either Group 1 or Group 2, but only use one group on any Contract. (Graded aggregate may be referred to hereinafter as “aggregate”.)

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204-3 Equipment.

Provide equipment meeting the requirements of 200-3.

204-4 Transporting Aggregate.

Transport aggregate as specified in 200-4.

204-5 Spreading Aggregate.

Spread aggregate as specified in 200-5.

204-6 Compacting and Finishing Base.

204-6.1 General: Meet the requirements of 200-7.1 with density requirements of 204-6.3.

204-6.1.1 Single-Course Base: Construct as specified in 200-6.1.1.

204-6.1.2 Multiple-Course Base: Construct as specified in 200-6.1.2.

204-6.2 Moisture Content: Meet the requirements of 200-6.2.

204-6.3 Density Requirements: After attaining the proper moisture conditions, uniformly compact the material to a density of not less than 100% of the maximum density as determined by FM 1-T 180, Method D. For shoulder only areas and shared use paths, obtain a minimum density of 98% of the maximum density as determined by FM 1-T 180, Method D.

204-6.4 Density Tests: Meet the requirements of 200-7.2.2.

204-6.5 Correction of Defects: Meet the requirements of 200-6.4.

204-6.6 Dust Abatement: Minimize the dispersion of dust from the base material during construction and maintenance operations by applying water or other dust control materials.

204-7 Testing Surface.

Test the surface in accordance with the requirements of 200-7.

204-8 Priming and Maintaining.

Meet the requirements of 200-8.

204-9 Thickness Requirements.

Meet the requirements of 285-6.

204-10 Calculations for Average Thickness of Base.

Calculations for determining the average thickness of base will be made in accordance with 285-7.

204-11 Method of Measurement.

204-11.1 General: The quantity to be paid for will be the plan quantity area, in square yards, completed and accepted.

204-11.2 Authorized Normal Thickness Base: The surface area of authorized normal thickness base will be the plan quantity area, omitting any areas not allowed for payment under the provisions of 204-9 and omitting areas which are to be included for payment under 204-11.3. The area for payment, of authorized normal thickness base, will be the surface area determined as provided above, adjusted by adding or deducting, as appropriate, the area of base represented by the difference between the calculated average thickness, determined as provided in 204-10, and the specified normal thickness, converted to equivalent square yards of normal thickness base.

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204-11.3 Authorized Variable Thickness Base: As specified in 200-10.3.

204-12 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including dust abatement, correcting all defective surface and deficient thickness, removing cracks and checks and the additional aggregate required for such crack elimination.

Payment will be made under:

Item No. 285- 7- Optional Base - per square yard.

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SECTION 210
REWORKING LIMEROCK BASE

210-1 Description.

Rework (or rework and widen) the existing rock base, by adding new limerock material as required by the Plans. Construct adjacent turnouts, entirely with new limerock.

210-2 Materials.

Meet the following requirements:

Limerock ..... Section 911
Prime Coat ..... Section 300

210-2.1 Limerock: Meet the limerock material requirements as specified in Section 911 if new limerock is needed. The Contractor may use limerock of either Miami Oolite or Ocala Formation but only use limerock of one formation on any Contract.

210-3 Equipment.

Provide equipment meeting the requirements of 200-3.

210-4 Existing Bituminous Surfaces.

210-4.1 Asphalt Concrete: Remove asphalt concrete surfaces from the base prior to excavating trenches or scarifying the rock. Dispose of removed materials as specified in 120-5.

210-4.2 Bituminous Surface Treatment: Remove and dispose of existing bituminous surface treatment only when specifically specified in the Plans. Otherwise, the Contractor may mix the existing bituminous surfacing in with the existing limerock material.

210-5 Trenches and Subgrade.

Where widening the existing base, excavate trenches along the edges of the existing pavement to the width and depth indicated in the Plans. Excavate the trenches before scarifying the existing base. Shape, compact, and maintain the subgrade of the trenches and turnouts as specified in 120-9, except that when stabilization of the subgrade is not included in the Plans, do not compact the trenches unless the native underlying material has been disturbed. Dispose of all excavated materials as specified in 120-5.

210-6 Spreading, Shaping, and Compacting Rock.

210-6.1 General: Scarify and disk, or otherwise loosen the existing base to such extent that no pieces larger than 3 1/2 inches in greatest dimension remain bonded together. Then, spread the material to the full width of the proposed new base course and to a grade and cross-section roughly parallel to the finished grade. Meet the requirements of 200-7.1.

210-6.2 Widening Strips: Where the widening strips are not of sufficient width to permit the use of standard compaction equipment, compact the rock in accordance with 200-6.5.

210-6.3 Construction Sequence: Do not spread any material for the upper course until the Engineer has made the density tests on the lower course and has determined that the specified compaction requirements have been met. Then, construct the second course of new limerock in accordance with the requirements of 200-5 through 200-7.

210-7 Priming and Maintaining.

Meet the requirements of 200-8.

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210-8 Method of Measurement.

210-8.1 Base: The quantity to be paid for will be the plan quantity, in square yards, completed and accepted, including the areas of widened base and of turnouts constructed of new limerock material.

210-8.2 Limerock Material: The quantity to be paid for will be the number of cubic yards of only the new limerock material actually placed in the road and accepted. The quantity will be determined by measurement in loose volume, in truck bodies, at the point of dumping on the road, with proper deduction for all materials wasted, left in trucks or otherwise not actually used in the road. For this purpose, level the material in the truck bodies to facilitate accurate measurement.

210-9 Basis of Payment.

Prices and payments will be full compensation for performing all work specified in this Section including prime coat application as specified in 300-7, except all earthwork required for this work, and the work of removal and disposal of the existing bituminous surfaces, if required, as indicated in the Plans.

When the plans do not provide for direct payment for such work, the cost will be included in the Contract unit price for reworking limerock base.

Payment will be made under:

Item No. 210-	1-	Reworking Limerock Base - per square yard.
Item No. 210-	2-	Limerock, New Material - per cubic yard.

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SECTION 230
LIMEROCK STABILIZED BASE

230-1 Description.

Construct a base course composed of roadbed soil stabilized with limerock.

230-2 Materials.

Meet the following requirements:

Limerock	Section 911
Prime Coat	Section 300

230-3 Equipment.

230-3.1 For Mixing: For mixing in the roadway, provide a heavy-duty rotary tiller or other equipment approved by the Engineer as equally effective for this work.

230-3.2 For Compaction: Select the equipment for compacting the stabilized material, except that for the final finish use a steel-wheeled roller.

230-4 Preparation of Roadbed.

Complete the area to be stabilized to the lines shown in the Plans and to a grade parallel to the finished elevation of the stabilized base, before adding the stabilizing material. Ensure that the elevation of the roadbed is such that the base will conform to the typical section upon completing the work. Dispose of any surplus excavated materials resulting from this work, as specified in 120-5.

230-5 Incorporation of Stabilizing Material and Mixing-In.

230-5.1 Spreading and Mixing: Place the limerock on the areas to be stabilized, and spread it uniformly to the loose depth shown in the Plans or ordered by the Engineer. Then, thoroughly mix the limerock with the soil. Perform mixing as soon as practicable but not later than one week after placing the limerock on the road. Do not spread more limerock in advance of the mixing operations than can be mixed-in with the soil within one week.

230-5.2 Further Mixing Operations: Repeat the mixing operations as often as may be necessary to distribute the limerock uniformly throughout the soil, as determined by the Engineer. Further manipulate the material to uniformly distribute the limerock throughout the width and depth of the base course.

230-5.3 Plant Mixing: The Contractor may mix the soil, limerock, and water using the central plant-mix method in lieu of mixing in place, provided he obtains a uniform mixture with the proper amount of water.

230-5.4 Shaping Surface: After mixing, shape the surface so it conforms to the grade and typical section shown in the Plans after compacting.

230-5.5 Depth of Mixing Stabilizing Material: Ensure that the depth of mixing of the stabilizing material is in accordance with Table 230-1 below:

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Table 230-1		
Specified Base Thickness (inches)	Required Mixing Depth (inches)	
	Minimum	Maximum
6	5-1/2	7-1/2
8	7-1/4	9-3/4
10	9	12

In the event that the measured depth of mixing is less than the minimum specified above, remix the base course, as directed by the Engineer, until the stabilizing material is distributed to the required depth throughout the base course.

Where the measured depth of mixing exceeds the maximum limits specified in Table 230-1 above, add 1 inch, loose measure, of stabilizing material for each 1 inch of mixing depth in excess of the allowable depth (but in no case less than 1 inch of material, for any excess depth), and mix the added material in the top 6 inches of the base as specified in 230-5.1 and 230-5.2, at no expense to the Department. The Department will not include the volume of stabilizing material, which is added to compensate for excess mixing depth, in the pay quantity, and will not allow any additional compensation for the extra mixing required.

230-6 Compacting and Finishing Base.

Meet the requirements of 200-6.

230-7 Testing Surface.

Test the surface in accordance with the requirements of 200-7.

230-8 Priming and Maintaining.

Meet the requirements of 200-8.

230-9 Method of Measurement.

230-9.1 General: The quantities to be paid for will be the plan quantity, in square yards, completed and accepted.

230-9.2 Quantity of Limerock: The quantity to be paid for will be as specified in 210-8.2.

230-10 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section, including furnishing, hauling, placing, spreading, mixing, compacting, prime coat application as specified in 300-7 and finishing all limerock stabilizing material; any necessary excavating below the finished grade of the base to provide for placing the stabilizing material; and disposing of all surplus excavation resulting from this work.

Where extra limerock material is placed at locations of culverts, etc., as detailed in the Plans, the volume of such material, determined as provided above, will be included in the quantity of limerock material to be paid for, but no adjustment will be made in the area of base to be paid for.

Payment will be made under:

Item No. 230- 1- Limerock Stabilized Base - per square yard.
Item No. 230- 2- Limerock Material - per cubic yard.

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SECTION 234
SUPERPAVE ASPHALT BASE

234-1 Description.

Construct a Superpave asphalt concrete base course as defined in these Specifications. Base course mixes are designated as Type B-12.5. The Contractor may use a Type SP-12.5 mixture (Traffic Level B, C, or E) or a Type SP-19.0 mixture (Traffic Level B, C, or E), in lieu of a Type B-12.5 at no additional cost to the Department.

Obtain Superpave asphalt base from a plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.

234-2 Materials.

234-2.1 General: Use materials that conform to the requirements of Division III. Specific references are as follows:

Superpave PG Asphalt Binder .....Section 916
Coarse Aggregate, Stone, Slag or
Crushed Gravel .....Section 901
Fine Aggregate.....Section 902

234-2.2 Reclaimed Asphalt Pavement (RAP): RAP may be used as a component material of the asphalt mixture provided the requirements of 334-2.3 are met.

234-3 General Composition of Mixture.

234-3.1 General: Compose the asphalt mixture using a combination of aggregate (coarse, fine or mixtures thereof), mineral filler if required, and asphalt binder material. Size, grade and combine the aggregate fractions to meet the grading and physical properties of the mix design. Aggregates from various sources may be combined.

234-3.2 Mix Design: Unless otherwise specified, design the mix such that all requirements for a Type SP-12.5, Traffic Level B or C mixture as specified in Section 334 are met.

234-3.2.1 Gradation Classification: Use a fine mix as defined in 334-3.2.2.1.

234-3.2.2 Aggregate Consensus Properties: Meet the aggregate consensus properties at design as specified in 334-3.2.3. Meet the criteria specified for a depth of top of pavement layer from surface of greater than 4 inches.

234-3.2.3 Mix Design Revisions: Meet the requirements of 334-3.3.

234-4 Contractor's Process Control.

Meet the requirements of 320-2, 330-2 and 334-4.

234-5 Acceptance of the Mixture.

The mixture will be accepted in accordance with the requirements of 334-5. Use the permissible variations from longitudinal and transverse grades as specified in 200-7.

234-6 Plant, Methods and Equipment.

Meet requirements of Section 320, with the following modifications:

234-6.1 Paving Equipment: A motor grader may be used to spread the first course of multiple course bases when the subgrade will not support the use of a mechanical spreader. The

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Engineer will not require mechanical spreading and finishing equipment for the construction of base widening strips less than 6 feet in width or where the shape or size of the area will not accommodate mechanical spreading and finishing equipment.

234-6.2 Compaction Equipment: In areas where standard rollers cannot be accommodated, vibratory rollers supplemented with trucks, motor graders, or other compaction equipment approved by the Engineer may be used.

234-7 Construction Requirements.

234-7.1 General: Meet the general construction requirements of Section 330, with the following modifications:

234-7.1.1 Temperature Limitations: Spread the mixture only when the air temperature is at least 40ºF. Do not place the material on frozen subgrade.

234-7.1.2 Tack Coat: Unless otherwise authorized by the Engineer, apply a tack coat between successive layers of base material.

234-7.1.3 Thickness of Layers: Construct each course in layers, such that the compacted thickness is in compliance with the layer thicknesses in 234-8.1.1 and spread rate tolerance in 234-8.2.

234-8 Thickness Requirements.

234-8.1 General: The total thickness of the Type B asphalt layers will be the plan thickness as shown in the Contract Documents. Before paving, propose a thickness for each individual layer meeting the requirements of this specification, which when combined with other layers (as applicable) will equal the plan thickness. For construction purposes, the plan thickness and individual layer thickness will be converted to spread rate based on the maximum specific gravity of the asphalt mix being used, as well as the minimum density level, as shown in the following equation:

Spread rate (lbs. per square yard) = $t \times G_{mm} \times 43.3$

Where: t = Thickness (in.) (Plan thickness or individual layer thickness)

G_{mm} = Maximum specific gravity from the verified mix design

The weight of the mixture shall be determined as provided in 320-3.2. For target purposes only, spread rate calculations should be rounded to the nearest whole number.

234-8.1.1 Layer Thicknesses: The allowable layer thicknesses for asphalt base mixtures are as follows:

Type B-12.5, SP-12.5.....1-1/2 to 3-1/2 inches

Type SP-19.0.....2 to 4 inches

234-8.2 Spread Rate Tolerance: Control the average spread rate on a daily basis to within plus or minus 5% of the target spread rate for the individual layers established by the Engineer. When the average daily spread rate is outside this tolerance from the target, adjust the spread rate to the required value established by the Engineer. The Engineer will periodically verify the spread rate at the job site during the paving operation.

234-8.3 Allowable Deficiencies: The Engineer will allow a maximum deficiency from the specified spread rate for the total thickness as follows:

1. For pavement of a specified thickness of 2-1/2 inches or more: 50 pounds per square yard.

2. For pavement of a specified thickness of less than 2-1/2 inches: 25 pounds per square yard.

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234-8.4 Pavement Exceeding Allowable Deficiency in Spread Rate: Where the deficiency in spread rate for the total thickness is in excess of 50 pounds per square yard for pavements with a specified thickness of 2-1/2 inches or more, or in excess of 25 pounds per square yard for pavements with a specified thickness of less than 2-1/2 inches, the Engineer may require removal and replacement at no cost or may require a correction as specified in 234-8.5. The Engineer may require the Contractor to core the pavement for thickness in order to determine the area of pavement with deficient thickness.

As an exception to the above, the Contractor may leave pavement outside the main roadway in place without compensation when the Engineer allows, even though the deficiency exceeds the tolerance as specified above.

The Department will not compensate the Contractor for any pavement removed or for the work of removing such pavement.

234-8.5 Correcting Deficiency by Adding New Surface Material: In the event the total thickness as determined by the spread rate is excessively deficient as defined above and if approved by the Engineer for each particular location, correct the deficient thickness by adding new surface material and compacting it using a rolling pattern as approved by the Engineer. The Engineer will determine the area to be corrected and the thickness of new material added. Perform all overlaying and compacting at no expense to the Department.

234-9 Method of Measurement.

The quantity to be paid for will be the plan quantity. For each pay item, the pay area will be adjusted based upon the following formula:

Pay Area = Surface Area (actual tonnage placed/adjusted plan quantity tonnage).

Where: The adjusted plan quantity tonnage is calculated by multiplying the plan quantity square yards (including any Engineer approved quantity revisions) times the spread rate as defined in 234-8.1 and dividing by 2,000 pounds per ton, except the pay item's tonnage-weighted average G_{mm} is used instead of the design G_{mm} as defined in 234-8.1.

The pay area shall not exceed 110% of the designed surface area.

Prepare and submit a Certification of Quantities to the Engineer in accordance with 9 2.1.2.

234-10 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section, including the applicable requirements of Sections 320, 330 and 334. The bid price for the asphalt mix will include the cost of the liquid asphalt binder and the tack coat application as directed in 300-8.

Payment will be made under:

Item No. 285- 7- Optional Base - per square yard.

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SECTION 283
RECLAIMED ASPHALT PAVEMENT BASE

283-1 Description.

Construct a base course composed of reclaimed asphalt pavement (RAP) material. Use RAP material as a base course only on non-limited access paved shoulders, shared use paths, or other non-traffic bearing applications.

283-2 Materials.

Meet the following requirements:

Recycled Asphalt Pavement (RAP) 334-2.3
Prime Coat* ..... Section 300
*Use products listed on the Department's Approved Products List (APL).

Obtain the RAP material by either milling or crushing an existing asphalt pavement. Use material so that at least 97% (by weight) pass a 3-1/2 inch sieve and is graded uniformly down to dust.

When the RAP material is from a Department project and the composition of existing pavement is known, the Engineer may approve material on the basis of the composition. When the composition of obtained RAP is not known, the following procedure will be used for approval:

1. Conduct a minimum of six extraction gradation analyses of the RAP material. Take samples at random locations in the stockpile. The average asphalt cement content of the six stockpile samples must be 4% or greater with no individual result below 3-1/2%.

2. Request the Engineer to make a visual inspection of the stockpile of RAP material. Based on this visual inspection of the stockpiled material and the results of the Contractor's extraction gradation analyses, the Engineer will determine the suitability of the materials.

3. The Engineer may require crushing of stockpiled material to meet the gradation criterion. Perform all crushing before the material is placed.

283-3 Spreading RAP Material.

283-3.1 Method of Spreading: Spread the RAP with a blade or device which strikes off the material uniformly to laying thickness and produces an even distribution of the RAP. The Contractor may also place the RAP material directly from the milling machine into the trench by a conveyor. When placing the RAP material by conveyor directly from the milling machine, obtain the Engineer's approval of the milling process.

283-3.2 Number of Courses: When the specified compacted thickness of the base is greater than 6 inches, construct the base in two courses. Place the first course to a thickness of approximately one half the total thickness of the finished base, or sufficient additional thickness to bear the weight of construction equipment without disturbing the subgrade.

Except as might be permitted by the Engineer for special cases, conduct all RAP base construction operations for shoulders before placing the final pavement on the adjacent traveled roadway.

283-4 Compacting and Finishing Base.

283-4.1 General: Meet the requirements of 200-6.1:

283-4.1.1 Single-Course Base: Construct as specified in 200-6.1.1.

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283-4.1.2 Multiple-Course Base: Construct as specified in 200-6.1.2.

283-4.2 Moisture Content: Meet the requirements of 200-6.2.

283-4.3 Density Requirements: Compact the material to a density of not less than 95% of maximum density as determined by FM 1-T180. Where the width of the base construction is not sufficient to permit use of standard base compaction equipment, perform compaction using vibratory compactors, trench rollers, or other special equipment which will provide the density requirements specified herein.

283-4.4 Density Tests: Meet the requirements of 200-7 with the exception of 200-7.2.1. Within the entire limits of the width and depth of the base, obtain a minimum density in any LOT of 95% of the maximum density as determined by FM 1-T180.

283-4.5 Thickness Requirements: Meets the thickness requirements of 285-6.

283-5 Testing Surface.

Test the surface in accordance with the requirements of 200-7-3.

283-6 Priming and Maintaining.

283-6.1 Priming: Apply the prime coat only when the base meets the specified density requirements and the moisture content in the top half of the base is within 2% of optimum. At the time of priming, ensure that the base is firm, unyielding, and in such condition that no undue distortion will occur. The Engineer will not allow priming if the surface is dry, dusty, or sloughing.

283-6.2 Maintaining: Meet the requirements of 200-8.2.

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SECTION 285
OPTIONAL BASE COURSE

285-1 Description.

Construct a base course composed of one of the optional materials shown on the typical sections.

285-2 Materials.

Meet the material requirements as specified in the Section covering the particular type of base to be constructed.

Graded Aggregate .....Section 204
Asphalt .....Section 234
Reclaimed Asphalt Pavement (RAP)* .....Section 283
Limerock .....Section 911
Shell Base.....Section 911
Shell-Rock.....Section 911
Cemented Coquina.....Section 911
Recycled Concrete Aggregate (RCA)** .....Section 911

*Only for use on non-limited access paved shoulders, shared use paths, or other non-traffic bearing applications.

**Do not use on interstate roadways.

285-3 Selection of Base Option.

The Plans will include typical sections indicating the various types of base construction (material and thickness) allowable.

When base options are specified in the Plans, use only those options. When base options are not specified, select one base option as allowed for each typical section shown in the Plans. Only one base option is permitted for each typical section. See Tables 285-1 and 285-2 for optional base materials, thickness and additional restrictions.

Notify the Engineer in writing of the base option selected for each typical section at least 45 calendar days prior to beginning placement of base material.

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Table 285-1 Optional Base Groups 1 through 7							
Base Materials	Base Group (Base Group Pay Item)						
	1 (701)	2 (702)	3 (703)	4 (704)	5 (705)	6 (706)	7 (707)
Limerock, LBR 100	4”	5”	5-1/2”	6”	7”	8”	8-1/2”
Cemented Coquina, LBR 100	4”	5”	5-1/2”	6”	7”	8”	8-1/2”
Shell Rock, LBR 100	4”	5”	5-1/2”	6”	7”	8”	8-1/2”
Bank Run Shell, LBR 100	4”	5”	5-1/2”	6”	7”	8”	8-1/2”
Recycled Concrete Aggregate, LBR 150(1)	4”	5”	5-1/2”	6”	7”	8”	8-1/2”
Graded Aggregate Base, LBR 100	4-1/2”	5-1/2”	6-1/2”	7-1/2”	8-1/2”	9”	10”
Type B-12.5	4” (3)	4” (3)	4” (3)	4” (3)	4-1/2”	5”	5-1/2”
B-12.5 and 4” Granular Subbase, LBR 100 (2)	-	-	-	-	-	-	-
RAP Base (4)	5” (4)	-	-	-	-	-	-

(1) Do not use on interstate roadways.
(2) The construction of both the subbase and Type B-12.5 will be bid and used as Optional Base. Granular subbases include limerock, cemented coquina, shell rock, bank run shell, recycled concrete aggregate and graded aggregate base. All subbase thicknesses are 4” minimum prior to adding the required prime coat.
(3) Based on minimum practical thickness.
(4) Only for use on non-limited access paved shoulders, shared use paths, or other non-traffic bearing applications.
(5) To be used for widening, three feet or less.

Table 285-1(continued) Optional Base Groups 8 through 15								
Base Materials	Base Group (Base Group Pay Item)							
	8 (708)	9 (709)	10 (710)	11 (711)	12 (712)	13 (713)	14 (714)	15 (715)
Limerock, LBR 100	9-1/2”	10”	11”	12”	12-1/2”	13-1/2” (5)	14” (5)	-
Cemented Coquina, LBR 100	9-1/2”	10”	11”	12”	12-1/2”	13-1/2” (5)	14” (5)	-
Shell Rock, LBR 100	9-1/2”	10”	11”	12”	12-1/2”	13-1/2” (5)	14” (5)	-
Bank Run Shell, LBR 100	9-1/2”	10”	11”	12”	12-1/2”	13-1/2” (5)	14 (5)	-
Recycled Concrete Aggregate, LBR 150 (1)	9-1/2”	10”	11”	12”	12-1/2”	13-1/2” (5)	14” (5)	-
Graded Aggregate Base, LBR 100	11”	12”	13”	14”	-	-	-	-
Type B-12.5	5-1/2”	6”	6-1/2”	7”	7-1/2”	8”	8-1/2”	9”
B-12.5 and 4” Granular Subbase, LBR 100 (2)	-	4”	4-1/2”	5”	5-1/2”	6”	6-1/2”	7”

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Table 285-1(continued) Optional Base Groups 8 through 15								
Base Materials	Base Group (Base Group Pay Item)							
	8 (708)	9 (709)	10 (710)	11 (711)	12 (712)	13 (713)	14 (714)	15 (715)
RAP Base [4]	-	-	-	-	-	-	-	-

(1) Do not use on interstate roadways.
(2) The construction of both the subbase and Type B-12.5 will be bid and used as Optional Base. Granular subbases include limerock, cemented coquina, shell rock, bank run shell, recycled concrete aggregate and graded aggregate base. All subbase thicknesses are 4" minimum prior to adding the required prime coat.
(3) Based on minimum practical thickness.
(4) Only for use on non-limited access paved shoulders, shared use paths, or other non-traffic bearing applications.
(5) To be used for widening, three feet or less.

Table 285-2: Limited Use Optional Base Groups[1]								
Base Materials	Base Group (Base Group Pay Item)							
	101 (701)	102 (702)	103 (703)	104 (704)	105 (705)	106 (706)	107 (707)	108 (708)
Limerock Stabilized, LBR 70	5"	6-1/2"	8"	9"	10"	11"	12-1/2"	-
Shell, LBR 70	5"	6-1/2"	8"	9"	10"	11"	12-1/2"	-
Shell Stabilized, LBR 70	7"	8-1/2"	9-1/2"	10-1/2"	12"	-	-	-
Sand-Clay, LBR 75	5"	6-1/2"	8"	9"	10"	11"	12-1/2"	-
Soil Cement (300 psi) (Plant Mixed)	5"	5-1/2"	6-1/2"	7-1/2"	8-1/2"	9"	10"	11"
Soil Cement (300 psi) (Road Mixed)	5"	5-1/2"	6-1/2"	7-1/2"	8-1/2"	-	-	-
Soil Cement (500 psi) (Plant Mixed)	4" [2]	4"	5"	5-1/2"	6"	7"	7-1/2"	8-1/2"

(1) Use only when specified in the Plans.
(2) Based on minimum practical thicknesses.

285-4 Construction Requirements.

Construct the base in accordance with the Section covering the particular type of base to be constructed.

Graded Aggregate .....Section 204
Asphalt .....Section 234
Reclaimed Asphalt Pavement (RAP)* .....Section 283
Limerock .....Section 200
Shell Base .....Section 200
Shell Rock .....Section 200
Cemented Coquina .....Section 200
Recycled Concrete Aggregate (RCA)** .....Section 200

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*Only for use on non-limited access paved shoulders, shared use paths, or other non-traffic

**Do not use on interstate roadways.

285-5 Variation in Earthwork Quantities.

The Plans will identify the optional materials used by the Department for determining the earthwork quantities (Roadway Excavation, Borrow Excavation, Subsoil Excavation, Subsoil Earthwork, or Embankment). The Department will not revise the quantities, for those items having final pay based on plan quantity, to reflect any volumetric change caused by the Contractor's selection of a different optional material.

285-6 Thickness Requirements.

285-6.1 Measurements: For non-asphalt bases, meet the requirements of 200-7.3.1.2.

For subbases, meet the thickness requirements of 290-4.

The Engineer will determine the thickness of asphalt base courses in accordance with 234-8.1.

285-6.2 Correction of Deficient Areas: For non-asphalt bases, correct all areas of the completed base having a deficiency in thickness in excess of 1/2 inch by scarifying and adding additional base material. As an exception, if authorized by the Engineer, such areas may be left in place without correction and with no payment.

For asphalt bases, correct all areas of deficient thickness in accordance with 234-8.

285-7 Calculation of Average Thickness of Base.

For bases that are not mixed in place, the Engineer will determine the average thickness from the measurements specified in 285-6.1, calculated as follows:

1. When the measured thickness is more than 1/2 inch greater than the design thickness shown on the typical section in the Plans, it will be considered as the design thickness plus 1/2 inch.

2. Average thickness will be calculated per typical section for the entire job as a unit.

3. Any areas of base left in place with no payment will not be included in the calculations.

4. Where it is not possible through borings to distinguish the base materials from the underlying materials, the thickness of the base used in the measurement will be the design thickness.

5. For Superpave asphalt base course, the average spread rate of each course shall be constructed in compliance with 234-8.

285-8 Method of Measurement.

The quantity to be paid for will be the plan quantity area in square yards, omitting any areas where under-thickness is in excess of the allowable tolerance as specified in 285-6. The pay area will be the surface area, determined as provided above, adjusted in accordance with the following formula:

$$Pay\ Area = Surface\ Area\ (\frac{Calculated\ \ Average\ Thickness\ per\ 285\text{-}7}{Plan\ Thickness})$$

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The pay area shall not exceed 105% of the surface area.

There will be no adjustment of the pay area on the basis of thickness for base courses constructed utilizing mixed-in-place operations.

For Superpave asphalt base course, the quantity to be paid for will be the plan quantity area in square yards. The pay area will be adjusted in accordance with 234-9.

285-9 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including tack coat between base layers, prime coat, cover material for prime coat, bituminous material used in bituminous plant mix, and cement used in soil-cement.

For superpave asphalt base course, a pay adjustment based upon the quality of the material will be applied in accordance with 334-8.

Where the Plans include a typical section which requires the construction of an asphalt base only, price adjustments for bituminous material provided for in 9-2.1.2 will apply to that typical section. For typical sections which permit the use of asphalt or other materials for construction of an optional base, price adjustments for bituminous material provided for in 9-2.1.2 will not apply.

Payment will be made under:

Item No. 285- 7- Optional Base - per square yard.

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SECTION 286
DRIVEWAY BASE

286-1 Description.

Construct a base course for paved or graded driveways in accordance with the Plans and Standard Plans, Index 330-001.

The Department does not include placing of pavement over driveway base in this Section. The requirements for concrete driveways are included in Section 522.

286-2 Materials.

For driveway base material, use any material meeting the minimum requirements provided in Standard Plans, Index 330-001 and currently specified by the Department for base or surface construction, except do not use hot bituminous mixtures intended for use as open-graded friction course. Proportion bituminous mixtures in accordance with a job-mix formula approved by the Department.

In general, the Engineer will accept the material based on visual inspection, with no testing required.

286-3 Excavation.

Excavate the area over which driveway construction is to be accomplished to the dimensions shown in the Plans. If the surface of the underlying soil is disturbed during the excavation operation, compact it to the approximate density of the surrounding undisturbed soil.

If an existing paved driveway lies within the specified limits for construction, leave the existing base and surface in place, as directed by the Engineer.

286-4 Spreading, Compacting, and Finishing Base.

Uniformly spread base material over the prepared area to a depth which will, upon completion of compaction and finishing, result in driveway base conforming with the specified lines and elevations. Then, strike off the base material to a plane paralleling the finished surface, and compact it in a manner similar to that used in the construction of roadway base. The Engineer will not require any specific density.

Finish the surface to the specified grade and cross slope.

286-5 Method of Measurement.

286-5.1 Driveway Base (Optional): The quantity to be paid for will be the plan quantity area, in square yards.

286-5.2 Driveway Asphalt Base: When specified in the Plans, asphalt base will be paid for by weight of mixture, the weight will be measured as specified in 320-3.

Prepare and submit a Certification of Quantities to the Engineer in accordance with 9-2.1.2.

286-6 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including excavating; compacting excavated areas; furnishing material; placing, compacting, and finishing of base; and incidental work.

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No separate payment will be made for any tack coat between base layers, prime coat, cover material for prime coat, bituminous material used in bituminous plant mix, and cement used in soil-cement.

Payment will be made under:

Item No. 286- 1- Driveway Base (Optional) - per square yard.

Item No. 286- 2- Driveway Asphalt Base - per ton.

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SECTION 287
ASPHALT TREATED PERMEABLE BASE

287-1 Description.

Construct asphalt treated permeable base (ATPB) and outlet pipe for use under concrete pavement, in accordance with the details shown in the Plans and Standard Plans, Index 446-001. Meet the plant and equipment requirements of Section 320 and the general construction requirements of Section 330, except as noted below.

287-2 Materials.

Meet the following requirements:

Coarse Aggregate, Stone, Slag, or Crushed Gravel	
Grade No. 57 or 67	Section 901
Superpave PG Asphalt Binder (PG 67-22) [(1)]	916-1
Hydrated Lime [(2)]	AASHTO M-303-89 Type 1
Polyvinyl-Chloride Pipe [(3)]	Section 948
Polyethylene Pipe [(3)]	Section 948
Geosynthetic Material	Section 985

1. Use PG 67-22 in the ATPB containing 0.50% heat-stable anti-strip additive (by weight of asphalt) from an approved source. Introduce and mix the anti-strip additive at the terminal.

2. For mixtures containing granite, add hydrated lime at a dosage rate of 1.0% by weight of the total dry aggregate in lieu of adding 0.50% anti-strip additive. Submit certified test results for each shipment of hydrated lime indicating compliance with the specifications. In addition, meet the requirements of 337-9.2 and 337-9.3.

3. Use either polyvinyl chloride pipe or polyethylene pipe, unless otherwise specified in the Contract Documents.

287-3 Composition of Mixture.

287-3.1 General: Use ATPB composed of a combination of coarse aggregate and asphalt cement. Use a mix design verified by the Engineer.

287-3.2 Mix Design: Submit a proposed mix design along with representative samples of all component materials to the Engineer, at least two weeks before the scheduled start of production. Establish the design asphalt content within the range of 2.0 - 4.0%, by weight of total mixture. During the mix design process, the Engineer may adjust the asphalt content within the 2.0 - 4.0% range. The Engineer may increase or decrease the specified asphalt content during production of the mix after testing and visual inspection. Ensure that a minimum of 95% of the aggregate is coated. There will be no separate payment for the bituminous material in the mix. Establish the mix temperature within the range of 230ºF to 250ºF, or as approved by the Engineer.

287-4 Control of Quality.

Provide the necessary control of the ATPB and construction in accordance with the applicable provisions of 320-2 and 330-2.

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287-5 Acceptance of the Mixture at the Plant.

The ATPB mixture will be accepted at the plant with respect to 334-5.1 with the following exceptions:

1. The mixture will be accepted with respect to gradation ($P_{-1/2}$ if No. 57 stone is used and $P_{-3/8}$ if No. 67 stone is used) and asphalt binder content (P_b) only.
2. Testing in accordance with AASHTO T312-12 and FM 1-T209 (and conditioning of the mix prior to testing) will not be required as part of 334-5.1.1.1.
3. The standard LOT size will be, 2,000 tons, with each LOT subdivided into four equal sublots of 500 tons each.
4. Initial production requirements of 334-5.1.3 do not apply.
5. The Between-Laboratory Precision Values described in Table 334-7 are modified to include ($P_{-1/2}$ and $P_{-3/8}$) with a maximum difference per FM 1-T030 (Figure 2).
6. Table 334-6 (Master Production Range) is replaced by Table 287-1.

Table 287-1
ATPB Master Production Range

Characteristic	Tolerance (1)
Asphalt Binder Content (%)	Target ± 0.60
Passing 1/2 inch Sieve (%) if using No. 57 stone	Target ± 12.00
Passing 3/8 inch Sieve (%) if using No. 67 stone	Target ± 12.00

(1) Tolerances for sample size of n = 1 from the verified mix design

287-5.1 Individual Test Tolerances for ATPB Production: In the event that an individual Quality Control test result of a sublot for gradation ($P_{-1/2}$ if No. 57 stone is used and $P_{-3/8}$ if No. 67 stone is used), or asphalt binder content does not meet the requirements of Table 287-1, take steps to correct the situation and actions taken shall be reported to the Engineer.

In the event that two consecutive individual Quality Control test results for gradation ($P_{-1/2}$ if No. 57 stone is used and $P_{-3/8}$ if No. 67 stone is used) or asphalt binder content do not meet the requirements of Table 287-1, the LOT will be automatically terminated and production of the mixture stopped until the problem is adequately resolved (to the satisfaction of the Engineer), unless it can be demonstrated to the satisfaction of the Engineer that the problem can immediately be (or already has been) resolved. Evaluate any material represented by the failing test result in accordance with 334-5.1.9.

287-6 Acceptance of the Mixture at the Roadway.

Acceptance of the Contractor's methods of placement and compaction will be based upon the completion of a 500 foot test section, (initially and at other times as determined by the Engineer), acceptable to the Engineer, prior to further placement. In the event that the placement/compaction method deviates from the approved method, cease placement of the mix until the problem is adequately resolved to the satisfaction of the Engineer.

287-7 Temperature and Storage Limitations.

Place the ATPB material when the atmospheric temperature is above 50ºF and rising. Do not use ATPB material that was mixed more than two hours prior to placement.

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287-8 Construction Requirements.

287-8.1 Placement: Ensure that the structural course on which ATPB is to be placed conforms to the compaction and elevation tolerances specified in the Contract Documents and is free of loose or extraneous material. Fill any area of the structural course which is lower than the grade established by the Plans with structural course material, at no additional cost to the Department.

Place and compact ATPB in one lift, with a compacted thickness of 4 inches plus or minus 1/2 inch (except the trench which includes the subdrainage pipe), in accordance with these Specifications, lines, grades, dimensions and notes as shown in the Plans.

Place and compact ATPB material around the subdrainage pipe for the full width of the trench, in layers not exceeding 8 inches (loose measure). Do not displace or damage the subdrainage pipe or filter fabric.

Remove and replace all ATPB material which is greater than 1/2 inch below the grade shown in the Plans or, in the opinion of the Engineer, is damaged or contaminated, at no additional cost to the Department.

287-8.2 Compaction: Compact the ATPB by one of the following methods:

1. A steel-wheeled, tandem roller which will produce an operating weight of not more than 140 PLI of drum width.

2. A steel-wheeled tandem roller weighing from 8 to 12 tons.

Compact the ATPB material (in the static mode only) as approved by the Engineer. Begin compaction as soon as the surface temperature has cooled to 190°F, or as approved by the Engineer and complete compaction before the surface temperature has cooled to 100°F. If necessary, cool the ATPB material with water.

287-8.3 Surface Requirements: Ensure that the finished surface of the ATPB does not vary more than plus or minus 1/2 inch from the grade shown in the Plans.

The Engineer may approve removal of high spots to within specified tolerance by a method which does not produce contaminating fines. Remove and replace ATPB material that is outside the established tolerance, at no additional cost to the Department. Grinding or milling will not be permitted.

287-9 Subdrainage Pipe and Geosynthetic Material.

Place the subdrainage pipe and geosynthetic material (filter fabric) in accordance with the Plans and Standard Plans, Index 446-001.

287-10 Outlet Pipe.

Install outlet fittings and pipes concurrent with subdrainage pipe to provide positive gravity drainage and eliminate soil intrusion. The Engineer will restrict installation of additional sections of ATPB, until appropriate outlets are installed.

Ensure that all fittings and materials are designed and installed to eliminate soil intrusion into the system.

Connect the open end of the outlet pipe into either an existing drainage structure, existing ditch pavement or terminate with a concrete apron.

Do not block the drainage system at any time. Ensure that at the time of inspection and project acceptance, all outlet pipes and concrete aprons are clear of earth material, vegetation, and other debris.

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287-11 Compensation.

Meet the requirements of 334-8 with the following exceptions:

1. Pay factors will be calculated for asphalt binder content and the percentages passing the 1/2 inch and the 3/8 inch sieves only.
2. Table 287-2 replaces Table 334-8.
3. Table 287-3 replaces Table 334-9.
4. The Composite Pay Factor in 334-8.3 is replaced with the following:

CPF = [(0.25 x PF 1/2 inch or 3/8 inch) + (0.75 x PF AC)]

Note: Use the PF for the 1/2 inch sieve if No. 57 stone is used in the mixture or use the PF for the 3/8 inch sieve if No. 67 stone is used in the mixture.

Table 287-2
Small Quantity Pay Table for ATPB

Pay Factor	1-Test Deviation	2-Test Average Deviation
Asphalt Binder Content (%)		
1.00	0.00-0.50	0.00-0.35
0.90	0.51-0.60	0.36-0.42
0.80	>0.60	>0.42
1/2 inch Sieve (%) if using No. 57 stone		
1.00	0.00-11.00	0.00-7.78
0.90	11.01-12.00	7.79-8.49
0.80	>12.00	>8.49
3/8 inch Sieve (%) if using No. 67 stone		
1.00	0.00- 11.00	0.00- 7.78
0.90	11.01-12.00	7.79-8.49
0.80	>12.00	>8.49

Table 287-3
Specification Limits for ATPB

Quality Characteristic	Specification Limits
Asphalt Binder Content (%)	Target ± 0.45
Passing 1/2 inch sieve (%) if using No. 57 stone	Target ± 10.00
Passing 3/8 inch sieve (%) if using No. 67 stone	Target ± 10.00

287-12 Low Quality Material.

Meet the requirements of 334-5.1.9. For ATPB, use the Master Production Range defined in Table 287-1 in lieu of Table 334-6.

287-13 Method of Measurement.

287-13.1 Asphalt Treated Permeable Base: The quantity of ATPB to be paid for will be the plan quantity, in cubic yards, completed and accepted, subject to 9-3.2. No allowance will be made for ATPB placed outside plan dimensions, unless otherwise ordered by the Engineer.

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Prepare and submit a Certification of Quantities to the Engineer in accordance with 9-2.1.2.

287-13.2 Outlet Pipe: The quantity of outlet pipe to be paid for will be the length, in feet, measured in place along the centerline and gradient of the pipe, completed and accepted.

287-14 Basis of Payment.

287-14.1 Asphalt Permeable Base: Price and payment will be full compensation for work specified in this Section, including furnishing all labor, materials (including the ATPB material, geosynthetic material, and subdrainage pipe), tools, equipment, and incidentals, necessary to complete the work.

287-14.2 Outlet Pipe: Price and payment will be full compensation for work specified in this Section, including removal of existing shoulder pavement, trench excavation, pipe and fittings, standard aprons, galvanized hardware cloth (rodent screens), grouting around and stubbing into existing or proposed drainage structures or ditch pavement; restoration of ditch pavement, sod and other areas disturbed by the Contractor, backfill in place, disposal of excess materials and incidentals, necessary to complete the work.

287-14.3 Payment Items: Payment will be made under:

Item No. 287- 1-	Asphalt Treated Permeable Base - per cubic yard.
Item No. 446- 71- 1-	Edgedrain Outlet Pipe - per foot.

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SECTION 288
CEMENT TREATED PERMEABLE BASE

288-1 Description.

288-1.1 General: Construct Cement Treated Permeable Base and Outlet Pipe as shown in the Plans and Standard Plans, Index 446-001. Use any one of the types of pipe listed in 288-2, unless a particular type is specifically required by the Contract Documents. Use only perforated pipe, and do not use open joints.

288-1.2 Concrete Plant and Cement Concrete pavement: Meet the requirements of Section 346 for plant and equipment, and Section 350 for general construction requirements.

Work will be accepted in accordance with the applicable provisions in Section 350.

288-2 Materials.

Meet the following requirements:

Coarse Aggregate	Section 901
Portland Cement	Section 921
Water	Section 923
Polyvinyl-Chloride Pipe	Section 948
Polyethylene Pipe	Section 948
Geotextile Fabric	Section 985

For Cement Treated Permeable Base, the concrete requirements of Section 346 are modified as follows:

Use Type I or II portland cement (no supplementary cementitious materials permitted).

Composition:

Grade of coarse aggregate (stone)	# 57 or # 67
Maximum Water/Cement ratio*	0.40
Minimum cement factor**	9 lb/ft^3
Maximum Slump Range	Not Applicable
Fine Aggregate	None
Admixtures	None

*The Engineer will approve the Water/Cement ratio.

**±2 lb/ft^3

Do not use materials which contain hardened lumps, crusts, or frozen matter, or are contaminated with dissimilar material.

288-3 Control of Quality.

288-3.1 General: Meet the provisions of this Section and Chapter 9.2 of the Materials Manual - Concrete Production Facilities Guidelines, which may be view at the following URL: https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/Section92V2.shtm.

288-3.2 Concrete Design Mix: Submit the proposed design mix prior to production, on the “Concrete Mix Design” form, for the Engineer’s approval. Use only Cement Treated Permeable Base design mixes having prior approval of the Engineer.

Furnish sufficient material of each component when requested by the Engineer, for verification of the proposed mix design by the State Materials Office. Verify the unit weight

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requirements as determined in accordance with FM 5-530. Also, submit one of the following with the design mix submittal:

1. Evidence from three sets of production data, either from Department acceptance tests or independently verifiable commercial mixes, that Cement Treated Permeable Base produced in accordance with the proposed design mix meets the requirements of this Section.

2. Test data from a single trial batch of a 1 yd^3 minimum is required, which demonstrates that the Cement Treated Permeable Base produced using the proposed mix, designated ingredients, and designated water-cement ratio meets the requirements of this Section.

288-3.3 Batch Adjustment - Materials: Meet the theoretical yield requirements of the approved mix design. Inform the Engineer of any adjustments to the approved mix design. Note any batch adjustments and record the actual quantities incorporated into the mix, on the concrete "Delivery Ticket/Certification" form.

288-3.4 Delivery Certification: Submit to the Engineer a complete "Delivery Ticket/Certification" form with each batch of Cement Treated Permeable Base prior to unloading at the site.

288-4 Acceptance of Placement.

Acceptance of the Contractor's method of placement and compaction will be based upon the completion of a 500 foot test section, acceptable to the Engineer, prior to further placement.

For the purpose of acceptance and partial payment, each day's production will be divided into LOTs as specified in Section 346 and in accordance with the applicable requirements of Sections 5, 6, and 9.

288-5 Temperature Requirements.

Place Cement Treated Permeable Base only when the atmospheric temperature is above 40°F and rising.

288-6 Construction Requirements.

288-6.1 Placement: Ensure that the structural course on which Cement Treated Permeable Base is to be placed conforms to the compaction and elevation tolerances specified in the Plans and is free of loose or extraneous material. Fill any area of the structural course which is lower than the grade established by the Plans with structural course material, at no additional cost to the Department.

Place and compact Cement Treated Permeable Base in one course (except the trench which includes the subdrainage pipe), in accordance with these Specifications, lines, grades, dimensions and notes as shown in the Plans. Placement may be accomplished by either the fixed-form or the slip-form method.

Place and compact Cement Treated Permeable Base material around the subdrainage pipe for the full width of the trench, in layers not exceeding 8 inches (loose measure). Do not displace or damage the subdrainage pipe or filter fabric.

Remove and replace all Cement Treated Permeable Base material which is greater than 1/2 inch below the grade shown in the Plans or is not covered with the next layer of material within five calendar days after initial placement or in the opinion of the Engineer is damaged or contaminated, at no additional cost to the Department.

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288-6.2 Compaction: Compact the Cement Treated Permeable Base by one of the following methods.

1. One complete coverage with a steel-wheeled, two-axle tandem roller weighing between 4 and 10 tons in static mode.
2. By vibratory plates or screeds.

There will be no density requirements for Cement Treated Permeable Base.

288-6.3 Curing: Sprinkle the Cement Treated Permeable Base surface with a fine spray of water every two hours for a period of eight hours or cover with polyethylene sheets for three or four calendar days.

Begin the curing process the morning after placement of the base.

288-6.4 Surface Requirements: Ensure that the finished surface of the Cement Treated Permeable Base does not vary more than ±1/2 inch from the grade shown in the Plans.

The Engineer may approve removal of high spots to within the specified tolerance by a method which does not produce contaminating fines. Remove and replace Cement Treated Permeable Base material that is above tolerance, at no additional cost to the Department. Neither grinding nor milling will be permitted.

288-7 Sampling and Testing.

The Engineer will take random samples of the Cement Treated Permeable Base at the point of placement in accordance with FM 5-530 to determine the unit weight. Cement Treated Permeable Base not within ± 3 lb/ft^3 of the unit weight of the approved mix design will be rejected.

Remove and replace all rejected Cement Treated Permeable Base at no cost to the Department.

288-8 Subdrainage Pipe and Geotextile Material.

Place the subdrainage pipe and geotextile material (filter fabric) in accordance with the Plans and Standard Plans, Index 446-001.

288-9 Outlet Pipe.

Install outlet fittings and pipes concurrent with subdrainage pipe to provide positive gravity drainage and eliminate soil intrusion. The Engineer will restrict installation of additional sections of Cement Treated Permeable Base, until appropriate outlets are installed.

Ensure that all fittings and materials are designed and installed to eliminate soil intrusion into the system.

Connect the open end of the outlet pipe into either an existing drainage structure, existing ditch pavement or terminate with a concrete apron.

Do not block the drainage system at any time. Ensure that at the time of inspection and project acceptance, all outlet pipes and concrete aprons are clear of earth material, vegetation, and other debris.

288-10 Method of Measurement.

288-10.1 Cement Treated Permeable Base: The quantity of cement treated permeable base to be paid for will be the plan quantity, in cubic yards, completed and accepted, subject to 9-3.2.

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288-10.2 Outlet Pipe: The quantity of outlet pipe to be paid for will be the length, in feet, completed and accepted, measured in place along the centerline and gradient of the outlet pipe.

288-11 Basis of Payment.

288-11.1 Cement Treated Permeable Base: Price and payment will be full compensation for work specified in this Section, including furnishing all labor, materials (including the cement treated permeable base material, geotextile, and subdrainage pipe), tools, equipment, and incidentals, necessary to complete the work.

288-11.2 Outlet Pipe: Price and payment will be full compensation for work specified in this Section, including removal of existing shoulder pavement, trench excavation, pipe and fittings, standard aprons, galvanized hardware cloth (rodent screens), grouting around and stubbing into existing or proposed inlets and drainage structures or paved ditches; restoration of ditch pavement and other areas disturbed by the Contractor, backfill in place, and disposal of excess materials and incidentals, necessary to complete the work.

Payment will be made under:

Item No. 288- 1-	Cement Treated Permeable Base - per cubic yard.
Item No. 446- 71- 1	Edgedrain Outlet Pipe - per foot.

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SECTION 290
GRANULAR SUBBASE

290-1 Description.

Construct a granular subbase as a component of an optional base.

290-2 Materials.

Select one of the materials listed below and conform to the following requirements:

Graded Aggregate	204-2
Limerock	Section 911
Bank Run Shell	Section 911
Shell Rock	Section 911
Cemented Coquina	Section 911
Recycled Concrete Aggregate (RCA)*	Section 911

*Do not use on interstate roadways.

290-3 Construction Methods.

For the subbase material selected, construct the subbase in conformance with the following:

Graded Aggregate	Section 204
Limerock	Section 200
Bank Run Shell	Section 200
Shell Rock	Section 200
Cemented Coquina	Section 200
Recycled Concrete Aggregate (RCA)*	Section 200

*Do not use on interstate roadways.

Straightedge and hard-planing provisions will not apply. Compact the subbase to a minimum of 98% of the maximum density as determined under FM 1-T180, Method D. Priming is not required.

When Granular Subbase is substituted for Subgrade on shoulders, achieve a minimum of 95% density of the maximum density as determined under FM 1-T180, Method D.

290-4 Thickness Requirements.

290-4.1 General: Do not substitute granular subbase materials in excess of the tolerance specified for the asphalt portion of the optional base.

290-4.2 Measurements: When the Department is ready to measure the finished subbase, provide the coring equipment and the operator and include this in the unit price for optional base. The Engineer will select the coring locations and make the acceptance measurements. Thickness measurements will be taken through 3 inch diameter holes. For subbase areas greater than 1,000 yd^2, the minimum frequency of measurement will be one per 200 feet of roadway. For smaller subbase areas, the minimum frequency of measurement will be one per 500 yd^2 of subbase.

290-4.3 Maximum Allowable Thickness: The maximum allowable thickness of the subbase is 4 1/4 inches. Remove and replace areas of subbase exceeding the maximum allowable thickness.

290-4.4 Minimum Allowable Thickness: The minimum allowable thickness of the subbase is 3-1/2 inches. Remove and replace areas not meeting the minimum allowable

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thickness. If authorized by the Engineer, additional asphalt may be substituted to achieve the full combined optional base thickness.

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SECTION 300
PRIME AND TACK COATS

300-1 Description.

Apply bituminous prime coats on previously prepared bases and apply bituminous tack coats on previously prepared bases and on existing pavement surfaces.

300-2 Materials.

Meet the following requirements:

Asphalt Emulsion for Prime Coat*	916-3
PG 52-28 Tack Coat*	916-2
Asphalt Emulsion for Tack Coat*	916-3
Sand	902-2, 902-6
Screenings	902-5

*Use products listed on the Department's APL.

300-2.1 Prime Coat: A copy of the Bill of Lading representing the material in the distributor tank must be in the truck and be always available.

Where prime coats are to be diluted, certify the dilution was done in accordance with the specific dilution requirements for each product and for each load of material used.

300-2.2 Cover Material for Prime Coat: Uniformly cover the primed base by a light application of cover material. The Contractor may use either sand or screenings for the cover material. For the sand, meet the requirements as specified in 902-2 or 902-6, and for the screenings, meet the requirements as specified in 902-5. If the primed base course will be exposed to general traffic, apply a cover material coated with 2 to 4% asphalt cement. Apply the asphalt coated material at approximately 10 pounds per square yard. Roll the entire surface of asphalt coated prime material with a traffic roller as required to produce a reasonably dense mat.

300-2.3 Tack Coat: Unless the Contract Documents call for a specific type or grade of tack coat, use PG 52-28 meeting the requirements of 916-2, heated to a temperature from 250 to 300ºF or use an undiluted emulsion listed on the APL, meeting the requirements of 916-3. Heat the emulsion to the temperature recommended by the tack coat manufacturer. A copy of the Bill of Lading representing the material in the distributor tank must be in the truck and be always available.

For night paving, use PG 52-28 tack coat. The Engineer may approve an emulsified tack coat for night paving if the Contractor demonstrates, at the time of use, the emulsion will break and not affect the progress of the paving operation.

300-3 Equipment.

300-3.1 Pressure Distributor: Provide a pressure distributor equipped with pneumatic tires having a sufficient width of rubber in contact with the road surface to avoid breaking the bond or forming a rut in the surface. Ensure the distance between the centers of openings of the outside nozzles of the spray bar is equal to the width of the application required, plus or minus two inches. Ensure the outside nozzle at each end of the spray bar has an area of opening greater than the opening of an interior nozzle by 25% to 75%. Ensure all other nozzles have uniform

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openings. When the application covers less than the full width, the Contractor may allow the normal opening of the end nozzle at the junction line to remain the same as the interior nozzles. A trailer-mounted pressure distributor can be used for non-mainline applications, if approved by the Engineer. It shall have a self-contained heat system, clean out system, calibration chart, manhole, and shall meet the requirements herein.

Clean the distributor tank at a minimum of every twelve months and whenever the product type in the tank is changed. Remove all emulsion and asphalt material during cleaning. Additionally, clean the distributor tank if the quality of the tack or prime shot diminishes or buildup causes the calibration of the tank to be affected.

300-3.2 Sampling Device: Equip all pressure distributors and transport tanks with an approved spigot-type sampling device.

300-3.3 Temperature Sensing Device: Equip all pressure distributors and transport tanks with an approved dial type thermometer.

Use a thermometer with a temperature range from 50 to 500ºF, no greater than 25ºF increments, and a minimum dial diameter of two inches.

Locate the thermometer near the midpoint of the tank's length and within the middle third of the tank's height, or as specified by the manufacturer (if in a safe and easily accessible location). Enclose the thermometer in a well with a protective window or by other means as necessary to keep the instrument clean and in the proper working condition.

300-4 Contractor's Quality Control.

Provide the necessary quality control of the prime and tack coats and application in accordance with the Contract requirements. If the application rate varies by more than 0.01 gallon per square yard from the rate set by the Engineer or varies beyond the range established in 300-7 or 300-8, immediately make all corrections necessary to bring the application rate into the acceptable range. The Engineer may take additional measurements at any time. The Engineer will randomly check the Contractor's measurement to verify the application rate.

300-5 Cleaning Base and Protection of Adjacent Work.

Before applying any bituminous material, remove all loose material, dust, sand, dirt, caked clay, and other foreign material which might prevent proper bond with the existing surface for the full width of the application. Take particular care in cleaning the outer edges of the strip to be treated, to ensure the prime or tack coat will adhere.

When applying prime or tack coat adjacent to curb and gutter, valley gutter, or any other concrete surfaces, cover such concrete surfaces, except where they are to be covered with a bituminous wearing course, with heavy paper or otherwise protect them as approved by the Engineer, while applying prime or tack coat. Remove any bituminous material deposited on such concrete surfaces.

300-6 Weather Limitations.

Do not apply prime and tack coats when the air temperature in the shade and away from artificial heat is less than 40ºF at the location where the application is to be made or when weather conditions or the surface conditions are otherwise unfavorable.

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300-7 Application of Prime Coat.

300-7.1 General: Clean the surface to be primed and ensure the moisture content of the base does not exceed the optimum moisture. Heat the prime coat material to the temperature recommended by the prime coat manufacturer. Apply the material with a pressure distributor. Determine the application amount based on the character of the surface. Use an amount sufficient to coat the surface thoroughly and uniformly with no excess.

The Contractor may elect to omit application of bituminous prime coat on previously prepared or exposed bases when an asphalt lift is placed within 24 hours of final preparation of such bases. Keep base moisture content within acceptable range. Protect finished base from rain and ensure base bonds adequately to the new lift of asphalt pavement. Apply prime to base when asphalt is not placed within 24 hours of final preparation of base. Apply prime to full depth reclamation and cement stabilized bases.

300-7.2 Application Rate: Use an application rate as defined in Table 300-1. Control the application rate within the minimum and plus 0.01 gallon per square yard of the minimum application rate. The minimum application rate may be adjusted by the Engineer to meet specific field conditions. Determine and record the application rate a minimum of twice per day, once at the beginning of each day's production and, as needed, to control the operation.

Table 300-1
Prime Coat - Minimum Application Rates

Base Type	Minimum Application Rate (gal/yd^2)
Limerock, Limerock Stabilized, Shell-Rock, Recycled Concrete Aggregate and Local Rock Bases	0.10
Sand-Clay, Cemented Coquina, Shell, and Shell Stabilized Bases	0.15

300-7.3 Sprinkling: If required by the Engineer, lightly sprinkle the base with water and roll it with a traffic roller in advance of the prime coat application.

300-7.4 Partial Width of Application: If traffic conditions warrant, the Engineer may require the application be made on only one-half the width of the base at one time, in which case, use positive means to secure the correct amount of bituminous material at the joint.

300-8 Application of Tack Coat.

300-8.1 General: Where the Engineer requires a tack coat prior to laying a bituminous surface, apply the tack coat as specified herein below. Coat the surface completely and uniformly with tack.

300-8.2 Where Required: Place a tack coat on all asphalt layers prior to constructing the next course. In general, the Engineer will not require a tack coat on primed bases except in areas that have become excessively dirty and cannot be cleaned, or in areas where the prime has cured to the extent all bonding effect has been lost.

300-8.3 Method of Application: Apply the tack coat with a pressure distributor except on small jobs, if approved by the Engineer, apply it by other mechanical devices or by hand methods. Heat the bituminous material to a suitable temperature as designated by the supplier.

300-8.4 Application Rate: Use an application rate defined in Table 300-2. Control the application rate within plus or minus 0.01 gallon per square yard of the target application rate. The target application rate may be adjusted by the Engineer to meet specific field conditions.

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Determine and record the application rate a minimum of twice per day, once at the beginning of each day's production and again, as needed, to control the operation. When using PG 52-28, multiply the target application rate by 0.6.

Table 300-2 Tack Coat Application Rates		
Asphalt Mixture Type	Underlying Pavement Surface	Target Tack Rate (gal/yd^2)[1]
Base Course, Structural Course, Dense-Graded Friction Course, Open-Graded Friction Course	Newly Constructed Asphalt Layers	0.06
	Milled Asphalt Pavement Surface, Oxidized and Cracked Asphalt Pavement, Concrete Pavement	0.09
Note 1: Target tack application rates greater than those specified may be used upon approval of the Engineer.		

When using a meter to control the tack or prime application rate, manually measure the volume in the tank at the beginning and end of the application area for a specific target application rate. Perform this operation at a minimum frequency of once per production shift. Resolve any differences between the manually measured method and the meter to ensure the target application rate is met in accordance with this Section. Adjust the application rate if the manually measured application rate is greater than plus 0.02 or minus 0.01 gallons per square yard when compared to the target application rate.

300-8.5 Curing and Time of Application: When using a distributor, apply tack coat sufficiently in advance of placing bituminous mix to permit drying, but do not apply tack coat so far in advance that it might lose its adhesiveness as a result of being covered with dust or other foreign material. When using a spray paver, the requirements above do not apply.

300-8.6 Protection: Keep the tack coat surface free from traffic until the subsequent layer of bituminous hot mix has been laid.

300-9 Method of Measurement.

300-9.1 General: The quantity specified will be the volume, in gallons, of bituminous material actually applied and accepted. This application rate will be determined from measurements made by the Contractor and verified by the Engineer based on tank calibrations, as specified in 300-9.2. Where it is specified prime coat material is to be diluted with water, the amount specified for the application rate will be the volume after dilution.

300-9.2 Calibration of Tanks: Ensure all distributors used for applying tack or prime coats are calibrated prior to use by a reliable and recognized firm engaged in calibrating tanks. Submit a certification of calibration and the calibration chart to the Engineer prior to use. In lieu of a volumetrically calibrated distributor, use a distributor equipped with a calibrated meter approved by the Engineer.

300-9.3 Temperature Correction: Measure the volume and increase or decrease the volume actually measured to a corrected volume at a temperature of 60ºF.

Make the correction for temperature by applying the applicable conversion factor (K), as shown below.

For petroleum oils having a specific gravity above 0.966 at 60°F, K = 0.00035 per degree.

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For petroleum oils having a specific gravity of between 0.850 and 0.966 at 60°F, K = 0.00040 per degree.

For emulsified asphalt, K = 0.00025 per degree.

When volume-correction tables based on the above conversion factors are not available, use the following formula in computing the corrections for volumetric change:

$$V = \frac{V^1}{K\,(T - 60) + 1}$$

Where:

V= Volume of bituminous material at 60ºF (pay volume).

V^1= Volume of bituminous material as measured.

K= Correction factor (Coefficient of Expansion).

T= Temperature (in ºF), of bituminous material when measured.

300-10 Basis of Payment.

There is no direct payment for the work specified in this Section, it is incidental to, and is to be included in the other items of related work.

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SECTION 320
HOT MIX ASPHALT -
PLANT METHODS AND EQUIPMENT

320-1 General.

This Section specifies the basic equipment and operational requirements for hot mix asphalt (including warm mix asphalt) production facilities used in the construction of asphalt pavements and bases. Establish and maintain a quality control system that provides assurance that all materials and products submitted for acceptance meet Contract requirements.

320-2 Quality Control (QC) Requirements.

320-2.1 Minimum Producer QC Requirements: Perform as a minimum the following activities:

1. Stockpiles:
    a. Assure materials are placed in the correct stockpile;
    b. Assure good stockpiling techniques;
    c. Inspect stockpiles for separation, contamination, segregation, and other similar items;
    d. Properly identify and label each stockpile.
2. Incoming Aggregate:
    a. Obtain gradations and bulk specific gravity (G_{sb}) values from aggregate supplier for reference;
    b. Determine the gradation of all component materials and routinely compare gradations and G_{sb} values to mix design.
3. Cold Bins:
    a. Calibrate the cold gate/feeder belt for each material;
    b. Determine cold gate/feeder belt settings;
    c. Observe operation of cold feeder for uniformity;
    d. Verify accuracy of all settings;
    e. Verify that the correct components are being used, and that all modifiers or additives or both are being incorporated into the mix.
4. Batch Plants:
    a. Determine percent used and weight to be pulled from each bin to assure compliance with the mix design;
    b. Check mixing time;
    c. Check operations of weigh bucket and scales.
5. Drum Mixer Plants:
    a. Determine aggregate moisture content;
    b. Calibrate the weigh bridge on the charging conveyor.
6. Control Charts: Maintain QC data and charts (updated daily) for all QC Sampling and Testing and make available upon demand. Provide the following charts:
    a. All components used to determine the composite pay factor (No. 8 sieve, No. 200 sieve, asphalt binder content, air voids, and density);
    b. Gradation of incoming aggregate;
    c. Gradation, asphalt binder content and maximum specific gravity (G_{mm}) of RAP;

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d. Any other test result or material characteristic (as determined by the Contractor) necessary for process control.

The above listed minimum activities are to be considered normal activities necessary to control the production of hot mix asphalt at an acceptable quality level. Depending on the type of process or materials, some of the activities listed may not be necessary and in other cases, additional activities may be required. The frequency of these activities will also vary with the process and the materials. When the process varies from the defined process average and variability targets, the frequency of these activities will be increased until the proper conditions have been restored.

320-2.2 Minimum Process Control Testing Requirements: Perform, as a minimum, the following activities at the testing frequencies provided in Table 320-1. QC tests used in the acceptance decision may be used to fulfill these requirements.

Table 320-1

Asphalt Plant - Materials Testing Frequencies

Material	Property	Minimum Testing Frequency
Aggregate	Gradation	Once per 1,000 tons of incoming aggregate
Asphalt Mix	Asphalt Binder Content	If daily production > 100 tons, once per day; If daily production > 1,000 tons, twice per day. *
Asphalt Mix	Bulk Specific Gravity (G_{mb})	If daily production > 100 tons, once per day; If daily production > 1,000 tons, twice per day. *
Asphalt Mix	Gradation	If daily production > 100 tons, once per day; If daily production > 1,000 tons, twice per day. *
Asphalt Mix	Maximum Specific Gravity (G_{mm})	If daily production > 100 tons, once per day; If daily production > 1,000 tons, twice per day. *
Asphalt Mix	Temperature	Each of first 5 loads, then once every 5 loads thereafter, per day per mix design.
RAP	Asphalt Binder Content	Once per 1,000 tons RAP
RAP	Gradation	Once per 1,000 tons RAP
RAP	Maximum Specific Gravity (G_{mm})	Once per 5,000 tons RAP

*If less than 100 tons of mix is produced on each of successive days of production, resulting in a cumulative quantity of greater than 100 tons, then perform the indicated test.

320-2.3 Personnel Qualifications: Provide QC Technicians in accordance with Section 105.

320-2.4 Hot Mix Asphalt Testing Laboratory Requirements: Furnish a fully equipped asphalt laboratory at the production site. The laboratory must be qualified under the Department's Laboratory Qualification Program, as described in Section 105. In addition, the laboratory shall meet the following requirements:

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1. Area - The effective working area of the laboratory shall be a minimum of 180 square feet, with a layout of which will facilitate multiple tests being run simultaneously by two technicians. This area does not include the space for desks, chairs and file cabinets. Any variations shall be approved by the Engineer.

2. Lighting - The lighting in the lab must be adequate to illuminate all areas of the work.

3. Temperature Control - Equip the lab with heating and air conditioning units that provide a satisfactory working environment.

4. Ventilation - Equip the lab with exhaust fans that will remove all hazardous fumes from within the laboratory in accordance with OSHA requirements.

5. Equipment and Supplies - Furnish the lab with the necessary sampling and testing equipment and supplies for performing contractor QC and Department Verification Sampling and Testing. A detailed list of equipment and supplies required for each test is included in the appropriate FDOT, AASHTO, or ASTM Test Method. In the event testing equipment goes out of service during production, the Contractor may elect to use replacement equipment at another laboratory qualified, as described in Section 105, for up to 72 hours upon notification of the Engineer.

6. Personal Computer - Provide a personal computer capable of running a Microsoft Excel™ spreadsheet program, along with a printer.

7. Communication - Provide a telephone and fax machine (with a private line) for the use of the testing facility's QC personnel. In addition, provide an internet connection capable of uploading data to the Department's database and for e-mail communications.

320-3 Requirements for All Plants.

320-3.1 General: Design, manufacture, coordinate, and operate the asphalt plant in a manner that will consistently produce a mixture within the required tolerances and temperatures specified.

320-3.2 Asphalt Plant Ticketing Systems: Use either a paper ticketing system or an electronic ticketing (E-Ticketing) system.

320-3.2.1 Electronic Weigh Systems for Paper Ticketing: Equip the asphalt plant with an electronic weigh system that has an automatic printout, is certified every six months by an approved certified scale technician, and meets monthly comparison checks with certified truck scales as specified in 320-3.2.1.4. Weigh all plant produced hot mix asphalt on the electronic weigh system, regardless of the method of measurement for payment.

Include, as a minimum, the following information on the printed delivery ticket:

1. Sequential load number
2. Project number
3. Date
4. Name and location of plant
5. Mix design number
6. Place for hand-recording mix temperature
7. Truck number
8. Gross, tare, and net tonnage per truck (as applicable)
9. Daily total tonnage of mix for the mix design

Print the delivery ticket with an original and at least one copy. Furnish the original to the Engineer at the plant and one copy to the Engineer at the paving site.

Utilize any one of the following three electronic weigh systems.

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320-3.2.1.1 Electronic Weigh System on the Truck Scales: Provide an electronic weigh system on all truck scales, which is equipped with an automatic recordation system that is approved by the Engineer. Use scales of the type that directly indicate the total weight of the loaded truck. Use scales meeting the requirements for accuracy, condition, etc., of the Bureau of Weights and Measures of the Florida Department of Agriculture, and re-certify such fact every six months, either by the Bureau of Weights and Measures or by a registered scale technician.

320-3.2.1.2 Electronic Weigh System on Hoppers Beneath a Surge or Storage Bin: Provide an electronic weigh system on the hopper (hopper scales or load cells) beneath the surge or storage bin, which is equipped with an automatic recordation system approved by the Engineer.

320-3.2.1.3 Automatic Batch Plants with Printout: For batch plants, provide an approved automatic printer system which will print the individual or cumulative weights of aggregate and liquid asphalt delivered to the pugmill and the total net weight of the asphalt mix measured by hopper scales or load cell type scales. Use the automatic printer system only in conjunction with automatic batching and mixing control systems that have been approved by the Engineer.

320-3.2.1.4 Monthly Electronic Weigh System Comparison Checks: Check the accuracy of the electronic weighing system at the commencement of production and thereafter by one of the following two methods and maintain a record of the weights in the Scale Check Worksheet. The time period between scale checks shall not exceed 35 calendar days.

320-3.2.1.4.1 Electronic Weigh System on Truck Scales:

1. The Engineer will randomly select a loaded truck of asphalt mix, a loaded aggregate haul truck, or another vehicle type approved by the Engineer and record the truck number and gross weight from the Contractor's delivery ticket.

2. Weigh the selected truck on a certified truck scale, which is not owned by the Contractor and record the gross weight for the comparison check. If another certified truck scale is not available, the Engineer may permit another set of certified truck scales owned by the Contractor to be used. The Engineer may elect to witness the scale check.

3. The gross weight of the loaded truck as shown on the Contractor's delivery ticket will be compared to the gross weight of the loaded truck from the other certified truck scale. The maximum permissible deviation is 8 pounds per ton of load, based on the certified truck scale weight.

4. If the distance from the asphalt plant to the nearest certified truck scale is enough for fuel consumption to affect the accuracy of the comparison checks, a fuel adjustment may be calculated by using the truck odometer readings for the distance measurement, and 6.1 miles per gallon for the fuel consumption rate, and 115 ounces per gallon for fuel weight.

5. During production, when an additional certified truck scale is not available for comparison checks, the Engineer may permit the Contractor to weigh the truck on his certified scales used during production and then weigh it on another certified truck scale, as soon the other scale is available for the comparison checks.

In addition to the periodic checks as specified above, check the scales at any time the accuracy of the scales becomes questionable. When such inaccuracy does not appear to be sufficient to seriously affect the weighing operations, the Engineer will allow a period of two calendar days for the Contractor to conduct the required scale check.

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However, in the event the indicated inaccuracy is sufficient to seriously affect the mixture, the Engineer may require immediate shut-down until the accuracy of the scales has been checked and necessary corrections have been made. Include the cost of all scale checks in the bid price for asphalt concrete, at no additional cost to the Department.

320-3.2.1.4.2 Electronic Weigh System on Hoppers Beneath a Surge or Storage Bin and Automatic Batch Plants with Printout:

1. The Engineer will randomly select a loaded truck of asphalt mix and record the truck number, and the net weight of the asphalt mix from the Contractor's delivery ticket.

2. Weigh the selected truck on a certified truck scale, which is not owned by the Contractor and record the gross weight for the comparison check. If another certified truck scale is not available, the Engineer may permit another set of certified truck scales owned by the Contractor to be used. The Engineer may elect to witness the scale check.

3. Deliver the asphalt mix to the project, then weigh the selected empty truck on the same certified truck scales. Record the tare weight of the truck.

4. Compare the net weight of the asphalt mix from the delivery ticket to the calculated net weight of the asphalt mix as determined by the certified truck scale weights. The maximum permissible deviation is 8 pounds per ton of load, based on the certified truck scale weight.

5. Use the fuel adjustment as specified in 320-3.2.4.1(4), when the distance from the asphalt plant to the nearest certified truck scale is enough for fuel consumption to affect the accuracy of the comparison checks.

6. During production, when an additional certified truck scale is not available for comparison checks, the Engineer may permit the Contractor to load a truck with aggregate from the pugmill, surge or storage bin, and follow the above procedures to conduct the comparison checks as soon as certified truck scale is available.

If the check shows a greater difference than the tolerance specified above, then recheck on a second set of certified scales. If the check and recheck indicate that the printed weight is out of tolerance, have a certified scale technician check the electronic weigh system and certify the accuracy of the printer. While the system is out of tolerance and before its adjustment, the Engineer may allow the Contractor to continue production only if provisions are made to use a set of certified truck scales to determine the truck weights.

320-3.2.2 Electronic Weigh Systems for E-Ticketing: Equip the asphalt plant with an electronic weigh system that has an automatic printout, is certified every six months by an approved certified scale technician, and meets monthly comparison checks with certified truck scales as specified in 320-3.2.2.3. Weigh all plant produced hot mix asphalt on the electronic weigh system, regardless of the method of measurement for payment.

Include, as a minimum, the following information in the electronic delivery ticket:

1. Sequential load number
2. Project's Financial Identification Number (FIN)
3. Date
4. Name and location of plant
5. Mix design number
6. Separate, individual, data entry locations for recording mix temperature by:

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a. Plant QC
b. Plant VT
c. Roadway QC
d. Roadway VT

7. Truck number
8. Gross, tare, and net tonnage per truck
9. Daily cumulative tonnage of mix for the mix design

320-3.2.2.1 Electronic Ticketing (E-Ticketing) System: Provide an e-Ticketing System (including any necessary software and hardware) capable of monitoring, collecting, storing, and reporting the information required by the Contract for all loads of asphalt mix delivered to the project. After each truck is loaded, electronically record and use a web service to upload the ticket information to the E-ticketing software database. The E-ticketing system shall provide each truck load's ticket information to users of the e-ticketing software.

E-ticketing software must provide the Engineer the ability to access real-time monitoring of asphalt truck load ticket information as described herein.

The e-Ticketing system shall be integrated with the Load Read-Out scale system at the asphalt plant site.

The e-ticketing system shall have offline capabilities to prevent data loss in the event of power loss or loss of connectivity.

320-3.2.2.1.1 E-Ticketing System Construction Requirements: Install and operate equipment in accordance with the manufacturer's specifications.

320-3.2.2.1.2 Data Deliverables: Provide to the Engineer a means of gathering report summaries by way of iOS or Android apps, web pages, or any other method at the disposal of the Engineer. The Engineer may request data at any time during paving operations. In addition to providing reports referenced in this specification, provide monthly reports, as well as, a final, end of project report in the e-ticketing software and in a comma separated value (.csv) file. Provide all e-ticketing database data required in this Section in the monthly and end of project reports and .csv files.

320-3.2.2.1.3 Real-Time Continuous e-Ticketing Data Items: Provide the Engineer access to the e-Ticketing system data viewer which displays the following information in real-time with a web-based or App-based system compatible with iOS, Windows, or Android environments:

1. Each Truck:
    a. Unique Truck ID
    b. Sequential Truck Load Number
    c. Mix Design Number
    d. Net Weight of material being transported (to the nearest 0.01 ton)
    e. Running Daily Total of Net Weight of material being transported (to the nearest 0.01 ton)
    f. Project's Financial Identification Number
2. Project Location

320-3.2.2.1.4 Daily Summary: Provide the following summary information to the Engineer electronically within 4 hours of beginning operations on the next working day:

1. List of Individual Loads

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a. Contractor Name
b. Project's Financial Identification Number (FIN)
c. Unique Truck ID
d. Sequential Load Number
e. Net Weight for Payment (nearest 0.01 tons)
f. Net Weight of Waste (nearest 0.01 tons)
g. Date Paved
h. Mix Temperature Measurements (Plant QC, Plant VT, Roadway QC, and Roadway VT)
i. Time Loaded at Plant site

320-3.2.2.2 Electronic Weigh Systems: Utilize any one of the following three electronic weigh systems.

320-3.2.2.2.1 Electronic Weigh System on the Truck Scales: Provide an electronic weigh system on all truck scales, which is equipped with an automatic recordation system that is approved by the Engineer. Use scales of the type that directly indicate the total weight of the loaded truck. Use scales meeting the requirements for accuracy, condition, etc., of the Bureau of Weights and Measures of the Florida Department of Agriculture, and re-certify such fact every six months, either by the Bureau of Weights and Measures or by a registered scale technician.

320-3.2.2.2.2 Electronic Weigh System on Hoppers Beneath a Surge or Storage Bin: Provide an electronic weigh system on the hopper (hopper scales or load cells) beneath the surge or storage bin, which is equipped with an automatic recordation system approved by the Engineer.

320-3.2.2.2.3 Automatic Batch Plants: For batch plants, provide an electronic weigh system, which is equipped with an automatic recordation system, that is approved by the Engineer, which will directly indicate the individual or cumulative weights of aggregate and liquid asphalt delivered to the pugmill and the total net weight of the asphalt mix measured by hopper scales or load cell type scales. Use the electronic systems only in conjunction with automatic batching and mixing control systems that have been approved by the Engineer.

320-3.2.2.3 Monthly Electronic Weigh System Comparison Checks: Check the accuracy of the electronic weighing system at the commencement of production and thereafter by one of the following three methods and maintain a record of the weights in the Scale Check Worksheet. The time period between scale checks shall not exceed 35 calendar days.

320-3.2.2.3.1 Electronic Weigh System on Truck Scales:

1. The Engineer will randomly select a loaded truck of asphalt mix, a loaded aggregate haul truck, or another vehicle type approved by the Engineer and record the truck number and gross weight from the Contractor's delivery ticket.
2. Weigh the selected truck on a certified truck scale, which is not owned by the Contractor and record the gross weight for the comparison check. If another certified truck scale is not available, the Engineer may permit another set of certified truck scales owned by the Contractor to be used. The Engineer may elect to witness the scale check.
3. The gross weight of the loaded truck as shown on the Contractor's delivery ticket will be compared to the gross weight of the loaded truck from the

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other certified truck scale. The maximum permissible deviation is 8 pounds per ton of load, based on the certified truck scale weight.

4. If the distance from the asphalt plant to the nearest certified truck scale is enough for fuel consumption to affect the accuracy of the comparison checks, a fuel adjustment may be calculated by using the truck odometer readings for the distance measurement, and 6.1 miles per gallon for the fuel consumption rate, and 115 ounces per gallon for fuel weight.

5. During production, when an additional certified truck scale is not available for comparison checks, the Engineer may permit the Contractor to weigh the truck on his certified scales used during production and then weigh it on another certified truck scale, as soon as the other scale is available for the comparison checks.

In addition to the periodic checks as specified above, check the scales at any time the accuracy of the scales becomes questionable. When such inaccuracy does not appear to be sufficient to seriously affect the weighing operations, the Engineer will allow a period of two calendar days for the Contractor to conduct the required scale check. However, in the event the indicated inaccuracy is sufficient to seriously affect the mixture, the Engineer may require immediate shut-down until the accuracy of the scales has been checked and necessary corrections have been made. Include the cost of all scale checks in the bid price for asphalt concrete, at no additional cost to the Department.

320-3.2.2.3.2 Electronic Weigh System on Hoppers Beneath a Surge or Storage Bin:

1. The Engineer will randomly select a loaded truck of asphalt mix and record the truck number, and the net weight of the asphalt mix from the Contractor's delivery ticket.

2. Weigh the selected truck on a certified truck scale, which is not owned by the Contractor and record the gross weight for the comparison check. If another certified truck scale is not available, the Engineer may permit another set of certified truck scales owned by the Contractor to be used. The Engineer may elect to witness the scale check.

3. Deliver the asphalt mix to the project, then weigh the selected empty truck on the same certified truck scales. Record the tare weight of the truck.

4. Compare the net weight of the asphalt mix from the delivery ticket to the calculated net weight of the asphalt mix as determined by the certified truck scale weights. The maximum permissible deviation is 8 pounds per ton of load, based on the certified truck scale weight.

5. Use the fuel adjustment as specified in 320-3.2.2.3.1(4), when the distance from the asphalt plant to the nearest certified truck scale is enough for fuel consumption to affect the accuracy of the comparison checks.

6. During production, when an additional certified truck scale is not available for comparison checks, the Engineer may permit the Contractor to load a truck with aggregate from the pugmill, surge or storage bin, and follow the above procedures to conduct the comparison checks as soon as certified truck scale is available.

If the check shows a greater difference than the tolerance specified above, then recheck on a second set of certified scales. If the check and recheck indicate that the printed weight is out of tolerance, have a certified scale technician check the electronic weigh system and certify the accuracy of the printer. While the system is out of tolerance and before its

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adjustment, the Engineer may allow the Contractor to continue production only if provisions are made to use a set of certified truck scales to determine the truck weights.

320-3.2.2.3.3 Electronic Weigh System on Hoppers Beneath a Surge or Storage Bin and Automatic Batch Plants with Printout:

1. The Engineer will randomly select a loaded truck of asphalt mix and record the truck number, and the net weight of the asphalt mix from the Contractor's delivery ticket.

2. Weigh the selected truck on a certified truck scale, which is not owned by the Contractor and record the gross weight for the comparison check. If another certified truck scale is not available, the Engineer may permit another set of certified truck scales owned by the Contractor to be used. The Engineer may elect to witness the scale check.

3. Deliver the asphalt mix to the project, then weigh the selected empty truck on the same certified truck scales. Record the tare weight of the truck.

4. Compare the net weight of the asphalt mix from the delivery ticket to the calculated net weight of the asphalt mix as determined by the certified truck scale weights. The maximum permissible deviation is 8 pounds per ton of load, based on the certified truck scale weight.

5. Use the fuel adjustment as specified in 320-3.2.1.4.1(4), when the distance from the asphalt plant to the nearest certified truck scale is enough for fuel consumption to affect the accuracy of the comparison checks.

6. During production, when an additional certified truck scale is not available for comparison checks, the Engineer may permit the Contractor to load a truck with aggregate from the pugmill, surge or storage bin, and follow the above procedures to conduct the comparison checks as soon as certified truck scale is available.

If the check shows a greater difference than the tolerance specified above, then recheck on a second set of certified scales. If the check and recheck indicate that the weight on the E-Ticket is out of tolerance, have a certified scale technician check the electronic weigh system and certify the accuracy of the E-Ticketing system. While the system is out of tolerance and before its adjustment, the Engineer may allow the Contractor to continue production only if provisions are made to use a set of certified truck scales to determine the truck weights.

320-3.3 Asphalt Binder: Meet the following requirements:

320-3.3.1 Transportation: Deliver the asphalt binder to the asphalt plant at a temperature not to exceed 370°F, and equip the transport tanks with sampling and temperature sensing devices meeting the requirements of 300-3.2.

320-3.3.2 Storage: Equip asphalt binder storage tanks to heat the liquid asphalt binder to the temperatures required for the various mixtures. Heat the material in such a manner that no flame comes in contact with the binder. Heat or insulate all pipe lines and fittings. Use a circulating system of adequate size to ensure proper and continuous circulation during the entire operating period. Locate a thermometer, reading from 200 to 400°F, either in the storage tank or in the asphalt binder feed line. Maintain the asphalt binder in storage within a range of 230 to 355°F in advance of mixing operations. Locate a sampling device on the discharge piping exiting the storage tank or at a location as approved by the Engineer. Provide a metal can of one quart capacity for binder sampling at the request of the Engineer.

320-3.4 Aggregate: Meet the following requirements:

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320-3.4.1 Stockpiles: Place each aggregate component in an individual stockpile, and separate each from the adjacent stockpiles, either by space or by a system of bulkheads. Prevent the intermingling of different materials in stockpiles at all times. Identify each stockpile, including RAP, as shown on the mix design.

Form and maintain stockpiles in a manner that will prevent segregation. If a stockpile is determined to be segregated, discontinue the use of the material on the project until the appropriate actions have been taken to correct the problem.

320-3.4.2 Blending of Aggregates: Stockpile all aggregates prior to blending or placing in the cold feed bins. If mineral filler or hydrated lime is required in the mix, feed or weigh it in separately from the other aggregates.

320-3.4.2.1 Cold Feed Bin: Provide a separate cold feed bin for each component of the fine and coarse aggregate required by the mix design. Equip the cold feed bins with accurate mechanical means for feeding the aggregate uniformly into the dryer in the proportions required for the finished mix to maintain uniform production and temperature. When using RAP as a component material, prevent any oversized RAP from being incorporated into the completed mixture by the use of: a grizzly or grid over the RAP bin; in-line roller or impact crusher; screen; or other suitable means. If oversized RAP material appears in the completed recycled mix, take the appropriate corrective action immediately. If the appropriate corrective actions are not immediately taken, stop plant operations.

Use separate bin compartments in the cold aggregate feeder that are constructed to prevent any spilling or leakage of aggregate from one cold feed bin to another. Ensure that each cold feed bin compartment has the capacity and design to permit a uniform flow of aggregates. Mount all cold feed bin compartments over a feeder of uniform speed, which will deliver the specified proportions of the separate aggregates to the drier at all times. If necessary, equip the cold feed bins with vibrators to ensure a uniform flow of the aggregates at all times.

320-3.4.2.2 Gates and Feeder Belts: Provide each cold feed bin compartment with a gate and feeder belt, both of which are adjustable to assure the aggregate is proportioned to meet the requirements of the mix design.

320-3.4.3 Screening Unit: Remove any oversized pieces of aggregate by the use of a scalping screen. Do not return this oversized material to the stockpile for reuse unless it has been crushed and reprocessed into sizes that will pass the scalping screen. Ensure that the quantity of aggregates being discharged onto the screens does not exceed the capacity of the screens to actually separate the aggregates into the required sizes.

320-3.5 Dryer: Provide a dryer of satisfactory design for heating and drying the aggregate. Use a dryer capable of heating the aggregate to within the specified temperature range for any mix, and equip the dryer with an electric pyrometer placed at the discharge chute to automatically register the temperature of the heated aggregates.

320-3.6 Asphalt Binder Control Unit: Provide a satisfactory means, either by weighing, metering, or volumetric measuring, to obtain the proper amount of asphalt binder material in the mix, within the tolerance specified for the mix design.

320-3.7 Contractor's Responsibilities: Acceptance of any automatic delivery ticket printout, electronic weight delivery ticket, other evidence of weight of the materials or approval of any particular type of material or production method will not constitute agreement by the Department that such matters are in accordance with the Contract Documents and it shall be the Contractor's responsibility to ensure that the materials delivered to the project are in accordance with the Contract Documents.

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320-4 Additional Requirements for Batch Plants.

320-4.1 Heating and Drying: Heat and dry the aggregate before screening. Control the temperature of the aggregate so the temperature of the completed mixture at the plant falls within the permissible range allowed by this Section.

320-4.2 Gradation Unit: Provide plant screens capable of separating the fine and coarse aggregates and of further separating the coarse aggregate into specific sizes. In addition, equip the gradation unit with a scalping screen to restrict the maximum size of the aggregates. In the event that the plant is equipped with cold feed bins that are capable of adequately controlling the gradation of the mixture, the use of plant screens is optional.

320-4.3 Hot Bins: Provide storage bins of sufficient capacity to supply the mixer when it is operating at full capacity. Provide hot bins with divided compartments to ensure separate and adequate storage of the appropriate fractions of the aggregate. Equip each compartment with an overflow chute of suitable size and location to prevent any backing up of material into other bins.

320-4.4 Weigh Box or Hopper: Equip the batch plant with a means for accurately weighing each bin size of aggregate and the mineral filler into the weigh box or hopper.

320-4.5 Pugmills: Utilize a pugmill capable of mixing the aggregate and the asphalt binder.

320-5 Additional Requirements for Drum Mixer Plants.

320-5.1 Weight Measurements of Aggregate: Equip the plant with a weigh-in-motion scale capable of measuring the quantity of aggregate (and RAP) entering the dryer.

320-5.2 Synchronization of Aggregate Feed and Asphalt Binder Feed: Couple the asphalt binder feed control with the total aggregate weight device, including the RAP feed, in such a manner as to automatically vary the asphalt binder feed rate as necessary to maintain the required proportions.

320-5.3 Hot Storage or Surge Bins: Equip the plant with either a surge bin or storage silo that is capable of storing an adequate amount of material to assure a uniform and consistent product.

320-6 Preparation of the Mixture.

320-6.1 Mixing: After the aggregate is dried and properly proportioned, mix the aggregate, along with any other components, with the asphalt binder to produce a thoroughly and uniformly coated mixture. Do not produce the mix by altering the component blend percentage of the RAP or sand by more than plus or minus 5.0% from the job mix formula on the approved mix design. For mix designs using fractionated RAP, the combined blend change for all RAP components must not exceed plus or minus 5.0%. The plus or minus 5.0% maximum component change does not apply to crushed virgin aggregate components during production.

320-6.2 Storage: If necessary, store the asphalt mixture in a surge bin or hot storage silo for a maximum of 72 hours. For FC-5 mixtures containing mineral fibers, store the asphalt mixture in a surge bin or hot storage silo for a maximum of one hour. For FC-5 mixtures containing cellulose fibers, store the asphalt mixture in a surge bin or hot storage silo for a maximum of 1-1/2 hours.

320-6.3 Mix Temperature: Produce the mixture with a temperature within the master range as defined in Table 320-2.

320-6.3.1 Test Requirements: Determine the temperature of the completed mixture using a quick-reading thermometer through a hole in the side of the loaded truck immediately after loading. Locate a 1/4 inch hole on both sides of the truck body within the

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middle third of the length of the body, and at a distance from 6 to 10 inches above the surface supporting the mixture. If a truck body already has a hole located in the general vicinity of the specified location, use this hole. At the Engineer's discretion, the Contractor may take the temperature of the load over the top of the truck in lieu of using the hole in the side of the truck.

320-6.3.2 Test Frequency: The normal frequency for taking asphalt mix temperatures will be for each day, for each design mix on the first five loads and one out of every five loads thereafter. Take the temperature of the asphalt mix at the plant and at the roadway before the mix is placed at the normal frequency. Record the temperature on the front of the respective delivery ticket. The Engineer shall review the plant and roadway temperature readings and may take additional temperature measurements at any time.

If any single load at the plant or at the roadway is within the master range shown in Table 320-2 but does not meet the criteria shown in Table 320-3, the temperature of every load will be monitored until the temperature falls within the specified tolerance range in Table 320-3; at this time the normal frequency may be resumed. For warm mix asphalt, the Contractor may produce the first five loads of the production day and at other times when approved by the Engineer, at a hot mix asphalt temperature not to exceed 330°F for purposes of heating the asphalt paver. For this situation, the upper tolerances of Tables 320-2 and 320-3 as applied to the warm mix asphalt mix design do not apply.

For windrow paving, in addition to the truck load temperature measurements noted above, perform windrow temperature measurements at a frequency of one measurement per 500 feet of windrow placed. Check the temperature of the windrow asphalt mixture using a quick-reading thermometer or directly in front of the windrow material transfer vehicle, but not so close that paving must be stopped. Measure the temperature of the windrow beneath the exposed surface by shoveling away a portion of the windrow and then measuring the temperature. For windrow temperature measurements, the requirements of Table 320-2 and 320-3 apply.

320-6.3.3 Rejection Criteria: Reject any load or portion of a load of asphalt mix at the plant or at the roadway with a temperature outside of its respective master range shown in Table 320-2. Notify the Engineer of the rejection immediately. The maximum temperature for any load of mixture containing PG 76-22 PMA or High Polymer binder shall not exceed 355°F.

Table 320-2	
Mix Temperature Master Range Tolerance	
Location	Acceptable Temperature Tolerance
Plant	Mixing Temperature ±30°F*
Roadway (mix in truck)	Compaction Temperature ±30°F*
Roadway (mix in windrow)	Compaction Temperature +30°F*, -40°F
*Not to exceed 355°F for mixtures containing PG 76-22 PMA or High Polymer binder.	

Table 320-3	
Mix Temperature Tolerance from Verified Mix Design	
Any Single Measurement	±25°F

320-7 Transportation of the Mixture.

Transport the mix in trucks of tight construction, which prevents the loss of material and the excessive loss of heat and previously cleaned of all foreign material. After cleaning, thinly

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coat the inside surface of the truck bodies with soapy water or an asphalt release agent as needed to prevent the mixture from adhering to the beds. Do not allow excess liquid to pond in the truck body. Do not use a release agent that will contaminate, degrade, or alter the characteristics of the asphalt mix or is hazardous or detrimental to the environment. Petroleum derivatives (such as diesel fuel), solvents, and any product that dissolves asphalt are prohibited. Provide each truck with a tarpaulin or other waterproof cover mounted in such a manner that it can cover the entire load when required. When in place, overlap the waterproof cover on all sides so that it can be tied down. Cover each load during cool and cloudy weather and at any time it appears rain is likely during transit with a tarpaulin or waterproof cover. Cover and tie down all loads of friction course mixtures.

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SECTION 327
MILLING OF EXISTING ASPHALT PAVEMENT

327-1 Description.

Remove existing asphalt concrete pavement by milling to improve the rideability and cross slope of the finished pavement, to lower the finished grade adjacent to existing curb before resurfacing, or to completely remove existing pavement.

When milling to improve rideability, the Plans will specify an average depth of cut.

Take ownership of milled material.

327-2 Equipment.

Provide a milling machine capable of maintaining a depth of cut and cross slope to achieve the results specified in the Contract Documents. Use a machine with a minimum overall length (out-to-out measurement excluding the conveyor) of 18 feet and a minimum cutting width of 6 feet.

Equip the milling machine with a built-in automatic grade control system that can control the transverse slope and the longitudinal profile to produce the specified results.

To start the project, the Engineer will approve any commercially manufactured milling machine that meets the above requirements. If it becomes evident after starting milling that the milling machine cannot consistently produce the specified results, the Engineer will reject the milling machine for further use.

The Contractor may use a smaller milling machine when milling to lower the grade adjacent to existing curb or other areas where it is impractical to use the above described equipment.

Equip the milling machine with means to effectively limit the amount of dust escaping during the removal operation.

For complete pavement removal, the Engineer may approve the use of alternate removal and crushing equipment instead of the equipment specified above.

327-3 Construction.

327-3.1 General: Remove the existing raised pavement markers (RPMs) before milling. Include the cost of removing existing RPMs in the price for milling.

When milling to improve rideability or cross slope, remove the existing pavement to the average depth specified in the Plans, in a manner that will restore the pavement surface to a uniform cross slope and longitudinal profile. The Engineer may require the use of a stringline to ensure maintaining the proper alignment.

Establish the longitudinal profile of the milled surface in accordance with the milling plans. Ensure the final cross slope of the milled surface parallels the surface cross slope shown in the Plans or as directed by the Engineer. Establish the cross slope of the milled surface by a second sensing device near the outside edge of the cut or by an automatic cross slope control mechanism. The Plans may waive the requirement of automatic grade or cross slope controls where the situation warrants such action.

Operate the milling machine to minimize the amount of dust being emitted. The Engineer may require prewetting of the pavement.

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Provide positive drainage of the milled surface and the adjacent pavement. Perform this operation on the same day as milling. Pave all milled surfaces no later than the day after the surface was milled.

If traffic is to be maintained on the milled surface before the placement of the new asphalt concrete, provide suitable transitions between areas of varying thickness to create a smooth longitudinal riding surface. Control milling operations to produce a pattern of striations and a texture that provide an acceptable riding surface.

Before opening an area which has been milled to traffic, sweep the pavement and gutters with a power broom or other approved equipment to remove, to the greatest extent practicable, fine material which will create dust under traffic. Sweep in a manner to minimize the potential for creation of a traffic hazard and to minimize air pollution. Do not sweep or allow milled asphalt into inlets.

Sweep the milled surface with a power broom before placing asphalt concrete.

In urban and other sensitive areas, use a street sweeper or other equipment capable of removing excess milled materials and controlling dust. Obtain the Engineer's approval of such equipment, contingent upon its demonstrated ability to do the work.

Perform the sweeping operation immediately after the milling operations or as directed by the Engineer.

327-3.1.1 Extended Time for Milled Surface Traffic: Upon approval of the Engineer, the time period for maintaining traffic on a milled surface may be extended up to 3 calendar days before paving is required, provided the Contractor can demonstrate the ability to produce a milled surface texture with continuous, longitudinal milling striations with no gaps in the longitudinal striations, and drop off conditions are not exceeded. Gaps in the milling striations and cases where gaps create a diagonal pattern or chevron appearance are to be milled again such that continuous, longitudinal striations are achieved prior to allowing traffic on the milled surface. Photos of acceptable and unacceptable surface texture are located at: https://www.fdot.gov/programmanagement/implemented/urlinspecs/milling-patterns

Maintain adequate drainage on the milled surface and at transitions between milled and non-milled surfaces on the same day as milling. At no cost to the Department, re-mill or pave any area the Engineer determines to have an unacceptable ride, does not provide adequate pavement structure, or does not provide adequate drainage.

If the Engineer determines the Contractor is unable to provide a milled surface meeting the Specification requirements above, at no cost to the Department, the Contractor will be required to pave all milled surfaces no later than the day after the surface was milled.

327-3.2 Quality Control Requirements: Furnish a four foot long electronic level accurate to 0.1 degree, approved by the Engineer for the control of cross slope. Make this electronic level available at the jobsite at all times during milling operations. Calibrate and compare electronic levels in accordance with 330-9.3.1 at a minimum frequency of once per day before any milling operation.

Multiple cuts may be made to achieve the required pavement configuration or depth of cut.

327-3.2.1 Cross Slope Measurement: Measure the cross slope of the milled surface by placing the level at the center of the lane and perpendicular to the roadway centerline. Record all the measurements to the nearest 0.1% on an approved form and submit the data to the Engineer.

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327-3.2.1.1 Cross Slope Measurement Frequency:

1. Tangent Sections: Measure the cross slope at a minimum frequency of one measurement every 100 feet per lane. When the average absolute deviation is consistently within the acceptance tolerance in Table 327-1, upon approval by the Engineer, the frequency of the cross slope measurements can be reduced to one measurement every 200 feet.

2. Superelevated Sections: Measure the cross slope every 100 feet per lane within the length of full superelevation. For curves where the length of full superelevation is less than 250 feet, measure the cross slope at the beginning point, midpoint, and ending point of the fully superelevated section. For transition sections, measure the cross slope at control points identified in the Plans or, if not shown in the Plans, at a control point at a location of 0.0% cross slope.

327-3.2.1.2 Cross Slope Deviations and Corrections: Calculate the absolute deviation of each cross slope measurement and the average of the absolute deviations of ten consecutive cross slope measurements. The absolute deviation is the positive value of a deviation. In superelevated sections, when the number of measurements is less than ten, average the absolute deviation of all measurements.

If the average absolute deviation of any cross slope measurement falls outside the acceptance tolerance shown in Table 327-1, stop the milling operations and make adjustments until the problem is resolved to the satisfaction of the Engineer. If an individual cross slope deviation falls outside the acceptance tolerance as shown in Table 327-1, make corrections only in the deficient area to the satisfaction of the Engineer at no cost to the Department. For pavement with multiple cuts, the deficient areas not caused by the final cut may be left in place upon approval of the Engineer. All milling corrections shall be completed before placement of the asphalt course unless stated otherwise in the Plans or as determined by the Engineer.

The limits of deficient areas requiring correction may be verified and adjusted with more accurate measurement methods, including survey instruments, upon approval of the Engineer and at no cost to the Department.

Should the Contractor wish to have any required corrections waived, submit a request to the Engineer for approval. The Engineer may waive the corrections at no reduction in payment if the deficiencies are sufficiently separated so as not to significantly affect the final cross slope or project grade.

For intersections, tapers, crossovers, transitions at the beginning and end of the project, bridge approaches and similar areas, adjust the cross slope to match the actual site conditions, or as directed.

Table 327-1
Cross Slope Milling Acceptance Tolerance

Roadway Feature	Individual Absolute Deviation	Average Absolute Deviation
Tangent section (including turn lanes)	0.4%	0.2%
Superelevated curve	0.4%	0.2%
Shoulder	0.5%	0.5%

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In the event the distance between two edges of deficient areas is less than 100 feet, the correction work shall include the area between the deficient areas.

327-3.3 Verification: The Engineer will verify the Contractor's cross slope measurements by randomly taking a minimum of ten cross slope measurements per lane per mile in tangent sections, at control points in transition sections, and a minimum of three cross slope measurements in fully superelevated sections. The Engineer will measure the cross slope of the milled surface by placing the level at the center of the lane and perpendicular to the roadway centerline.

327-3.3.1 Cross Slope Deviations and Corrections: If the average absolute deviation or an individual cross slope deviation falls outside the acceptance tolerance in Table 327-1, immediately make a comparison check at the QC test locations to verify the QC measurements in the section. If the comparisons are beyond the acceptable comparison tolerance in accordance with 327-3.2, stop the milling operation until the issue is resolved to the satisfaction of the Engineer. Correct any cross slope not meeting the individual deviation acceptance tolerance at no cost to the Department. The Engineer reserves the right to check the cross slope of the milled surface at any time by taking cross slope measurements at any location.

327-4 Milled Surface.

Provide a milled surface with a reasonably uniform texture, within 1/4 inch of a true profile grade, and with no deviation in excess of 1/4 inch from a straightedge applied to the pavement perpendicular to the centerline. Ensure the variation of the longitudinal joint between multiple cut areas does not exceed 1/4 inch. The Engineer may accept areas varying from a true surface in excess of the above stated tolerance without correction if the Engineer determines they were caused by a pre-existing condition which could not have reasonably been corrected by the milling operations. Correct any unsuitable texture or profile, as determined by the Engineer, at no cost to the Department.

The Engineer may require remilling of any area where a surface lamination causes a non-uniform texture to occur.

327-5 Method of Measurement.

The quantity to be paid for will be the plan quantity area, in square yards, over which milling is completed and accepted.

327-6 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including hauling off and stockpiling or otherwise disposing of the milled material.

Payment will be made under:

Item No. 327- 70- Milling Existing Asphalt Pavement - per square yard.

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SECTION 330
HOT MIX ASPHALT -
GENERAL CONSTRUCTION REQUIREMENTS

330-1 Description.

This Section specifies the basic equipment and construction requirements for hot mix asphalt (including warm mix asphalt) pavements and bases. Establish and maintain a quality control system that provides assurance that all materials, products and completed construction submitted for acceptance meet Contract requirements.

330-1.1 Materials: Meet the following requirements:

Prime and Tack Coats .....Section 300

330-2 Quality Control (QC) Requirements.

330-2.1 Minimum QC Requirements: Perform as a minimum, the following activities necessary to maintain process control and meet Specification requirements:

1. Pavement Density: Monitor the pavement temperature with an infrared temperature device so compaction is completed before the surface temperature of the pavement drops to the extent that effective compaction may not be achieved or the rollers begin to damage the pavement. Monitor the roadway density with either 6-inch diameter roadway cores, a nuclear density gauge, or other density measuring device, at a minimum frequency of once per 1,500 feet of pavement.

2. Mix Temperature: Determine the mix temperature at the roadway for the first five loads and one out of every five loads thereafter.

3. Mix Spread Rate: Monitor the mix spread rate at the beginning of each day's production, and as needed to control the operations, at a minimum of once per 200 tons placed. When determining the spread rate, use, at a minimum, an average of five truckloads of mix.

4. Pavement Texture: Monitor the pavement texture to minimize pavement segregation. Use density gauges, infrared temperature measurement devices, or roadway cores at the beginning of each day's production, and as necessary, both at truck exchanges and during normal paving operations.

5. Reporting: Ensure the accuracy of the QC Roadway Reports on the Department's approved form to reflect the actual surface area of the finished work and be in compliance with the requirements of the Contract Documents.

6. Electronic Ticketing (E-Ticketing): When E-Ticketing is used, provide a tablet computer on site with the Paving Operation capable of running the E-Ticketing system software outlined in Section 320. Use the E-ticketing software to obtain truck ticket information and record mix temperatures. Use the E-ticketing data for entry into the Asphalt Roadway – Daily Report of Quality Control.

330-2.2 Personnel Qualifications: Provide QC Technicians in accordance with Section 105.

330-3 Limitations of Operations.

330-3.1 Weather Limitations: Do not transport asphalt mix from the plant to the roadway unless all weather conditions are suitable for the paving operations.

330-3.2 Limitations of Paving Operations:

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330-3.2.1 General: Place the mixture only when the surface upon which it is to be placed has been previously prepared, is intact, firm, dry, clean, and the tack or prime coat, with acceptable spread rate, is properly broken or cured. Do not place friction course until the adjacent shoulder area has been dressed and grassed.

330-3.2.2 Ambient Air Temperature: Place the mixture only when the air temperature in the shade and away from artificial heat meets requirements of Table 330-1. The minimum ambient temperature requirement may be reduced by 5ºF when using warm mix technology, if mutually agreed to by both the Engineer and the Contractor.

Table 330-1

Ambient Air Temperature Requirements for Paving

Layer Thickness or Asphalt Binder Type	Minimum Temperature (°F)
≤ 1 inch	50
Any mixture > 1 inch containing a PG asphalt binder with a high temperature designation ≥ 76°C	45
Any mixture > 1 inch containing a PG asphalt binder with a high temperature designation < 76°C	40
FC-5[(1)]	65

[(1)]As an exception, place the mixture at temperatures no lower than 60ºF, only when approved by the Engineer based on the Contractor's demonstrated ability to achieve a satisfactory surface texture and appearance of the finished surface. For mixtures containing PG 76-22 binder, the minimum ambient temperature may be further reduced to 55ºF when using warm mix technology, if agreed to by both the Engineer and the Contractor.

330-3.2.3 Rain and Surface Conditions: Immediately cease transportation of asphalt mixtures from the plant when rain begins at the roadway. Do not place asphalt mixtures while rain is falling, or when there is water on the surface to be covered. Once the rain has stopped, standing water has been removed from the tacked surface to the satisfaction of the Engineer, and the temperature of the mixture caught in transit still meets the requirements as specified in 320-6.3, the Contractor may then place the mixture caught in transit.

For windrow paving, immediately cease dumping of asphalt material when rain begins at the roadway. Stop paving operations while rain is falling or where there is water on the surface to be covered. Remove windrowed asphalt mixture exposed to rain. Once the rain has stopped, standing water has been removed from the tacked surface to the satisfaction of the Engineer, and the temperature of the mixture caught in transit still meets the requirements as specified in 320-6.3, the Contractor may then windrow the remaining material caught in transit.

330-3.2.4 Wind: Do not place the mixture when the wind is blowing to such an extent that proper and adequate compaction cannot be maintained or when sand, dust, etc., are being deposited on the surface being paved to the extent the bond between layers will be diminished.

330-4 Surface Preparation.

330-4.1 Cleaning: Before placing the mixture, clean the surface of the base or underlying pavement of all loose and deleterious material by the use of power brooms or blowers, supplemented by hand brooming where necessary.

330-4.1.1 Application over Asphalt Membrane Interlayer (AMI): Where an asphalt mix is to be placed over a newly constructed AMI, do not sweep or otherwise disturb the cover material before placing the asphalt mix, unless directed by the Engineer.

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330-4.2 Tacking: Apply a tack coat on all existing pavement surfaces that are to be overlaid with an asphalt mix as specified in Section 300 and between successive layers of all asphalt mixes. Apply tack on a clean surface.

Do not place tack while rain is falling or when there is water on the surface to be tacked. Once the rain has stopped, standing water has been removed from the surface to be tacked to the satisfaction of the Engineer, the Contractor may then apply tack.

Apply a tack coat on freshly primed bases only when directed by the Engineer.

330-5 Paving Equipment.

330-5.1 General Requirements: Use mechanically-sound equipment capable of consistently meeting Specification requirements.

330-5.2 Asphalt Paver:

330-5.2.1 General: Provide a self-propelled asphalt paver that can be steered, and is equipped with a receiving and distribution hopper and a mechanical screed. Use a mechanical screed capable of adjustment to regulate the depth of material spread and to produce the desired cross slope.

When asphalt mix is placed in windrows, operate windrow pickup equipment so substantially all of the mixture deposited on the roadbed is picked up and loaded into the paver. Prevent the windrow pickup equipment from contaminating the mixture.

330-5.2.2 Automatic Screed Control: For all asphalt courses placed with an asphalt paver, equip the paver with automatic longitudinal screed controls of either the skid type, traveling stringline type, or non-contact averaging ski type with a minimum length of 25 feet. On the final layer of asphalt base, overbuild, structural courses, and friction courses, use the joint matcher instead of the skid, traveling stringline, or non-contact averaging ski on all passes after the initial pass. Equip the asphalt paver with electronic cross slope controls.

330-5.2.3 Screed Width: Provide an asphalt paver with a screed width greater than 8 feet when required to pave full width lanes. Do not use extendable screed strike-off devices that do not provide preliminary compaction of the mat in place of fixed screed extensions. Use a strike-off device only on irregular areas that would normally be done by hand and on shoulders 5 feet or less in width. When using the strike-off device on shoulders, instead of an adjustable screed extension, demonstrate the ability to obtain acceptable texture, density, and thickness.

When using an extendable screed device to extend the screed's width on the full width lane or shoulder by 24 inches or greater, the Engineer will require an auger extension, paddle, or kicker device unless the Contractor can demonstrate the ability to achieve an acceptable pavement with respect to density, surface texture, and pavement smoothness without such devices.

330-5.3 Rollers:

330-5.3.1 Steel-Wheeled Rollers: Provide compaction equipment capable of meeting the density requirements described in the Specifications. When density testing is not required, and the standard rolling pattern is used, provide a tandem steel-wheeled roller weighing 5 to 15 tons for breakdown rolling. For finish rolling, use a separate roller weighing 5 to 15 tons. Variations from these requirements shall be approved by the Engineer.

330-5.3.2 Traffic Rollers: Provide compaction equipment capable of meeting the density requirements described in the Specifications. When density testing is not required, and the standard rolling pattern is used, provide a self-propelled, pneumatic-tired traffic roller equipped with at least seven smooth-tread, low pressure tires, equipped with pads or scrapers on

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each tire. Maintain the tire pressure between 50 and 55 psi or as specified by the manufacturer. Use rollers with a minimum weight of 6 tons. Do not use wobble-wheeled rollers. Variations from these requirements shall be approved by the Engineer.

330-5.3.3 Prevention of Adhesion: Do not allow the mixture to adhere to the wheels of any rollers. Do not use fuel oil or other petroleum distillates to prevent adhesion. Do not use any method which results in water being sprinkled directly onto the mixture.

330-5.4 Coring Equipment: Furnish a suitable saw or drill for obtaining the required density cores.

330-5.5 Hand Tools: Provide the necessary hand tools such as rakes, shovels, and other similar tools, and a suitable means for keeping them clean. Do not use diesel fuel or other petroleum-based solvents contained in an open container for cleaning purposes on the paver.

330-6 Placing Mixture.

330-6.1 Requirements Applicable to All Pavement Types:

330-6.1.1 Alignment of Edges: Place all asphalt mixtures by the stringline method to obtain an accurate, uniform alignment of the pavement edge. As an exception, pavement edges adjacent to curb and gutter or other true edges do not require a stringline. Control the unsupported pavement edge to ensure it will not deviate from the stringline more than plus or minus 1.5 inches.

330-6.1.2 Paving Width: If necessary due to the traffic requirements, place the mixture in strips in such a manner as to provide for the passage of traffic. As an option, where the road is closed to traffic, place the mixture to the full width with machines traveling in echelon.

330-6.1.3 Mix Temperature: Maintain the mix temperature at the time of paving within the master range as defined in 320-6.3. Take mix temperatures on the roadway at the minimum frequency indicated in 320-6.3. Any load, or portion of a load, of asphalt mix on the roadway with a temperature outside of the master range shall be rejected for use on the project. Immediately notify the Engineer of the rejection.

Remove any windrow material not meeting the temperature requirements of 320-6.3.2 from the area of deficient temperature and replace with new asphalt meeting the temperature requirements.

330-6.1.4 Speed of Paver: Establish the forward speed of the asphalt paver based on the rate of delivery of the mix to the roadway, but not faster than the optimum speed needed to adequately compact the pavement.

330-6.1.5 Thickness and Spread Rate of Layers: Construct each layer as defined in the following Table 330-2:

Table 330-2	
Thickness and Target Spread Rate Requirements	
Mix Type	Specification Section and Article
Type SP	334-1
Type FC	337-8
Type B	234-8
ATPB	287-8

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330-6.1.5.1 Thickness Control: Ensure the spread rate is within plus or minus 10% of the target spread rate. When determining the spread rate, use, at a minimum, an average of five truckloads of mix and at a maximum, an average of 10 truckloads of mix, except for windrow paving, use an average of three truckloads of mix. When the average spread rate is beyond plus or minus 10% of the target spread rate, monitor the thickness of the pavement layer closely and adjust the construction operations.

When the average spread rate for two consecutive days is beyond plus or minus 10% of the target spread rate, stop the construction operation until the issue is resolved.

330-6.1.5.2 Maximum Spread Rate Tolerances: When an individual spread rate, measured in accordance with 330-6.1.5.1, is beyond plus or minus 20% of the target spread rate, stop the construction operation until the issue is resolved. Address the unacceptable pavement in accordance with 330-9.5. The following areas are exempt from a work stoppage based solely on the calculated spread rate: median crossovers, turnouts, variable thickness overbuild courses, leveling courses, miscellaneous asphalt pavement, as well as, turn lanes and ramps less than 1,000 feet.

As an exception, the Engineer may allow the Contractor to leave areas in place if it is determined by the Engineer that the deficiency is not a significant detriment to the pavement quality. For areas of deficient thickness, a reduction to the pay item quantity will be made in accordance with 330-9.5.2.

330-6.1.6 Correcting Defects: Before starting any rolling, check the surface; correct any irregularities; remove all drippings, sand accumulations from the screed, and fat spots from any source; and replace them with satisfactory material. Do not skin patch. When correcting a depression while the mixture is hot, scarify the surface and add fresh mixture.

330-6.1.7 Hand Work: In limited areas where the use of the paver is impossible or impracticable, the Contractor may place and finish the mixture by hand.

330-7 Compacting Mixture.

330-7.1 General Requirements: When density testing for acceptance is required, select equipment, sequence, and coverages of rolling to meet the specified density requirement. Regardless of the rolling procedure used, complete the final rolling before the surface temperature of the pavement drops to the extent effective compaction may not be achieved or the rollers begin to damage the pavement.

No vibratory compaction in the vertical direction will be allowed for layers one inch or less in thickness or, if the Engineer or Contract Documents limit compaction to the static mode only. Compact these layers in the static mode only. Other non-vertical vibratory modes of compaction will be allowed, if approved by the Engineer; however, no additional compensation, cost or time, will be made.

330-7.2 Standard Rolling Procedure: When density testing for acceptance is not required, propose an alternative rolling pattern to be approved by the Engineer or use the following standard rolling procedure:

1. Breakdown rolling: Provide two static coverages with a tandem steel-wheeled roller, following as close behind the paver as possible without pick-up, undue displacement, or blistering of the mix.

2. Intermediate rolling: Provide five static coverages with a pneumatic-tire roller, following as close behind the breakdown rolling operation as the mix will permit.

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3. Finish rolling: Provide one static coverage with a tandem steel-wheeled roller, after completing the breakdown rolling and intermediate rolling, but before the surface pavement temperature drops to the extent effective compaction may not be achieved or the rollers begin to damage the pavement.

330-7.3 Rolling Procedures: Use procedures that will uniformly compact the pavement layer to the desired density level, while meeting the appropriate smoothness requirements, without damaging the pavement surface, crushing aggregate or leaving excessive roller marks, roller heads, or ripples. While rolling is in progress, monitor the surface continuously, and adjust the compaction operations to comply with the surface requirements.

330-7.4 Compaction of Areas Inaccessible to Rollers: Use hand tamps or other satisfactory means to compact areas which are inaccessible to a roller, such as areas adjacent to curbs, gutters, bridges, manholes, etc.

330-7.5 Correcting Defects: Do not allow the compaction equipment to deposit contaminants onto the pavement surface. Remove and replace any areas damaged by such deposits as directed by the Engineer. Correct any depressions that develop before completing the rolling by loosening the mixture and adding new mixture to bring the depressions to a true surface. Should any depression remain after obtaining the final compaction, remove the full depth of the mixture, and replace it with enough new mixture to form a true and even surface. Correct all defects before laying the subsequent course.

330-7.6 Use of Traffic Roller: Use a traffic roller on the first overbuild course. Use a traffic roller or vibratory roller (unless restricted by the Contract Documents) on the first structural layer placed on an AMI.

330-7.7 Compaction at Bridge Structures: Compact asphalt mixtures placed over bridge decks and approach slabs using static compaction only. Use the standard rolling procedure described in 330-7.2 or an alternative procedure approved by the Engineer.

330-8 Joints.

330-8.1 General: When laying fresh mixture against the exposed edges of joints, place it in close contact with the exposed edge to produce an even, well-compacted joint after rolling.

330-8.2 Transverse Joints: Place the mixture as continuously as possible to minimize transverse joints. When constructing permanent transverse joints, meet the surface requirements as defined in 330-9. Construct temporary transverse joints in such a manner to allow traffic to pass over it. When resuming the paving operation, construct a transverse joint by cutting back on the previously placed pavement at a location where the straightedge requirements are met. At the project limits, tie into the adjoining pavement layers as shown in the Plans.

330-8.3 Longitudinal Joints: Place each layer of pavement so all longitudinal construction joints are offset 6 to 12 inches laterally between successive layers. Plan offsets in advance so the longitudinal joints of the friction course are not in wheel path areas. The longitudinal joints for friction course layers should be within 6 inches of the lane edge or at the center of the lane. The Engineer may waive this requirement where offsetting is not feasible due to the sequence of construction.

330-8.4 Placing Asphalt Next to Concrete Pavement: When placing asphalt next to concrete pavement, construct the joint as shown in the Plans.

330-9 Surface Requirements.

330-9.1 General: Construct a smooth pavement with good surface texture and the proper cross-slope.

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330-9.2 Texture of the Finished Surface of Paving Layers: Produce a finished surface of uniform texture and compaction with no pulled, torn, raveled, crushed or loosened portions and free of segregation, bleeding, flushing, sand streaks, sand spots, or ripples. Some examples of pavement deficiencies are displayed at the following URL: https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/Pavement.shtm. Address any pavement not meeting the requirements of this specification in accordance with 330-9.5.

For dense-graded structural and dense-graded friction course mixtures, in areas not defined as density testing exceptions per 334-5.1.2, obtain for the Engineer, three 6-inch diameter roadway cores at locations visually identified by the Engineer to be segregated. For areas that the Engineer identifies as being segregated, obtain and submit cores within 30 days of notification. The Engineer will determine the density of each core in accordance with FM 1-T166 and calculate the percent G_{mm} of the segregated area using the average G_{mb} of the roadway cores and the QC sublot G_{mm} for the questionable material. If the average percent G_{mm} is less than 89.5, address the segregated area in accordance with 330-9.5.

Do not use asphalt concrete mixtures containing aggregates that cause a different color appearance in the final wearing surface unless the section is greater than or equal to one mile in length and across the full width of the pavement, including shoulders and turn lanes. Exceptions to these requirements will be permitted if approved by the Engineer.

330-9.3 Cross Slope: Construct a pavement surface with cross slopes in compliance with the requirements of the Contract Documents. Furnish a four-foot-long electronic level accurate to 0.1 degree, approved by the Engineer for the control of cross slope. Make this electronic level available at the jobsite at all times during paving operations.

330-9.3.1 QC Calibration and Comparison: Calibrate the electronic levels a minimum of once per day before paving operations begin, in accordance with manufacturer's instructions.

Compare the QC level with the Verification level before paving operations begin, and at any time as directed. If the comparison between the QC and Verification levels is within plus or minus 0.2%, the QC level is considered to compare favorably and can be used for measurement and acceptance of cross-slopes. If the levels do not compare favorably, perform a second comparison using another calibrated electronic level (Department or Contractor) for resolution. If the resolution level compares favorably with the QC level, the QC level is considered to be verified. If the resolution level does not compare favorably with the QC level, discontinue the use of the QC electronic level and obtain another approved electronic level that meets the requirements of this specification. The Contractor assumes all risk associated with placing the pavement at the correct cross slope.

330-9.3.2 Cross Slope Measurement: Measure the cross slope of the compacted pavement surface by placing the level at the center of the lane and perpendicular to the roadway centerline. Record all measurements to the nearest 0.1% on an approved form and submit the data to the Engineer.

330-9.3.2.1 Cross Slope Measurement Frequency:

1. Tangent Sections: Measure the cross-slope at a minimum frequency of one measurement every 100 feet per lane. When the average absolute deviation is consistently within the acceptance tolerance in Table 330-3, upon the approval of the Engineer, the cross-slope measurements may be reduced to one measurement every 200 feet.

2. Superelevated Sections: Measure the cross slope every 100 feet per lane within the length of the full superelevation. For curves where the length of full

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superelevation is less than 250 feet, measure the cross slope at the beginning point, midpoint, and ending point of the fully superelevated section. For transition sections, measure the cross slope at control points identified in the Plans, or if not shown in the Plans, at a control point at the location of 0.0% cross slope.

330-9.3.2.2 Cross Slope Deviations and Corrections: Calculate the absolute deviation of each cross-slope measurement and the average of the absolute deviations of ten consecutive cross slope measurements. The absolute deviation is the positive value of a deviation. In superelevated sections, when the number of measurements is less than ten, average the absolute deviation of all measurements.

If the average absolute deviation of any cross-slope measurement falls outside the acceptance tolerance shown in Table 330-3, stop the paving operation and make adjustments until the problem is resolved to the satisfaction of the Engineer.

Address, in accordance with 330-9.5, all individual cross slope deviations outside the acceptance tolerances shown in Table 330-3. Complete all corrections before placement of the final pavement surface layer. For pavement with multiple layers, the deficient areas for the structural course may be left in place, if approved by the Engineer. For friction course layers, make corrections in accordance with 330-9.5.

The limits of deficient areas requiring correction may be verified and adjusted with more accurate measurement methods, including survey instruments, upon approval of the Engineer and at no cost to the Department.

Should the Contractor wish to have any required corrections waived, submit a request to the Engineer for approval. The Engineer may waive the corrections at no reduction in payment if the deficiencies are sufficiently separated so as not to affect the pavement's overall traffic safety, surface drainage, ride quality, or surface texture.

For intersections, tapers, crossovers, transitions at the beginning and end of the project, bridge approaches and similar areas, adjust the cross slope to match the actual site conditions or as directed by the Engineer.

Table 330-3
Cross Slope Acceptance Tolerance

Roadway Feature	Individual Absolute Deviation	Average Absolute Deviation
Tangent section (including turn lanes)	0.4%	0.2%
Superelevated curve	0.4%	0.2%
Shoulder	0.5%	0.5%

In the event the distance between two edges of deficient areas is less than 100 feet, the correction work shall include the area between the deficient areas.

330-9.3.3 Verification: The Engineer will verify the Contractor's cross slope measurements by randomly taking a minimum of ten cross slope measurements per lane per mile in tangent sections, at control points in transition sections, and a minimum of three cross slope measurements in fully superelevated sections.

The Engineer will measure the cross slope of the compacted pavement surface by placing the level at the center of the lane and perpendicular to the roadway centerline.

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330-9.3.3.1 Cross Slope Deviations and Corrections: If the average absolute deviation or an individual cross slope deviation falls outside of the acceptance tolerance in Table 330-3, immediately make a comparison check at the QC test locations to verify the QC measurements in the section. If the comparisons are beyond the acceptable comparison tolerance in accordance with 330-9.3.1, stop the paving operations until the issue is resolved to the satisfaction of the Engineer. Correct any cross slope not meeting the individual deviation acceptance tolerance in accordance with 330-9.5 at no cost to the Department. The Engineer reserves the right to check the pavement cross slope at any time by taking cross slope measurements at any location.

330-9.4 Pavement Smoothness: Construct a smooth pavement meeting the requirements of this Specification.

330-9.4.1 General: Furnish a 15-foot manual and a 15-foot rolling straightedge meeting the requirements of FM 5-509. Obtain a smooth surface on all pavement courses placed, and then straightedge all layers as required by this Specification.

330-9.4.2 Test Method: Perform all straightedge testing in accordance with FM 5-509 in the outside wheel path of each lane. The Engineer may require additional testing at other locations within the lane.

330-9.4.3 Traffic Control: Provide traffic control in accordance with Section 102 and Standard Plans, Index 102-607 or 102-619 during all testing. When traffic control cannot be provided in accordance with Index 102-607 or 102-619, submit an alternative Traffic Control Plan as specified in 102-4. Include the cost of this traffic control in the Contract bid prices for the asphalt items.

330-9.4.4 Process Control Testing: Assume full responsibility for controlling all paving operations and processes such that the requirements of these Specifications are met at all times.

330-9.4.5 QC Testing:

330-9.4.5.1 General: Straightedge the final Type SP structural layer and friction course layer in accordance with 330-9.4.2, with the exception that if the method of acceptance is by laser profiler, then straightedging of the friction course layer is not required unless otherwise stated in the Specifications. If the project's method of acceptance is by laser profiler, areas not suitable for testing with the laser profiler will be tested and accepted by straightedging. Test all pavement lanes and ramps where the width is constant and document all deficiencies in excess of 3/16 inch on a form approved by the Engineer.

330-9.4.5.2 Straightedge Exceptions: Straightedge testing will not be required in the following areas: shoulders, intersections, tapers, crossovers, sidewalks, shared use paths, parking lots, raised crosswalks, speed tables, and similar areas, or in the following areas when they are less than 250 feet in length: turn lanes, acceleration/deceleration lanes and side streets. The limits of the intersection will be from stop bar to stop bar for both the mainline and side streets.

As an exception, in the event the Engineer identifies an objectionable surface irregularity in the above areas, straightedge and address all deficiencies in excess of 3/8 inch in accordance with 330-9.5.

The Engineer may waive straightedge requirements for transverse joints at the beginning and end of the project, at the beginning and end of bridge structures, at manholes, and at utility structures if the deficiencies are caused by factors beyond the control of the Contractor, as determined by the Engineer. In addition, the Engineer may also waive the

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straightedging requirements on ramps and superelevated sections where the geometrical orientation of the pavement results in an inaccurate measurement with the rolling straightedge.

330-9.4.5.3 Intermediate Layers and Temporary Pavement: When the design speed is 55 mph or greater and the intermediate Type SP layer or temporary pavement is to be opened to traffic, if the Engineer identifies an objectionable surface irregularity, straightedge and address all deficiencies in excess of 3/8 inch within 72 hours of placement in accordance with 330-9.5.

330-9.4.5.4 Final Type SP Structural Layer: Straightedge the final Type SP structural layer in accordance with 330-9.4.2, either behind the final roller of the paving train or as a separate operation. Notify the Engineer of the location and time of straightedge testing a minimum of 48 hours before beginning testing. The Engineer will verify the straightedge testing by observing the QC straight edging operations. Address all deficiencies in excess of 3/16 inch in accordance with 330-9.5.

When the final structural course is to be opened to traffic and the design speed is 55 mph or greater, if any defect is 3/8 inch or greater, the Engineer may require deficiencies to be corrected within 72 hours after opening to traffic.

330-9.4.5.5 Friction Course Layer: Where required per 330-9.4.5.1, and in areas noted in 330-9.4.6.2 as not suitable for testing with the Laser Profiler, straightedge the friction course layer in accordance with 330-9.4.2, either behind the final roller of the paving train or as a separate operation upon completion of all paving operations. Notify the Engineer of the location and time of straightedge testing a minimum of 48 hours before beginning testing. The Engineer will verify the straightedge testing by observing the QC straightedging operations. Address all deficiencies in excess of 3/16 inch in accordance with 330-9.5.

330-9.4.6 Acceptance:

330-9.4.6.1 Straightedge Acceptance: For areas of roadways where the design speed is less than 55 miles per hour, and for areas of roadways where the design speed is greater than or equal to 55 miles per hour which are noted in 330-9.4.6.2 as not suitable for testing with the Laser Profiler, acceptance for pavement smoothness of the friction course will be based on verified QC measurements using the straightedge as required by 330-9.4.5. The Engineer will verify the straightedge testing by observing the QC straightedging operations.

330-9.4.6.2 Laser Acceptance: For areas of high speed roadways where the design speed is equal to or greater than 55 miles per hour, acceptance testing for pavement smoothness of the friction course (for mainline traffic lanes only) will be based on the Laser Profiler. Ramps, acceleration and deceleration lanes, and other areas not suitable for testing with the Laser Profiler will be tested and accepted with the straightedge in accordance with 330-9.4.5.5 and 330-9.4.6.1.

The pavement smoothness of each lane will be determined by a Laser Profiler furnished and operated by the Department in accordance with FM 5-549 and a report issued with the Ride Number (RN) reported to one decimal place. If corrections are made, as required following Laser Acceptance, the pavement will not be retested for smoothness using the Laser Profiler.

For this testing, the pavement will be divided into 0.1 mile segments. Partial segments equal to or greater than 0.01 mile will be considered as a 0.1 mile segment. The pavement will be accepted as follows:

1. For segments with a RN greater than or equal to 4.0, the pavement will be accepted at full pay.

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2. For segments with a RN less than 4.0, the Engineer will further evaluate the data in 0.01 mile intervals for both wheel paths.

If the RN is 3.5 or above for all 0.01 mile intervals in both wheel paths, the segment will be accepted at full payment.

If the RN is less than 3.5 for one or more 0.01 mile intervals, the segment will be tested with the rolling straightedge in both wheel paths in accordance with FM 5-509. If approved by the Engineer, this straightedging may be completed (in both wheel paths) as part of the QC straightedging operations described in 330-9.4.5.5, before testing with the laser profiler. Notify the Engineer of the location and time of straightedge testing a minimum of 48 hours before beginning testing. The Engineer will verify the straightedge testing by observing the QC straightedging operations. Address all deficiencies in excess of 3/16 inch in accordance with 330-9.5.

Test and accept areas at the beginning and ending of the project, bridge approaches and departures, and areas where the segment is less than 0.01 mile, with the straightedge in accordance with 330-9.4.5.5 and 330-9.4.6.1.

330-9.5 Unacceptable Pavement:

330-9.5.1 Corrections: Address all areas of unacceptable pavement at no cost to the Department. Retest all corrected areas and assure the requirements of these Specifications are met.

330-9.5.1.1 Structural Layers: Correct all deficiencies, as defined in the Specifications, in the Type SP structural layers by removing and replacing the full depth of the layer, extending a minimum of 50 feet on both sides (where possible) of the defective area for the full width of the paving lane.

The following options only apply if the structural layer is not the final surface layer:

1. As an option for high and low straightedge deficiencies 5/16 of an inch or less, pave over with friction course to correct the deficiency.

2. As an option for high straightedge deficiencies, mill the pavement surface the full lane width to a depth and length adequate to remove the deficiency.

3. As an option for low straightedge deficiencies 8/16 of an inch or less, mill the pavement surface the full lane width to a depth and length adequate to remove the deficiency.

330-9.5.1.2 Friction Course: Correct deficiencies in the friction course or final surface layer by removing and replacing the full depth of the layer, extending a minimum of 50 feet on both sides (where possible) of the defective area for the full width of the paving lane. As an exception, the Engineer may allow the Contractor to leave these areas in place if it is determined by the Engineer that the deficiency is not a significant detriment to the pavement quality. A reduction to the pay item quantity will be made in accordance with 330-9.5.2.

330-9.5.2 Reduction in Pay Item Quantity: When the Engineer elects to waive corrections, the Department will reduce the pay quantity for the pay item in question by the amount of material within the defective area. For all mix types, when the measured deficiency lane length is less than 5 feet, use 5 feet for the deficiency lane length when determining the pay reduction. When the pay quantity is in tons, the Department will base the reduction on the volume of material within the defective area (the deficiency lane length by the lane width by layer thickness) multiplied by the maximum specific gravity of the mix as determined through the following equation:

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Quantity (tons) = L x W x t x G_{mm} x 0.0024

Where: L = Deficiency Lane length (ft.)
W = Lane width (ft.)
t = Layer thickness (in.)
G_{mm} = Maximum specific gravity from verified mix design

For FC-5 open-graded friction course, the Department will base the reduction on the area within the defective area (the deficiency lane length by lane width) multiplied by a spread rate of 80 pounds per square yard as determined through the following equation:

Quantity (tons) = L x W x 0.0044

Where: L = Deficiency Lane length (ft.)
W = Lane width (ft.)

330-10 Protection of Finished Surface.

Keep sections of newly compacted asphalt concrete, which are to be covered by additional courses, clean until the successive course is laid.

Do not dump embankment or base material directly on the pavement. Dress shoulders before placing the friction course on adjacent pavement.

Equip blade graders operating adjacent to the pavement during shoulder construction with a 2 inch by 8 inch or larger board, or other attachment providing essentially the same results, attached to their blades so it extends below the blade edge and protects the pavement surface from damage by the grader blade.

To prevent rutting or other distortion, protect sections of newly finished dense-graded friction course and the last structural layer before friction course from traffic until the surface temperature has cooled below 160ºF.

The Contractor may use artificial methods to cool the pavement to expedite paving operations. The Department may direct the Contractor to use artificial cooling methods when maintenance of traffic requires opening the pavement to traffic at the earliest possible time.

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SECTION 334
SUPERPAVE ASPHALT CONCRETE

334-1 Description.

334-1.1 General: Construct a Superpave Asphalt Concrete pavement with the type of mixture specified in the Contract Documents, or when offered as alternates, as selected. Superpave mixes are identified as Type SP-9.5, Type SP-12.5 or Type SP-19.0.

Obtain Superpave Asphalt Concrete from a plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105. Producers must meet the requirements of Section 320 for plant and equipment and the general construction requirements of Section 330.

334-1.2 Traffic Levels: The requirements for Type SP Asphalt Concrete mixtures are based on the design traffic level of the project. The traffic levels for the project are as specified in the Contract Documents.

334-1.3 Gradation Classification: The Superpave mixes are classified as fine and are defined in 334-3.2.2.

The equivalent AASHTO nominal maximum aggregate size Superpave mixes are as follows:

Type SP-9.5..... 9.5 mm
Type SP-12.5..... 12.5 mm
Type SP-19.0..... 19.0 mm

334-1.4 Thickness: The total thickness of the Type SP asphalt layers will be the plan thickness as shown in the Contract Documents. Before paving, propose a thickness for each individual layer meeting the requirements of this specification, which when combined with other layers (as applicable) will equal the plan thickness. For construction purposes, the plan thickness and individual layer thickness will be converted to spread rate based on the maximum specific gravity of the asphalt mix being used, as well as the minimum density level, as shown in the following equation:

$$\text{Spread rate (lb/yd}^2\text{)} = t \times G_{mm} \times 43.3$$

Where: t = Thickness (in.) (plan thickness or individual layer thickness)

G_{mm} = Maximum specific gravity from the verified mix design

The weight of the mixture shall be determined as provided in 320-3.2. For target purposes only, spread rate calculations should be rounded to the nearest whole number.

Note: Plan quantities are based on a G_{mm} of 2.540, corresponding to a spread rate of 110 lb/yd^2-in. Pay quantities will be based on the actual maximum specific gravity of the mix being used.

334-1.4.1 Layer Thicknesses: The allowable layer thicknesses for Type SP Asphalt Concrete mixtures are as follows:

Type SP-9.5.....1 to 1-1/2 inches
Type SP-12.5.....1-1/2 to 3 inches
Type SP-19.0..... 2 to 4 inches

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In addition to the minimum and maximum thickness requirements, the following restrictions are placed on mixes when used as a structural course:

Type SP-9.5 - Limited to the top two structural layers, two layers maximum.

Type SP-9.5 - Do not place less than 1-1/2 inches thick for Traffic Level E applications.

Type SP-19.0 - Do not use for the final (top) structural layer below FC-5 mixtures. Type SP-19.0 mixtures are permissible for the layer directly below FC-9.5 and FC-12.5 mixtures. Do not use for the final (top) layer of shoulders.

334-1.4.2 Additional Requirements: The following requirements also apply to Type SP Asphalt Concrete mixtures:

1. A minimum 1-1/2 inch initial lift is required over an Asphalt Membrane Interlayer (AMI).

2. When construction includes the paving of adjacent shoulders (less than or equal to 5 feet wide), the layer thickness for the upper pavement layer and shoulder must be the same and paved in a single pass, unless called for differently in the Contract Documents.

3. All overbuild layers must be Type SP Asphalt Concrete designed at the traffic level as stated in the Contract Documents. Use the minimum and maximum layer thicknesses as specified above unless called for differently in the Contract Documents. On variable thickness overbuild layers, the minimum and maximum allowable thicknesses will be as specified below, unless called for differently in the Contract Documents.

Type SP-9.5..... 3/8 to 2 inches
Type SP-12.5..... 1/2 to 3 inches
Type SP-19.0.....1-1/2 to 4 inches

4. Variable thickness overbuild layers constructed using a Type SP-9.5 or SP-12.5 mixtures may be tapered to zero thickness provided the contract documents require a minimum of 1-1/2 inches of dense-graded mix placed over the variable thickness overbuild layer.

334-2 Materials.

334-2.1 General Requirements: Meet the following requirements:

Superpave PG Asphalt Binder* .....Section 916
Coarse Aggregate.....Section 901
Fine Aggregate.....Section 902
*Use products on the Department's Approved Product List (APL).

334-2.2 Superpave Asphalt Binder: Unless specified otherwise in the Contract Documents, use an asphalt binder grade as determined from Table 334-2.

High polymer binder mixtures may be used in lieu of mixtures with other specified binders at no additional cost to the Department, provided they meet the traffic level and mixture type requirements of the project.

High polymer binder may be substituted in a mixture at no additional cost to the Department when the mix design contains a maximum of 20% RAP.

334-2.3 Reclaimed Asphalt Pavement (RAP) Material:

334-2.3.1 General requirements: RAP may be used as a component of the asphalt mixture subject to the following requirements:

1. When using a PG 76-22 asphalt binder in friction course mixtures, limit the amount of RAP material used in the mix to a maximum of 20% by weight of total aggregate. As an exception, amounts greater than 20% RAP by weight of total aggregate can be used if no

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more than 20% by weight of the total asphalt binder comes from the RAP material. When using a PG 76-22 asphalt binder in structural course mixtures, refer to 334-2.3.6. RAP is not allowed in mixtures containing High Polymer asphalt binder. High Polymer asphalt is defined in Section 916.

2. Assume full responsibility for the design, production and construction of asphalt mixes which incorporate RAP as a component material.

3. Use RAP from a Department approved stockpile or millings from a Department project.

4. Provide stockpiled RAP material that is reasonably consistent in characteristics and contains no aggregate particles which are soft or conglomerates of fines.

5. Provide RAP material having a minimum average asphalt binder content of 4.0% by weight of RAP. As an exception, when using fractionated RAP, the minimum average asphalt binder content for the coarse portion of the RAP shall be 2.5% by weight of the coarse portion of the RAP. The coarse portion of the RAP shall be the portion of the RAP retained on the No. 4 sieve. The Engineer may sample the stockpiles to verify that this requirement is met.

334-2.3.2 Material Characterization for Mix Design: Assume responsibility for establishing the asphalt binder content, gradation, and bulk specific gravity (G_{sb}) of the RAP material based on a representative sampling of the material by roadway cores or stockpile samples. For roadway core samples, assume responsibility for the degradation that will occur during the milling operation.

334-2.3.3 RAP Stockpile Approval: Prior to the incorporation of RAP into the asphalt mixture, stockpile the RAP material and obtain approval for the stockpile by one of the following methods:

1. Continuous stockpile: When RAP is obtained from one or multiple sources and is either processed, blended, or fractionated, and stockpiled in a continuous manner, assure an adequate number of test results are obtained for stockpile approval. Test the RAP material for gradation and asphalt content at a minimum frequency of one sample per 1,000 tons with a minimum of six test results. Test the RAP material for G_{mm} (for G_{sb} determination) at a minimum frequency of one sample per 5,000 tons with a minimum of two test results. Based on visual inspection and a review of the test data, the Engineer will determine the suitability of the stockpiled material. In addition, address the details and specifics of the processing, sampling, testing and actions to be taken in the Producer Quality Control (QC) Plan.

When RAP is added to the continuous stockpile after original approval of the stockpile as described above, test the RAP material for gradation and asphalt content at a minimum frequency of one sample per 1,000 tons with a minimum of six test results. Test the RAP material for G_{mm} (for G_{sb} determination) at a minimum frequency of one sample per 5,000 tons with a minimum of two test results. Monitor test results during crushing operations for conformance to the requirements of Table 334-1. After the minimum frequency of tests have been performed, the Engineer will review the test data and visually inspect the stockpiled material. The average gradation and G_{mm} of the added material shall be within the allowable ranges shown in Table 334-1 from the originally approved stockpile values. If the added RAP material does not meet the conditions of Table 334-1, then the Contractor must create a new stockpile when resuming crushing operations and the stockpile will receive a new number designation from the Department. The previously crushed material, which was added to

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the continuous stockpile and did not meet the conditions of Table 334-1, may remain and that stockpile used until depleted.

Table 334-1 Allowable Ranges for Continuous RAP Stockpile Properties	
Characteristic	Limit from Original Approved Stockpile Gradation
No. 8 sieve and coarser	± 6.0%
No. 16 sieve	± 5.0%
No. 30 sieve	± 5.0%
No. 50 sieve	± 4.0%
No. 100 sieve	± 4.0%
No. 200 sieve	± 2.0%
G_{mm}	± 0.040

2. Non-continuous single stockpile: When an individual stockpile is being constructed, obtain representative samples at random locations and test the RAP material for gradation and asphalt content at a minimum frequency of one sample per 1,000 tons with a minimum of six test results. Test the RAP material for G_{mm} (for G_{sb} determination) at a minimum frequency of one sample per 5,000 tons with a minimum of two test results. Based on visual inspection and a review of the test data, the Engineer will determine the suitability of the stockpiled material. If the properties of the new stockpile compare with the properties of an existing stockpile within the ranges provided in Table 334-1, the RAP in the new stockpile may be added to the existing stockpile. Once the RAP stockpile has been approved, do not add additional material without prior approval of the Engineer.

Determine the asphalt binder content and gradation of the RAP material in accordance with FM 5-563 and FM 1-T 030, respectively. Establish the G_{sb} of the RAP material by using one of the following methods:

a. Calculate the G_{sb} value based upon the effective specific gravity (G_{se}) of the RAP material, determined on the basis of the asphalt binder content and maximum specific gravity (G_{mm}) of the RAP material. The Engineer will approve the estimated asphalt binder absorption value used in the calculation.

b. Measure the G_{sb} of the RAP aggregate, in accordance with FM 1-T 084 and FM 1-T 085. Obtain the aggregate by using a solvent extraction method.

334-2.3.4 Pavement Coring Report: When the Contract includes milling of the existing asphalt pavement, the Pavement Coring Report may be available on the Department's website.

334-2.3.5 Asphalt Binder for Mixes with RAP: Select the appropriate asphalt binder grade based on Table 334-2. The Engineer reserves the right to change the asphalt binder grade at design based on the characteristics of the RAP asphalt binder, and reserves the right to make changes during production.

Table 334-2 Asphalt Binder Grade for Mixes Containing RAP	
Percent RAP	Asphalt Binder Grade
0 - 15	PG 67-22
16 - 30	PG 58-22
>30	PG 52-28

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334-2.3.6 Allowable RAP Percentages for Type SP Structural Mixtures with PG 76-22 Asphalt Binder: For Type SP structural mixtures using PG 76-22 asphalt binder, select the percentage of RAP material based on Table 334-3.

Table 334-3
Allowable RAP Percentages[1] in Type SP Structural Mixtures with PG 76-22 Asphalt Binder

		Coarse RAP	Intermediate RAP	Fine RAP
Gradation % Passing #16 Sieve[2]		≤ 40%	> 40% to ≤ 50%	> 50%
PG_{HT}[3] > 100.0° C	Allowable RAP Percentage	≤ 25%	≤ 20%	≤ 20%
PG_{HT}[3] ≤ 100.0° C		≤ 30%	≤ 25%	

Notes:
1. RAP aggregate by weight of total aggregate or RAP binder by weight of total binder.
2. RAP gradations based on ignition oven extraction of RAP material in accordance with FM 5-563.
3. PG_{HT}: asphalt binder high temperature continuous performance grade of RAP in accordance with Section 916.

334-2.4 Recycled Crushed Glass: Recycled crushed glass may be used as a component of the asphalt mixture subject to the following requirements:

1. Consider the recycled crushed glass a local material and meet all requirements specified in 902-6.
2. Limit the amount of recycled crushed glass to a maximum of 15% by weight of total aggregate.
3. Use an asphalt binder that contains an anti-stripping agent listed on the Approved Product List (APL). The anti-strip additive shall be introduced into the asphalt binder by the supplier during loading.
4. Do not use recycled crushed glass in friction course mixtures or in structural course mixtures which are to be used as the final wearing surface.

334-3 General Composition of Mixture.

334-3.1 General: Compose the asphalt mixture using a combination of aggregate (coarse, fine or mixtures thereof), mineral filler, if required, and asphalt binder material. Size, grade and combine the aggregate fractions to meet the grading and physical properties of the mix design. Aggregates from various sources may be combined.

334-3.2 Mix Design:

334-3.2.1 General: Design the asphalt mixture in accordance with AASHTO R 35, except as noted herein. Prior to the production of any asphalt mixture, submit the proposed mix design with supporting test data indicating compliance with all mix design criteria to the Engineer. For all mix designs, include representative samples of all component materials, including asphalt binder. Allow the Director of the Office of Materials a maximum of four weeks to either conditionally verify or reject the mix as designed.

At no additional cost to the Department, for a Type SP mix the following Traffic Level substitutions are allowed:

Traffic Level E can be substituted for Traffic Level C.
Traffic Level C can be substituted for Traffic Level B.

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The same traffic level and binder type that is used for the mainline traffic lanes may be placed in the shoulder at no additional cost to the Department, even if the conditions stated above are not met for the shoulder.

Warm mix technologies (additives, foaming techniques, etc.) listed on the Department's website may be used in the production of the mix. The URL for obtaining this information, if available, is: https://www.fdot.gov/materials/laboratory/asphalt/index.shtm.

When warm mix technologies are used, for mixtures containing a PG 52-28, PG 58-22, or PG 67-22 binder, a mixture will be considered a warm mix asphalt design if the mixing temperature is 285°F or less. For mixtures containing a PG 76-22 or High Polymer binder, a mixture will be considered a warm mix asphalt design if the mixing temperature is 305°F or less.

The Engineer will consider any marked variations from original test data for a mix design or any evidence of inadequate field performance of a mix design as sufficient evidence that the properties of the mix design have changed, and the Engineer will no longer allow the use of the mix design.

334-3.2.2 Mixture Gradation Requirements: Combine the coarse and fine aggregate in proportions that will produce an asphalt mixture meeting all of the requirements defined in this specification and conform to the gradation requirements at design as defined in AASHTO M 323. Aggregates from various sources may be combined.

334-3.2.2.1 Mixture Gradation Classification: Plot the combined mixture gradation on an FHWA 0.45 Power Gradation Chart. Include the Control Points from AASHTO M 323, as well as the Primary Control Sieve (PCS) Control Point from AASHTO M 323. Fine mixes are defined as having a gradation that passes above the primary control sieve control point and above the maximum density line for all sieve sizes smaller than the primary control sieve and larger than the No. 30 sieve.

334-3.2.3 Aggregate Consensus Properties: For Traffic Level C and E mixtures, meet the following consensus properties at design for the aggregate blend. Aggregate consensus properties do not apply to Traffic Level B mixtures.

334-3.2.3.1 Coarse Aggregate Angularity: When tested in accordance with ASTM D5821, meet the percentage of fractured faces requirements specified in AASHTO M 323.

334-3.2.3.2 Fine Aggregate Angularity: When tested in accordance with AASHTO T 304, Method A, meet the uncompacted void content of fine aggregate specified in AASHTO M 323. For Traffic Level C and E base and structural course mixtures, a fine aggregate angularity value less than 45.0 and greater than or equal to 42.0 is allowable provided testing parameters of AASHTO T 340-10 (2019) meet the following requirements:

1. Rutting tests are performed on two gyratory specimens compacted to N_{des} level of gyrations with a height of 115 ± 5 mm and a diameter of 150 mm.
2. The air void (V_a) content of each gyratory specimen after compacting to N_{des} shall be within the following range: $3.0 \leq V_a \leq 4.8$.
3. Rutting tests are performed at 64.0 C.
4. The average rut depth for two specimens shall not exceed 4.5 mm.

334-3.2.3.3 Flat and Elongated Particles: When tested in accordance with ASTM D4791, (with the exception that the material passing the 3/8-inch sieve and retained on the No. 4 sieve shall be included), meet the requirements specified in AASHTO M 323.

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Measure the aggregate using the ratio of 5:1, comparing the length (longest dimension) to the thickness (shortest dimension) of the aggregate particles.

334-3.2.3.4 Sand Equivalent: When tested in accordance with AASHTO T 176, meet the sand equivalent requirements specified in AASHTO M 323.

334-3.2.4 Gyratory Compaction: Compact the design mixture in accordance with AASHTO T 312, with the following exception: use the number of gyrations at N_{design} as defined in Table 334-4. Measure the inside diameter of gyratory molds in accordance with AASHTO T 312.

Table 334-4
Gyratory Compaction Requirements

Traffic Level	N_{design} Number of Gyrations
B	65
C	75
E	100

334-3.2.5 Design Criteria: Meet the requirements for nominal maximum aggregate size as defined in AASHTO M 323, as well as for relative density, VMA, VFA, and dust-to-binder ratio as specified in AASHTO M 323. $N_{initial}$ and $N_{maximum}$ requirements are not applicable.

334-3.2.6 Moisture Susceptibility:

1. For all traffic levels, use a liquid anti-strip agent listed on the APL at the specified dosage rate. Hydrated lime may be used instead of the liquid anti-strip agent.

2. Provide a mixture having a retained tensile strength ratio of at least 0.80 and a minimum tensile strength (unconditioned) of 100 psi in accordance with FM 1-T 283.

334-3.2.7 Additional Information: In addition to the requirements listed above, provide the following information with each proposed mix design submitted for verification:

1. The design traffic level and the design number of gyrations (N_{design}).

2. The source and description of the materials to be used.

3. The Department source number and the Department product code of the aggregate components furnished from a Department approved source.

4. The gradation and proportions of the raw materials as intended to be combined in the paving mixture. The gradation of the component materials shall be representative of the material at the time of use. Compensate for any change in aggregate gradation caused by handling and processing as necessary.

5. A single percentage of the combined mineral aggregate passing each specified sieve. Degradation of the aggregate due to processing (particularly material passing the No. 200 sieve) should be accounted for and identified.

6. The bulk specific gravity (G_{sb}) value for each individual aggregate and RAP component, as identified in the Department's aggregate control program.

7. A single percentage of asphalt binder by weight of total mix intended to be incorporated in the completed mixture, shown to the nearest 0.1%.

8. A target temperature for the mixture at the plant (mixing temperature) and a target temperature for the mixture at the roadway (compaction temperature) in accordance with 320-6.3. Do not exceed a target temperature of 340°F for High Polymer asphalt binders, 330°F for PG 76-22 asphalt binders, and 315°F for unmodified asphalt binders.

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9. Provide the physical properties at the optimum asphalt content, which must conform to all specified requirements.

10. The name of the Construction Training Qualification Program (CTQP) Qualified Mix Designer.

11. The ignition oven and maximum specific gravity (G_{mm}) calibration factors.

12. The warm mix technology, if used.

334-3.3 Mix Design Revisions: During production, the Contractor may request a target value revision to a mix design, subject to meeting the following requirements: the target change falls within the limits defined in Table 334-5, appropriate data exists demonstrating that the mix complies with production air voids specification criteria, and the mixture gradation meets the basic gradation requirements defined in 334-3.2.2.

Table 334-5
Limits for Potential Adjustments to Mix Design Target Values

Characteristic	Limit from Original Mix Design
Asphalt Binder Content [1]	±0.3%
Gradation and Aggregate Component [2]	
No. 8 sieve and Coarser	± 5.0%
No. 16 sieve	± 4.0%
No. 30 sieve	± 4.0%
No. 50 sieve	± 3.0%
No. 100 sieve	± 3.0%
No. 200 sieve	± 1.0%
Each Component of Aggregate Blend	± 5.0 %

[1] Reductions to the asphalt binder content will not be permitted if the VMA during production is lower than 1.0% below the design criteria.
[2] The Engineer may waive the limits for the individual sieves and component of the aggregate blend contingent upon the quality of the production data for the mixture. Revisions to FC-5 mixtures to be determined by the Engineer.

Submit all requests for revisions to mix designs, along with supporting documentation, to the Engineer. In order to expedite the revision process, the request for revision or discussions on the possibility of a revision may be made verbally, but must be followed up by a written request. The verified mix design will remain in effect until the Engineer authorizes a change. In no case will the effective date of the revision be established earlier than the date of the first communication between the Contractor and the Engineer regarding the revision.

A new design mix will be required if aggregate sources change, or for any substitution of an aggregate product with a different aggregate code, unless approved by the Engineer.

334-4 Producer Process Control (PC).

Assume full responsibility for controlling all operations and processes such that the requirements of these Specifications are met at all times. Perform any tests necessary at the plant and roadway for process control purposes. Enter all PC test data into the Department's database. The Engineer will not use these test results in the acceptance payment decision.

Address in the Producer QC Plan how PC failures will be handled. When a PC failure occurs, investigate, at a minimum, the production process, testing equipment and/or sampling

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methods to determine the cause of the failure, and make any necessary changes to assure compliance with these Specifications. Obtain a follow up sample immediately after corrective actions are taken to assess the adequacy of the corrections. In the event the follow-up PC sample also fails to meet Specification requirements, cease production of the asphalt mixture until the problem is adequately resolved to the satisfaction of the QC Manager.

334-5 Acceptance of the Mixture.

334-5.1 General: The mixture will be accepted at the plant with respect to gradation (P_{-8} and P_{-200}), asphalt content (P_b), and volumetrics (volumetrics is defined as air voids at N_{design}). The mixture will be accepted on the roadway with respect to density of roadway cores. Acceptance will be on a LOT by LOT basis (for each mix design) based on tests of random samples obtained within each sublot taken at a frequency of one set of samples per sublot. A roadway LOT and a plant production LOT shall be the same. Acceptance of the mixture will be based on Contractor QC test results that have been verified by the Department.

334-5.1.1 Sampling and Testing Requirements: Obtain the samples in accordance with FM 1-T 168. Obtain samples at the plant of a sufficient quantity to be split into three smaller samples; one for QC, one for Verification testing and one for Resolution testing. Obtain each split sample of a sufficient quantity, approximately 40 pounds, for all required testing. The split samples for Verification testing and Resolution testing shall be reduced in size and stored in three boxes each. The approximate size of each box must be 12 inches x 8 inches x 4 inches. Provide, label, and safely store sample boxes in a manner agreed upon by the Engineer for future testing.

The asphalt content of the mixture will be determined in accordance with FM 5-563. The gradation of the recovered aggregate will be determined in accordance with FM 1-T 030. Volumetric testing will be in accordance with AASHTO T 312 and FM 1-T 209. Prior to testing volumetric samples, condition the test-sized sample for one hour, plus or minus five minutes, at the target roadway compaction temperature in a shallow, flat pan, such that the mixture temperature at the end of the one-hour conditioning period is within plus or minus 20°F of the roadway compaction temperature.

If one of the QC gyratory specimens is damaged, make an additional gyratory specimen.

For situations where two properly prepared gyratory specimens do not meet single-operator precision requirements for G_{mb} as provided in FM 1-T 166:

1. Retest both gyratory specimens in accordance FM 1-T 166.
2. Following the retest, if the newly measured G_{mb} values do not meet single-operator precision requirements, QC shall prepare a third gyratory specimen in accordance with AASHTO T 312 and test in accordance with FM 1-T 166. All three test results shall be input into MAC. The average G_{mb} will be determined by MAC after performing an outlier check in accordance with ASTM E178.

Test for roadway density in accordance with FM 1-T 166.

334-5.1.2 Acceptance Testing Exceptions: When the total combined quantity of hot mix asphalt for the project, as indicated in the Plans for Type B-12.5, Type SP and Type FC mixtures only, is less than 2,000 tons, the Engineer will accept the mix on the basis of visual inspection. The Engineer may require the Contractor to run process control tests for informational purposes, as defined in 334-4, or may run independent verification tests to determine the acceptability of the material.

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Density testing for acceptance will not be performed on widening strips or shoulders with a width of 5 feet or less, open-graded friction courses, variable thickness overbuild courses, leveling courses, any SP-9.5 or SP-12.5 asphalt layer placed on subgrade with a layer thickness less than or equal to 3 inches, miscellaneous asphalt pavement, shared use paths, crossovers, gore areas, raised crosswalks, speed tables, or any course with a specified thickness less than 1 inch or a specified spread rate that converts to less than 1 inch as described in 334-1.4. Density testing for acceptance will not be performed on asphalt courses placed on bridge decks or approach slabs; compact these courses in static mode only per the requirements of 330-7.7. In addition, density testing for acceptance will not be performed on the following areas when they are less than 500 feet (continuous) in length: turning lanes, acceleration lanes, deceleration lanes, shoulders, parallel parking lanes, ramps, or unsignalized side streets with less than four travel lanes and speed limits less than 35 mph. Do not perform density testing for acceptance in situations where the areas requiring density testing is less than 50 tons within a sublot.

Density testing for acceptance will not be performed in intersections. The limits of the intersection will be from stop bar to stop bar for both the mainline and side streets. A random core location that occurs within the intersection shall be moved forward or backward from the intersection at the direction of the Engineer.

Where density testing for acceptance is not required, compact these courses (with the exception of open-graded friction courses) in accordance with the rolling procedure (equipment and pattern) as approved by the Engineer or with Standard Rolling Procedure as specified in 330-7.2. In the event that the rolling procedure deviates from the procedure approved by the Engineer, or the Standard Rolling Procedure, placement of the mix shall be stopped.

The density pay factor (as defined in 334-8.2) for areas not requiring density testing for acceptance will be paid at the same density pay factor as for the areas requiring density testing within the same LOT. If the entire LOT does not require density testing for acceptance, the LOT will be paid at a density pay factor of 1.00.

334-5.2 Full LOTs: Each LOT will be defined (as selected by the Contractor prior to the start of the LOT) as either (1) 2,000 tons, with each LOT subdivided into four equal sublots of 500 tons each, or (2) 4,000 tons, with each LOT subdivided into four equal sublots of 1,000 tons each. As an exception to this, the initial LOT of all new mix designs shall be defined as 2,000 tons, subdivided into four equal sublots of 500 tons each. Before the beginning of a LOT, the Engineer will develop a random sampling plan for each sublot and direct the Contractor on sample points, based on tonnage, for each sublot during construction.

334-5.3 Partial LOTs: A partial LOT is defined as a LOT size that is less than a full LOT. A partial LOT may occur due to the following:

l. The completion of a given mix type or mix design on a project.

2. Closure of the LOT due to time. LOTs will be closed 30 calendar days after the start of the LOT. Time periods other than 30 calendar days may be used if agreed to by both the Engineer and the Contractor, but under no circumstances shall the LOT be left open longer than 90 days.

3. A LOT is terminated per 334-5.4.4.

All partial LOTs will be evaluated based on the number of tests available, and will not be redefined. If a LOT is closed before the first plant random sample is obtained, then the LOT will be visually accepted by the Engineer and the LOT pay factor will be 1.00.

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334-5.4 QC Sampling and Testing: Obtain all samples randomly as directed by the Engineer.

Should the Engineer determine that the QC requirements are not being met or that unsatisfactory results are being obtained, or should any instances of falsification of test data occur, acceptance of the Producer's QC Plan will be suspended and production will be stopped.

334-5.4.1 Lost or Missing Verification/Resolution Samples: In the event that any of the Verification and/or Resolution asphalt mixture samples that are in the custody of the Contractor are lost, damaged, destroyed, or are otherwise unavailable for testing, the minimum possible pay factor for each quality characteristic as described in 334-8.2 will be applied to the entire LOT in question, unless called for otherwise by the Engineer. Specifically, if the LOT in question has more than two sublots, the pay factor for each quality characteristic will be 0.55. If the LOT has two or less sublots, the pay factor for each quality characteristic will be 0.80. If only the roadway cores are lost, damaged, destroyed, or are otherwise unavailable for testing, then the minimum possible pay factor for density will be applied to the entire LOT in question. In either event, the material in question will also be evaluated in accordance with 334-5.9.5.

If any of the Verification and/or Resolution samples that are in the custody of the Department are lost, damaged, destroyed or are otherwise unavailable for testing, the corresponding QC test result will be considered verified, and payment will be based upon the Contractor's data.

334-5.4.2 Plant Sampling and Testing Requirements: Obtain one random sample of mix per sublot in accordance with 334-5.1.1 as directed by the Engineer. Test the QC split sample for gradation, asphalt binder content and volumetrics in accordance with 334-5.1.1. Complete all QC testing within one working day from the time the samples were obtained.

334-5.4.3 Roadway Sampling and Testing Requirements: Obtain five 6 inch diameter roadway cores within 24 hours of placement at random locations as directed by the Engineer within each sublot. Test these QC samples for density (G_{mb}) in accordance with 334-5.1.1. Obtain a minimum of three cores per sublot at random locations as identified by the Engineer in situations where the sublot/LOT was closed or terminated before the random numbers were reached or where it is impractical to cut five cores per sublot. Do not obtain cores any closer than 12 inches from an unsupported edge. The Engineer may adjust randomly generated core locations for safety purposes or as the Engineer deems necessary. Do not perform density testing for acceptance in a sublot if the plant random sample for that sublot has not been obtained. Maintain traffic during the coring operation; core the roadway, patch the core holes (within three days of coring); and trim the cores to the proper thickness prior to density testing.

Density for the sublot shall be based on the average value for the cores cut from the sublot with the target density being a percentage of the maximum specific gravity (G_{mm}) of the sublot, as defined in the Contract. Once the average density of a sublot has been determined, do not retest the samples unless approved by the Engineer. Ensure proper handling and storage of all cores until the LOT in question has been accepted.

334-5.4.4 Individual Test Tolerances for QC Testing: Terminate the LOT if any of the following QC failures occur:

1. An individual test result of a sublot for air voids does not meet the requirements of Table 334-6,
2. The average sublot density does not meet the requirements of Table 334-6,

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3. Two consecutive test results within the same LOT for gradation or asphalt binder content do not meet the requirements of Table 334-6,

When a LOT is terminated due to a QC failure, stop production of the mixture until the problem is resolved to the satisfaction of the QC Manager and/or Asphalt Plant Level II technician responsible for the decision to resume production after a QC failure, as identified in Section 105. In the event that it can be demonstrated that the problem can immediately be or already has been resolved, it will not be necessary to stop production. When a LOT is terminated, make all necessary changes to correct the problem. Do not resume production until appropriate corrections have been made. Prior to resuming production, inform the Engineer of the problem and corrections made to correct the problem. After resuming production, sample and test the material to verify that the changes have corrected the problem. Summarize this information and provide it to the Engineer prior to the end of the work shift when production resumes.

In the event that a QC failure is not addressed as defined above, the Engineer's approval will be required prior to resuming production after any future QC failures.

Address any material represented by a failing test result, as defined above in this subarticle, in accordance with 334-5.9.5. Any LOT terminated under this subarticle will be limited to a maximum Pay Factor of 1.00 (as defined in 334-8.2) for all quality characteristics and will include all material placed up to the point when the LOT was terminated.

In the event that a G_{mm} test result differs by more than 0.040 from the mix design G_{mm}, investigate the causes of the discrepancy and report the findings and proposed actions to the Engineer.

Table 334-6
Master Production Range

Characteristic	Tolerance (1)
Asphalt Binder Content (%)	Target ±0.55
Passing No. 200 Sieve (%)	Target ±1.50
Air Voids (%)	2.30 – 6.00
Density (minimum % G_{mm})(2)	89.50

(1) Tolerances for sample size of n = 1 from the verified mix design
(2) Based on an average of three to five randomly located cores

334-5.5 Verification Testing: In order to determine the validity of the Contractor's QC test results prior to their use in the Acceptance decision, the Engineer will run verification tests.

334-5.5.1 Plant Testing: At the completion of each LOT, the Engineer will test a minimum of one Verification split sample randomly selected from the LOT. Results of the testing and analysis for the LOT will be made available to the Contractor within one working day from the time the LOT is completed. Verification samples shall be reheated at the target roadway compaction temperature for 1-1/2 hours, plus or minus 5 minutes, reduced to the appropriate testing size, and conditioned and tested as described in 334-5.1.1. In lieu of the 1-1/2 hours reheating procedure, the mixture may be reheated to within plus or minus 20°F of the roadway compaction temperature using a microwave oven. Stir the mixture as necessary during the reheating process to maintain temperature uniformity. Subsequently, condition and test the mixture as described in 334-5.1.1.

The Verification test results will be compared with the QC test results based on the between-laboratory precision values shown in Table 334-7.

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Table 334-7 Between-Laboratory Precision Values	
Property	Maximum Difference
G_{mm}	0.016
G_{mb} (gyratory compacted samples)	0.022
G_{mb} (roadway cores)	0.014
P_b	0.44%
P_{-200}	FM 1-T 030 (Figure 2)
P_{-8}	FM 1-T 030 (Figure 2)

If all of the specified mix characteristics compare favorably, then the LOT will be accepted, with payment based on the Contractor's QC test data for the LOT.

If any of the results do not compare favorably, then the Resolution samples from the LOT will be sent to the Resolution laboratory for testing, as described in 334-5.6.

334-5.5.2 Roadway Testing: At the completion of each LOT, the Engineer will determine the density (G_{mb}) of each core (previously tested by QC) as described in 334-5.1.1 from the same sublot as the plant samples. For situations where roadway density is not required for the random sublot chosen, then another sublot shall be randomly chosen for roadway density cores only. Results of the testing and analysis for the LOT will be made available to the Contractor within one working day from the time the LOT is completed.

The individual Verification test results will be compared with individual QC test results by the Engineer based on the between-laboratory precision values given in Table 334-7.

If each of the core test results compare favorably, then the LOT will be accepted with respect to density, with payment based on the Contractor's QC test data for the LOT.

If any of the results do not compare favorably, then the core samples from the LOT will be sent to the Resolution laboratory for testing as specified in 334-5.6.

334-5.6 Resolution System:

334-5.6.1 Plant Samples: In the event of an unfavorable comparison between the Contractor's QC test results and the Engineer's Verification test results on any of the properties identified in Table 334-7, the Resolution laboratory will test all of the split samples from the LOT for only the property (or properties) in question. Resolution samples shall be reheated at the target roadway compaction temperature for 1-1/2 hours, plus or minus 5 minutes, reduced to the appropriate testing size, and conditioned and tested as described in 334-5.1.1. In lieu of the 1-1/2 hours reheating procedure, the mixture may be reheated to within plus or minus 20°F of the roadway compaction temperature using a microwave oven. Stir the mixture as necessary during the reheating process to maintain temperature uniformity. Subsequently, condition and test the mixture as described in 334-5.1.1.

334-5.6.2 Roadway Samples: In the event of an unfavorable comparison between the Contractor's QC test data and the Engineer's Verification test data on the density results, the Resolution laboratory will test all of the cores from the LOT. Testing will be as described in 334-5.1.1.

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334-5.6.3 Resolution Determination: The Resolution test results (for the property or properties in question) will be compared with the QC test results based on the between-laboratory precision values shown in Table 334-7.

If the Resolution test results compare favorably with all of the QC results, then acceptance and payment for the LOT will be based on the QC results, and the Department will bear the costs associated with Resolution testing. No additional compensation, either monetary or time, will be made for the impacts of any such testing.

If the Resolution test results do not compare favorably with all of the QC results, then acceptance and payment for the LOT will be based on the Resolution test data for the LOT, and the costs of the Resolution testing will be deducted from monthly estimates. No additional time will be granted for the impacts of any such testing.

In addition, the material failure requirements of 334-5.4.4 apply to the Resolution test data. Address any material represented by the failing test results in accordance with 334-5.9.5. For this situation, the LOT will be limited to a maximum Pay Factor of 1.00 (as defined in 334-8.2) for all quality characteristics.

In the event of an unfavorable comparison between the Resolution test results and QC test results, make the necessary adjustments to assure that future comparisons are favorable.

334-5.7 Independent Verification (IV) Testing:

334-5.7.1 Plant: The Contractor shall provide sample boxes and take samples as directed by the Engineer for IV testing. Obtain enough material for three complete sets of tests (two samples for IV testing by the Engineer and one sample for testing by the Contractor). If agreed upon by both the Engineer and the Contractor, only one sample for IV testing by the Engineer may be obtained. IV samples will be reheated at the target roadway compaction temperature for 1-1/2 hours, plus or minus 5 minutes, reduced to the appropriate testing size, and conditioned and tested as described in 334-5.1.1. The Contractor’s split sample, if tested immediately after sampling, shall be reduced to the appropriate testing size, and conditioned and tested as described in 334-5.1.1. If the Contractor’s sample is not tested immediately after sampling, then the sample shall be reheated at the target roadway compaction temperature for 1-1/2 hours, plus or minus 5 minutes, reduced to the appropriate testing size, and conditioned and tested as described in 334-5.1.1. For the IV and Contractor's samples, in lieu of the 1-1/2 hours reheating procedure, the mixture may be reheated to within plus or minus 20°F of the roadway compaction temperature using a microwave oven. Stir the mixture as necessary during the reheating process to maintain temperature uniformity. Subsequently, condition and test the mixture as described in 334-5.1.1. The Contractor’s test results shall be provided to the Engineer within one working day from the time the sample was obtained.

If any of the IV test results do not meet the requirements of Table 334-6, then a comparison of the IV test results and the Contractor’s test results, if available, will be made. If a comparison of the IV test results and the Contractor’s test results meets the precision values of Table 334-7 for the material properties in question, or if the Contractor’s test results are not available, then the IV test results are considered verified and the Contractor shall cease production of the asphalt mixture until the problem is adequately resolved (to the satisfaction of the Engineer), unless it can be demonstrated to the satisfaction of the Engineer that the problem can immediately be (or already has been) resolved. Address any material represented by the failing test results in accordance with 334-5.9.5.

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If a comparison of the IV test results and the Contractor's test results does not meet the precision values of Table 334-7 for the material properties in question, then the second IV sample shall be tested by the Engineer for the material properties in question. If a comparison between the first and second IV test results does not meet the precision values of Table 334-7 for the material properties in question, then the first IV test results are considered unverified for the material properties in question and no action shall be taken, with the following exception: if the first and second IV test results do not meet the precision values of Table 334-7 and the first IV test result and Contractor's test result do not meet the precision values of Table 334-7, yet all three test results do not meet the requirements of Table 334-6, then address any material represented by the failing test results in accordance with 334-5.9.5.

If a comparison between the first and second IV test results meets the precision values of Table 334-7 for the material properties in question, then the first IV sample is considered verified and the Contractor shall cease production of the asphalt mixture until the problem is adequately resolved (to the satisfaction of the Engineer), unless it can be demonstrated to the satisfaction of the Engineer that the problem can immediately be (or already has been) resolved. Address any material represented by the failing test results in accordance with 334-5.9.5.

The Engineer has the option to use the IV sample for comparison testing as specified in 334-6.

334-5.7.1.1 Asphalt Binder and Mixture Sampling for Determination of Asphalt Binder Quality: At the Department's request, obtain an asphalt binder sample from the asphalt plant storage tank and a corresponding asphalt mixture sample using binder from the same storage tank. Samples of asphalt binder and mixture shall be sampled the same day. The asphalt binder from the storage tank and the asphalt binder recovered from the asphalt mixture will be tested by the Department for compliance with Contract Documents.

334-5.7.2 Roadway: Obtain five 6-inch diameter roadway cores within 24 hours of placement, as directed by the Engineer, for IV testing. In situations where it is impractical to cut five cores per sublot, obtain a minimum of three cores per sublot at random locations, as identified by the Engineer. These independent cores will be obtained from the same LOTs and sublots as the Independent Verification Plant samples, or as directed by the Engineer. The density of these cores will be obtained as described in 334-5.1.1. If the average of the results for the sublot does not meet the requirements of Table 334-6 for density, then a comparison of the IV G_{mm} test results and the Contractor's G_{mm} test results, if available, will be made in accordance with the procedure provided in 334-5.7.1. Address any material represented by the failing test results in accordance with 334-5.9.5.

334-5.8 Surface Tolerance: The asphalt mixture will be accepted on the roadway with respect to surface tolerance in accordance with the applicable requirements of 330-9.

334-5.9 Minimum Acceptable Quality Levels:

334-5.9.1 PFs Below 0.90: In the event that an individual pay factor for any quality characteristic of a LOT falls below 0.90, take steps to correct the situation and report the actions to the Engineer. In the event that the pay factor for the same quality characteristic for two consecutive LOTs is below 0.90, cease production of the asphalt mixture until the problem is adequately resolved (to the satisfaction of the Engineer), unless it can be demonstrated to the satisfaction of the Engineer that the problem can immediately be (or already has been) resolved. Actions taken must be approved by the Engineer before production resumes.

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334-5.9.2 CPFs Less Than 0.90 and Greater Than or Equal to 0.80: If the composite pay factor for the LOT is less than 0.90 and greater than or equal to 0.80, cease production of the asphalt mixture until the problem is adequately resolved (to the satisfaction of the Engineer), unless it can be demonstrated to the satisfaction of the Engineer that the problem can immediately be (or already has been) resolved. Actions taken must be approved by the Engineer before production resumes.

334-5.9.3 CPFs Less Than 0.80 and Greater Than or Equal to 0.75: If the CPF for the LOT is less than 0.80 and greater than or equal to 0.75, address the defective material in accordance with 334-5.9.5.

334-5.9.4 CPFs Less Than 0.75: If the CPF for the LOT is less than 0.75, remove and replace the defective LOT at no cost to the Department, or as approved by the Engineer.

334-5.9.5 Defective Material: Assume responsibility for removing and replacing all defective material placed on the project, at no cost to the Department.

As an exception to the above and upon approval of the Engineer, obtain an engineering analysis in accordance with Section 6 by an independent laboratory (as approved by the Engineer) to determine the disposition of the material. The engineering analysis must be signed and sealed by a Professional Engineer licensed in the State of Florida.

The Engineer may determine that an engineering analysis is not necessary or may perform an engineering analysis to determine the disposition of the material.

Any material that remains in place will be accepted with a CPF as determined by 334-8, or as determined by the Engineer.

If the defective material is due to a high air void failure, gradation, asphalt binder content or density failure, upon the approval of the Engineer the Contractor may perform delineation tests on roadway cores in lieu of an engineering analysis to determine the limits of the defective material that may require removal and replacement. Prior to any delineation testing, all sampling locations shall be approved by the Engineer. All delineation sampling and testing shall be monitored and verified by the Engineer. For materials that are defective due to low air voids, an engineering analysis is required.

When evaluating defective material by engineering analysis or delineation testing, at a minimum, evaluate all material located between passing QC, PC or IV test results. Any additional PC samples obtained in the same work shift after an IV sample has been obtained shall include enough material for three complete sets of tests (PC, IV and IV check samples) in the event the Contractor requests using the PC test results for engineering analysis or delineation. These additional PC samples must compare with verified IV test results as determined by the comparison process of 334-5.7.1 in order to be used for engineering analysis or delineation. Exceptions to this requirement shall be approved by the Engineer.

334-6 Comparison Testing.

At the start of the project (unless waived by the Engineer) and at other times as determined necessary by the Engineer, provide split samples for comparison testing with the Engineer. The purpose of these tests is to verify that the testing equipment is functioning properly and that the testing procedures are being performed correctly. In the event that the Engineer determines that there is a problem with the Contractor's testing equipment and/or testing procedures, immediately correct the problem to the Engineer's satisfaction. In the event that the problem is not immediately corrected, cease production of the asphalt mixture until the problem is adequately resolved to the satisfaction of the Engineer.

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If so agreed to by both the Contractor and the Engineer, the split sample used for comparison testing may also be used for the QC sample. The split sample used for comparison testing must also meet the requirements for IV testing described in 334-5.7.

334-7 Method of Measurement.

For the work specified under this Section (including the pertinent provisions of Sections 320 and 330), the quantity to be paid for will be the weight of the mixture, in tons. For each pay item, excluding overbuild, the pay quantity will be based on the quantity placed on the project, limited to 110% of the adjusted plan quantity for the pay item. The adjusted plan quantity will be determined by dividing the pay item's original plan quantity (including any Engineer approved quantity revisions) by the design G_{mm} stated in 334-1.4, then multiplying it by the tonnage-weighted average G_{mm} of the mixes used for the pay item.

The bid price for the asphalt mix will include the cost of the liquid asphalt and the tack coat application as directed in 300-8. There will be no separate payment or unit price adjustment for the asphalt binder material in the asphalt mix. For the calculation of unit price adjustments of bituminous material, the average asphalt content will be based on the percentage specified in 9-2.1.2. The weight will be determined as provided in 320-3.2 (including the provisions for the automatic recordation system).

Prepare and submit a Certification of Quantities to the Engineer in accordance with 9-2.1.2.

334-8 Basis of Payment.

334-8.1 General: Price and payment will be full compensation for all the work specified under this Section (including the applicable requirements of Sections 320 and 330).

For materials accepted in accordance with 334-5, based upon the quality of the material, a pay adjustment will be applied to the bid price of the material as determined on a LOT by LOT basis. The pay adjustment will be assessed by calculating a Pay Factor for the following individual quality characteristics: pavement density, air voids, asphalt binder content, and the percentage passing the No. 200 and No. 8 sieves. The pay adjustment will be computed by multiplying a Composite Pay Factor (CPF) for the LOT by the bid price per ton.

334-8.2 Pay Factors:

334-8.2.1 Partial LOTs: For Partial LOTs where no random sample is obtained due to insufficient tonnage, a CPF of 1.00 shall be applied.

334-8.2.2 Two or Less Sublot Test Results: In the event that two or less sublot test results are available for a LOT, Pay Factors will be determined based on Table 334-8, using the average of the accumulated deviations from the target value. (Except for density, deviations are absolute values with no plus or minus signs.) Use the 1-Test column when there is only one sublot test result and use the 2-Tests column when there are two sublots.

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Table 334-8 Small Quantity Pay Table		
Pay Factor	1 Sublot Test Deviation	2 Sublot Test Average Deviation
Asphalt Binder Content		
1.05	0.00-0.23	0.00-0.16
1.00	0.24-0.45	0.17-0.32
0.90	0.46-0.55	0.33-0.39
0.80	>0.55	>0.39
No. 8 Sieve		
1.05	0.00-2.25	0.00-1.59
1.00	2.26-4.50	1.60-3.18
0.90	4.51-5.50	3.19-3.89
0.80	>5.50	>3.89
No. 200 Sieve		
1.05	0.00-0.55	0.00-0.39
1.00	0.56-1.10	0.40-0.78
0.90	1.11-1.50	0.79-1.06
0.80	>1.50	>1.06
Air Voids		
1.05	0.00-0.50	0.00-0.35
1.00	0.51-1.00	0.36-0.71
0.90	1.01-1.70	0.72-1.20
0.80	1.71-2.00	1.21-1.41
0.70	2.01-2.50	1.42-1.77
0.55	>2.50	>1.77
Density (1) Target = 93.00 percent of G_{mm}		
1.05	+ (0.00-3.50), - (0.00-0.50)	+ (0.00-3.25), - (0.00-0.35)
1.00	+ (3.51-4.50), - (0.51-1.00)	+ (3.26-4.25), - (0.36-0.71)
0.95	+ (4.51-5.00), - (1.01-2.00)	+ (4.26-4.75), - (0.72-1.41)
0.90	+ (5.01-5.50), - (2.01-3.00)	+ (4.76-5.25) – (1.42-2.12)
0.80	+ (>5.50), - (>3.00)	+ (>5.25), - (>2.12)
Density (1) Target = 92.00 percent of G_{mm}		
1.05	+ (0.00-4.50), - (0.00-0.50)	+ (0.00-4.25), - (0.00-0.35)
1.00	+ (4.51-5.50), - (0.51-1.00)	+ (4.26-5.25), - (0.36-0.71)
0.95	+ (5.51-6.00), - (1.01-1.50)	+ (5.26-5.75), - (0.72-1.41)
0.90	+ (6.01-6.50), - (1.51-2.00)	+ (5.76-6.25) – (1.42-2.12)
0.80	+ (>6.50), - (>2.00)	+ (>6.25), - (>2.12)

(1). Each density test result is the average of three to five randomly located cores. The target density is 93.00 percent of G_{mm} (92.00 percent when compaction is limited to the static mode or for layers specified to be one inch thick). When compaction is limited to the static mode, no vibratory mode in the vertical direction will be allowed. Other vibratory modes will be allowed, if approved by the Engineer. In this case, the target density is 92.00 percent of G_{mm}.

334-8.2.3 Three or More Sublot Test Results: When three or more sublot test results are available for a LOT, the variability-unknown, standard deviation method will be used to determine the estimated percentage of the LOT that is within the specification limits. The

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number of significant figures used in the calculations will be in accordance with requirements of AASHTO R 11/ASTM E29, Absolute Method.

334-8.2.3.1 Percent Within Limits: The percent within limits (PWL) and Pay Factors for the LOT will be calculated as described below. Variables used in the calculations are as follows:

x = individual test value (sublot)
n = number of tests (sublots)
s = sample standard deviation
$\Sigma(x^2)$ = summation of squares of individual test values
$(\Sigma x)^2$ = summation of individual test values squared
Q_U = upper quality index
USL = upper specification limit (target value plus upper specification limit from Table 334-9)
Q_L = lower quality index
LSL = lower specification limit (target value minus lower specification limit from Table 334-9)
P_U = estimated percentage below the USL
P_L = estimated percentage above the LSL

1. Calculate the arithmetic mean $(\overline{X})$ of the test values:

$$\overline{X} = \frac{\sum x}{n}$$

2. Calculate the sample standard deviation (s):

$$s = \sqrt{\frac{n\sum\left(x^2\right) - \left(\sum x\right)^2}{n(n-1)}}$$

3. Calculate the upper quality index (Q_U):

$$Q_U = \frac{\text{USL} - \overline{\text{X}}}{\text{s}}$$

4. Calculate the lower quality index (Q_L):

$$Q_L = \frac{\overline{X} - LSL}{s}$$

5. From Table 334-10, determine the percentage of work below the USL (P_U).

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6. From Table 334-10, determine percentage of work above the LSL (P_L) Note: If USL or LSL is not specified; percentages within (USL or LSL) will be 100.

7. If Q_U or Q_L is a negative number, then calculate the percent within limits for Q_U or Q_L as follows: enter Table 334-10 with the positive value of Q_U or Q_L and obtain the corresponding percent within limits for the proper sample size. Subtract this number from 100.00. The resulting number is the value to be used in the next step (Step 8) for the calculation of quality level.

8. Calculate the percent within limits (PWL) = $(P_U + P_L) - 100$

9. Calculate the Pay Factor (PF) for each quality characteristic using the equation given in 334-8.2.3.2.

Table 334-9
Specification Limits

Quality Characteristic	Specification Limits
Passing No. 8 sieve (percent)	Target ± 3.1
Passing No. 200 sieve (percent)	Target ± 1.0
Asphalt Content (percent)	Target ± 0.40
Air Voids (percent)	4.00 ± 1.20
Density, vibratory mode (percent of G_{mm}):	93.00 + 4.00, - 1.20
Density, static mode (percent of G_{mm}):	92.00 + 5.00, - 1.50 (1)

(1): No vibratory mode in the vertical direction will be allowed. Other vibratory modes will be allowed, if approved by the Engineer.

Table 334-10
Percent Within Limits

Quality Index	Percent within Limits for Selected Sample Size	
	n = 3	n = 4
0.00	50.00	50.00
0.05	51.38	51.67
0.10	52.76	53.33
0.15	54.15	55.00
0.20	55.54	56.67
0.25	56.95	58.33
0.30	58.37	60.00
0.35	59.80	61.67
0.40	61.26	63.33
0.45	62.74	65.00
0.50	64.25	66.67
0.55	65.80	68.33
0.60	67.39	70.00
0.65	69.03	71.67
0.70	70.73	73.33

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Table 334-10 Percent Within Limits		
Quality Index	Percent within Limits for Selected Sample Size	
	n = 3	n = 4
0.75	72.50	75.00
0.80	74.36	76.67
0.85	76.33	78.33
0.90	78.45	80.00
0.95	80.75	81.67
1.00	83.33	83.33
1.05	86.34	85.00
1.10	90.16	86.67
1.15	97.13	88.33
1.20	100.00	90.00
1.25	100.00	91.67
1.30	100.00	93.33
1.35	100.00	95.00
1.40	100.00	96.67
1.45	100.00	98.33
1.50	100.00	100.00
1.55	100.00	100.00
1.60	100.00	100.00
1.65	100.00	100.00
1.70	100.00	100.00
1.75	100.00	100.00
1.80	100.00	100.00
1.85	100.00	100.00
1.90	100.00	100.00
1.95	100.00	100.00
2.00	100.00	100.00
2.05	100.00	100.00
2.10	100.00	100.00
2.15	100.00	100.00
2.20	100.00	100.00
2.25	100.00	100.00
2.30	100.00	100.00
2.35	100.00	100.00
2.40	100.00	100.00
2.45	100.00	100.00

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Table 334-10 Percent Within Limits		
Quality Index	Percent within Limits for Selected Sample Size	
	n = 3	n = 4
2.50	100.00	100.00
2.55	100.00	100.00
2.60	100.00	100.00
2.65	100.00	100.00

334-8.2.3.2 Pay Factors (PF): Pay Factors will be calculated by using the following equation:

Pay Factor = (55 + 0.5 x PWL) / 100

The PWL is determined from Step (8) of 334-8.2.3.1.

334-8.3 Composite Pay Factor (CPF): A CPF for the LOT will be calculated based on the individual PFs with the following weighting applied: 40% Density (D), 25% Air Voids (V_a), 20% asphalt binder content (P_b), 10% Passing No. 200 (P_{-200}) and 5% Passing No. 8 (P_{-8}). Calculate the CPF by using the following formula:

CPF = [(0.400 x PF D) + (0.250 x PF V_a) + (0.200 x PF P_b) + (0.100 x PF P_{-200}) + (0.050 x PF P_{-8})]

Where the PF for each quality characteristic is determined in either 334-8.2.2 or 334-8.2.3, depending on the number of sublot tests. Note that the number after each multiplication will be rounded to the nearest 0.01.

The pay adjustment shall be computed by multiplying the CPF for the LOT by the bid price per ton.

334-8.4 Payment: Payment will be made under:

Item No. 334- 1- Superpave Asphaltic Concrete - per ton.

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SECTION 337
ASPHALT CONCRETE FRICTION COURSES

337-1 Description.

Construct an asphalt concrete friction course pavement with the type of mixture specified in the Contract Documents, or when offered as alternates, as selected. This Section specifies mixes designated as FC-5, FC-9.5, and FC-12.5.

Obtain Superpave asphalt concrete friction course from a plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105. Producers must meet the plant and equipment requirements of Section 320, as modified herein. Meet the general construction requirements of Section 330, as modified herein.

337-2 Materials.

337-2.1 General Requirements: Meet the requirements specified in Division III as modified herein. The Engineer will base continuing approval of material sources on field performance. Warm mix technologies (additives, foaming techniques, etc.) listed on the Department's website may be used in the production of the mix. The URL for obtaining this information is: https://www.fdot.gov/materials/laboratory/asphalt/index.shtm.

337-2.2 Asphalt Binder: Meet the requirements of Section 916, and any additional requirements or modifications specified herein for the various mixtures.

337-2.3 Coarse Aggregate: Meet the requirements of Section 901, and any additional requirements or modifications specified herein for the various mixtures.

337-2.4 Fine Aggregate: Meet the requirements of Section 902, and any additional requirements or modifications specified herein for the various mixtures.

337-2.5 Hydrated Lime: Meet the requirements of AASHTO M 303, Type 1. Provide certified test results for each shipment of hydrated lime indicating compliance with the specifications.

337-2.6 Liquid Anti-Strip Additive: Meet the requirements of 916-4 and be listed on the Department's Approved Product List (APL).

337-2.7 Fiber Stabilizing Additive (Required for FC-5 only): Use either a mineral or cellulose fiber stabilizing additive. Meet the following requirements:

337-2.7.1 Mineral Fibers: Use mineral fibers (made from virgin basalt, diabase, or slag) treated with a cationic sizing agent to enhance the disbursement of the fiber, as well as to increase adhesion of the fiber surface to the bitumen. Meet the following requirements for physical properties:

1. Size Analysis
   - Average fiber length: 0.25 inch (maximum)
   - Average fiber thickness: 0.0002 inch (maximum)
2. Shot Content (ASTM C612)
   - Percent passing No. 60 Sieve: 90 - 100
   - Percent passing No. 230 Sieve: 65 - 100

Provide certified test results for each batch of fiber material indicating compliance with the above tests.

337-2.7.2 Cellulose Fibers: Use cellulose fibers meeting the following requirements:

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1. Fiber length: 0.25 inch (maximum)
2. Sieve Analysis
    a. Alpine Sieve Method
        Percent passing No. 100 sieve: 60-80
    b. Ro-Tap Sieve Method
        Percent passing No. 20 sieve: 80-95
        Percent passing No. 40 sieve: 45-85
        Percent passing No. 100 sieve: 5-40
3. Ash Content: 18% non-volatiles (plus or minus 5%)
4. pH: 7.5 (plus or minus 1.0)
5. Oil Absorption: 5.0% (plus or minus 1.0) (times fiber weight)
6. Moisture Content: 5.0% by weight (maximum)

Provide certified test results for each batch of fiber material indicating compliance with the above tests.

337-3 General Composition of Mixes.

337-3.1 General: Use a bituminous mixture composed of aggregate (coarse, fine, or a mixture thereof), asphalt binder, and in some cases, fibers and/or hydrated lime. Size, uniformly grade and combine the aggregate fractions in such proportions that the resulting mix meets the requirements of this Section.

337-3.2 Specific Component Requirements by Mix:

337-3.2.1 FC-5:

337-3.2.1.1 Aggregates: Use an aggregate blend which consists of either 100% Class A friction aggregate or 100% Class B and/or C aggregates in accordance with Table 337-1. Do not blend Class A aggregate with Class B or C aggregate for FC-5 mixtures.

A list of aggregates approved for use in friction course may be available on the Department's website. The URL for obtaining this information, if available, is: https://mac.fdot.gov/.

337-3.2.1.2 Asphalt Binder: Use an asphalt binder as called for in the Contract Documents meeting the requirements of Section 916. High polymer binder may be substituted in a mixture with PG 76-22 binder at no additional cost to the Department.

337-3.2.1.3 Hydrated Lime: Add hydrated lime at a dosage rate in accordance with Table 337-1.

337-3.2.1.4 Liquid Anti-Strip Additive: Use a liquid anti-strip additive at the approved dosage rate as indicated on the APL for all mixtures.

337-3.2.1.5 Fiber Stabilizing Additive: Add either mineral fibers at a dosage rate of 0.4% by weight of the total mix, or cellulose fibers at a dosage rate of 0.3% by weight of total mix.

337-3.2.2 FC-9.5 and FC-12.5:

337-3.2.2.1: Aggregates: Use an aggregate blend of approved friction course aggregates in accordance with Table 337-1. For classifications that allow non-friction aggregate, up to 20% RAP and the remaining fine aggregate from other sources of aggregate not approved for friction courses may be used. Mixtures utilizing High Polymer (HP) binder are not allowed to contain RAP.

A list of aggregates approved for use in friction course may be available on the Department's website. The URL for obtaining this information, if available, is: https://mac.fdot.gov/.

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337-3.2.2.2: Asphalt Binder: Use an asphalt binder as called for in the Contract Documents meeting the requirements of Section 916. High polymer binder may be substituted in a mixture with PG 76-22 binder at no additional cost to the Department.

Table 337-1
Friction Aggregate Classification

Classification	Minimum percentage of approved friction course aggregates for FC-5 mixtures	Minimum percentage of approved friction course aggregates for FC-9.5 and FC-12.5 mixtures	Percentage of hydrated lime required in FC-5 mixtures
A	100	100	0
B	100	60	1.0
C	100	60	1.5

337-3.3 Grading Requirements:

337-3.3.1 FC-5: Use a mixture having a gradation at design within the ranges shown in Table 337-2.

Table 337-2
FC-5 Gradation Design Range

3/4 inch	1/2 inch	3/8 inch	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
100	85-100	60-75	15-25	5-10	--	--	--	--	2-5

337-3.3.2 FC-9.5: Meet the design gradation requirements for a SP-9.5 Superpave fine mix as defined in 334-3.2.2.

337-3.3.3 FC-12.5: Meet the design gradation requirements for a SP-12.5 Superpave fine mix as defined in 334-3.2.2.

337-4 Mix Design.

337-4.1 FC-5: The Department will design the FC-5 mixtures. Furnish the materials and all appropriate information (source, gradation, etc.) as specified in 334-3.2.7. The Department will have three weeks to design the mix.

The Department will establish the design binder content for FC-5 within the following ranges based on aggregate type:

Table 337-3
FC-5 Percent Binder Content

Aggregate Classification	Percent Binder Content
A	6.0 - 7.5
B or C	6.5 - 8.0

337-4.2 FC-9.5 and FC-12.5: Provide a mix design conforming to the requirements of 334-3.2 unless otherwise designated in the plans. Where the plans call for an FC-12.5, an FC-9.5 may be substituted for the FC-12.5 at no additional cost provided the thickness requirements of 334-1.4.1 are met.

337-4.3 Revision of Mix Design: For FC-5, FC-9.5 and FC-12.5, meet the requirements

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of 334-3.3. For FC-5, all revisions must fall within the gradation limits defined in Table 337-2.

337-5 Contractor's Process Control.

Provide the necessary process control of the friction course mix and construction in accordance with the applicable provisions of 320-2, 330-2 and 334-4.

The Engineer will monitor the spread rate periodically to ensure uniform thickness. Perform quality control procedures for daily monitoring and control of spread rate variability. If the spread rate varies by more than 5% of the spread rate set by the Engineer in accordance with 337-8, immediately make all corrections necessary to bring the spread rate into the acceptable range.

337-6 Acceptance of the Mixture.

337-6.1 FC-9.5 and FC-12.5: Meet the requirements of 334-5.

337-6.2 FC-5: Meet the requirements of 334-5 with the following exceptions:

1. The mixture will be accepted with respect to gradation ($P_{-3/8}$, P_{-4}, and P_{-8}), and asphalt binder content (P_b) only.
2. Testing in accordance with AASHTO T 312 and FM 1-T 209 (and conditioning prior to testing) will not be required as part of 334-5.1.1.
3. The standard LOT size of FC-5 will be 2,000 tons, with each LOT subdivided into four equal sublots of 500 tons each.
4. The Between-Laboratory Precision Values described in Table 334-7 are modified to include ($P_{-3/8}$, P_{-4}, and P_{-8}) with a maximum difference per FM 1-T 030 (Figure 2).
5. Table 334-6 (Master Production Range) is replaced by Table 337-4.
6. The mixture will be accepted on the roadway with respect to surface tolerance in accordance with 334-5.8. No density testing will be required for these mixtures.

Table 337-4
FC-5 Master Production Range

Characteristic	Tolerance (1)
Asphalt Binder Content (%)	Target ± 0.60
Passing 3/8 inch Sieve (%)	Target ± 7.50
Passing No. 4 Sieve (%)	Target ± 6.00
Passing No. 8 Sieve (%)	Target ± 3.50
(1) Tolerances for sample size of n = 1 from the verified mix design	

337-6.2.1 Individual Test Tolerances for FC-5 Production: Terminate the LOT if any of the following Quality Control (QC) failures occur:

1. An individual test result of a sublot for asphalt binder content does not meet the requirements of Table 337-4,
2. Two consecutive test results within the same LOT for gradation on any of the following sieve sizes ($P_{-3/8}$, P_{-4}, and P_{-8}) do not meet the requirements of Table 337-4. The two consecutive failures must be on the same sieve.

When a LOT is terminated due to a QC failure, stop production of the mixture until the problem is resolved to the satisfaction of the QC Managers and/or Asphalt Plant Level II Technicians responsible for the decision to resume production after a QC failure, as identified in Section 105. In the event that it can be demonstrated that the problem can

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immediately be or already has been resolved, it will not be necessary to stop production. When a LOT is terminated, make all necessary changes to correct the problem. Do not resume production until appropriate corrections have been made. Inform the Engineer of the problem and corrections made to correct the problem. After resuming production, sample and test the material to verify that the changes have corrected the problem. Summarize this information and provide it to the Engineer prior to the end of the work shift when production resumes.

In the event that a QC failure is not addressed as defined above, the Engineer's approval will be required prior to resuming production after any future QC failures.

Address any material represented by a failing test result in accordance with 334-5.9.5. Any LOT terminated under this Subarticle will be limited to a maximum Pay Factor of 1.00 (as defined in 337-12.3) for each quality characteristic.

337-7 Special Construction Requirements.

337-7.1 Hot Storage of FC-5 Mixtures: When using surge or storage bins in the normal production of FC-5, do not leave mixtures containing mineral fibers in the surge or storage bin for more than one hour. Do not leave mixtures containing cellulose fibers in the surge or storage bin for more than 1-1/2 hours.

337-7.2 Longitudinal Grade Controls for Open-Graded Friction Courses: On FC-5, use either longitudinal grade control (skid, ski or traveling stringline) or a joint matcher.

337-7.3 Temperature Requirements for FC-5:

337-7.3.1 Air Temperature at Laydown: Meet the requirements of Table 330-1.

337-7.3.2 Temperature of the Mix: Heat and combine the asphalt binder and aggregate in a manner to produce a mix having a temperature, when discharged from the plant, meeting the requirements of 320-6.3. Meet all requirements of 330-6.1.3 at the roadway. The target mixing temperature shall be established by the Contractor. The target mixing temperature may be reduced when using warm mix technology.

337-7.4 Compaction of FC-5: Provide two, static steel-wheeled rollers, with an effective compactive weight in the range of 135 to 200 pounds per linear inch (PLI), determined as follows:

$$\text{PLI} = \frac{\text{Total Weight of Roller (pounds)}}{\text{Total Width of Drums (inches)}}$$

(Any variation of this equipment requirement must be approved by the Engineer.) Establish an appropriate rolling pattern for the pavement in order to effectively seat the mixture without crushing the aggregate. In the event that the roller begins to crush the aggregate, reduce the number of coverages or the PLI of the rollers. If the rollers continue to crush the aggregate, use a tandem steel-wheel roller weighing not more than 135 PLI of drum width.

337-7.5 Temperature Requirements for FC-9.5 and FC-12.5:

337-7.5.1 Air Temperature at Laydown: Meet the requirements of Table 330-1.

337-7.5.2 Temperature of the Mix: Heat and combine the asphalt binder and aggregate in a manner to produce a mix having a temperature, when discharged from the plant, meeting the requirements of 320-6.3. Meet all requirements of 330-6.1.3 at the roadway.

337-7.6 Prevention of Adhesion: To minimize adhesion to the drum during the rolling operations, the Contractor may add a small amount of liquid detergent to the water in the roller.

At intersections and in other areas where the pavement may be subjected to cross-

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traffic before it has cooled, spray the approaches with water to wet the tires of the approaching vehicles before they cross the pavement.

337-7.7 Transportation Requirements of Friction Course Mixtures: Cover all loads of friction course mixtures with a tarpaulin, or waterproof cover, meeting requirements of 320-7.

337-8 Thickness of Friction Courses.

337-8.1 FC-9.5 and FC-12.5: The thickness of the friction course layer will be the plan thickness as shown in the Contract Documents. For construction purposes, the plan thickness will be converted to spread rate as defined in 334-1.4.

Plan quantities are based on a G_{mm} of 2.540, corresponding to a spread rate of 110 lb/yd^2-in. Pay quantities will be based on the actual maximum specific gravity of the mix being used.

337-8.2 FC-5: The total thickness of the FC-5 layer will be the plan thickness as shown in the Contract Documents. For construction purposes, the plan thickness will be converted to spread rate based on the combined aggregate bulk specific gravity of the asphalt mix being used as shown in the following equation:

$$\text{Spread rate (lb/yd}^2) = t \times G_{sb} \times 40.5$$

Where: t = Thickness (in.) (Plan thickness)

G_{sb} = Combined aggregate bulk specific gravity from the verified mix design

The weight of the mixture shall be determined as provided in 320-3.2.

Plan quantities are based on a G_{sb} of 2.635, corresponding to a spread rate of 80 pounds per square yard for a 3/4 inch layer. Pay quantities will be based on the actual combined aggregate bulk specific gravity (G_{sb}) of the mix being used.

337-9 Special Equipment Requirements for FC-5.

337-9.1 Fiber Supply System: Use a separate feed system to accurately proportion the required quantity of fibers into the mixture in such a manner that uniform distribution is obtained. Interlock the proportioning device with the aggregate feed or weigh system to maintain the correct proportions for all rates of production and batch sizes. Control the proportion of fibers to within plus or minus 10% of the amount of fibers required. Provide flow indicators or sensing devices for the fiber system, interlocked with plant controls so that an alarm will be activated if introduction of the fiber fails. Stop production of the asphalt mixture and resume production once the fiber supply system is operating correctly.

When a batch plant is used, add the fiber to the aggregate in the weigh hopper or as approved and directed by the Engineer. Increase the batch dry mixing time by 8 to 12 seconds, or as directed by the Engineer, from the time the aggregate is completely emptied into the pugmill. Ensure that the fibers are uniformly distributed prior to the addition of asphalt binder into the pugmill.

When a drum-mix plant is used, add and uniformly disperse the fiber with the aggregate prior to the addition of the asphalt binder. Add the fiber in such a manner that it will not become entrained in the exhaust system of the drier or plant.

337-9.2 Hydrated Lime Supply System: For FC-5 mixes containing Class B or C aggregate, use a separate feed system to accurately proportion the required quantity of hydrated lime into the mixture in such a manner that uniform coating of the aggregate is obtained prior to

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the addition of the asphalt binder. Add the hydrated lime in such a manner that it will not become entrained in the exhaust system of the drier or plant. Interlock the proportioning device with the aggregate feed or weigh system to maintain the correct proportions for all rates of production and batch sizes and to ensure that all mixture produced is properly treated with hydrated lime. Control the proportion of hydrated lime to within plus or minus 10% of the amount of hydrated lime required. Provide flow indicators or sensing devices for the hydrated lime system, interlocked with plant controls so that an alarm will be activated if introduction of the hydrated lime fails. Stop production of the asphalt mixture and resume production once the hydrated lime supply system is operating correctly. The addition of the hydrated lime to the aggregate may be accomplished by Method A or B as follows:

337-9.2.1 Method A - Dry Form: Add hydrated lime in a dry form to the mixture according to the type of asphalt plant being used.

When a batch plant is used, add the hydrated lime to the aggregate in the weigh hopper or as approved and directed by the Engineer. Increase the batch dry mixing time by eight to twelve seconds, or as directed by the Engineer, from the time the aggregate is completely emptied into the pugmill. Uniformly distribute the hydrated lime prior to the addition of asphalt binder into the pugmill.

When a drum-mix plant is used, add and uniformly disperse the hydrated lime to the aggregate prior to the addition of the asphalt binder. Add the hydrated lime in such a manner that it will not become entrained in the exhaust system of the drier or plant.

337-9.2.2 Method B - Hydrated Lime/Water Slurry: Add the required quantity of hydrated lime (based on dry weight) in a hydrated lime/water slurry form to the aggregate. Provide a solution consisting of hydrated lime and water in concentrations as directed by the Engineer. Use a plant equipped to blend and maintain the hydrated lime in suspension and to mix it with the aggregates uniformly in the proportions specified.

337-9.3 Hydrated Lime Pretreatment: For FC-5 mixes containing Class B or C aggregate, as an alternative to 337-9.2, pretreat the aggregate with hydrated lime prior to incorporating the aggregate into the mixture. Use a feed system to accurately proportion the aggregate and required quantity of hydrated lime and mix them in such a manner that uniform coating of the aggregate is obtained. Control the proportion of hydrated lime to within plus or minus 10% of the amount required. Aggregate pretreated with hydrated lime in this manner shall be incorporated into the asphalt mixture within 45 days of pretreatment.

337-9.3.1 Hydrated Lime Pretreatment Methods: Pretreat the aggregate using one of the following two methods:

Pretreatment Method A - Dry Form: Add the required quantity of hydrated lime in a dry form to the aggregate. Assure that the aggregate at the time of pretreatment contains a minimum of 3% moisture over saturated surface dry (SSD) conditions. Utilize equipment to accurately proportion the aggregate and hydrated lime and mix them in such a manner as to provide a uniform coating.

Pretreatment Method B - Hydrated Lime/Water Slurry: Add the required quantity of hydrated lime (based on dry weight) in a hydrated lime/water slurry form to the aggregate. Provide a solution consisting of hydrated lime and water in a concentration to provide effective treatment. Use equipment to blend and maintain the hydrated lime in suspension, to accurately proportion the aggregate and hydrated lime/water slurry, and to mix them to provide a uniform coating.

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337-9.3.2 Blending QC Records: Maintain adequate QC records for the Engineer's review for all pretreatment activities. Include as a minimum the following information (for each batch or day's run of pretreatment): pretreatment date, aggregate certification information, certified test results for the hydrated lime, aggregate moisture content prior to blending, as-blended quantities of aggregate and hydrated lime, project number, customer name, and shipping date.

337-9.3.3 Certification: In addition to the aggregate certification, provide a certification with each load of material delivered to the hot mix asphalt plant, that the material has been pretreated in conformance with these specifications. Include also the date the material was pretreated.

337-10 Failing Material.

Meet the requirements of 334-5.9. For FC-5, use the Master Production Range defined in Table 337-4 in lieu of Table 334-6.

337-11 Method of Measurement.

For the work specified under this Section (including the pertinent provisions of Sections 320 and 330), the quantity to be paid for will be the weight of the mixture, in tons. For each pay item, the pay quantity will be based on the quantity placed on the project, limited to 110% of the adjusted plan quantity for the pay item. For dense-graded mixes, the adjusted plan quantity will be determined by dividing the pay item's original plan quantity (including any Engineer approved quantity revisions) by the design G_{mm} stated in 334-1.4, then multiplying it by the tonnage-weighted average G_{mm} of the mixes used for the pay item. For open graded mixes, the adjusted plan quantity will be determined by dividing the pay item's original plan quantity (including any Engineer approved quantity revisions) by the design G_{sb} stated in 337-8.2, then multiplying it by the tonnage-weighted average G_{sb} of the mixes used for the pay item.

The bid price for the asphalt mix will include the cost of the asphalt binder (asphalt rubber (or polymer), asphalt cement, ground tire rubber, anti-stripping additive, blending and handling) and the tack coat application as directed in 300-8, as well as fiber stabilizing additive and hydrated lime (if required). There will be no separate payment or unit price adjustment for the asphalt binder material in the asphalt mix. The weight will be determined as provided in 320-3.2 (including the provisions for the automatic recordation system).

Prepare and submit a Certification of Quantities to the Engineer in accordance with 9-2.1.2.

337-12 Basis of Payment.

337-12.1 General: Price and payment will be full compensation for all the work specified under this Section (including the applicable requirements of Sections 320 and 330).

Based upon the quality of the material, a pay adjustment will be applied to the bid price of the material as determined on a LOT by LOT basis. The pay adjustment will be assessed by calculating a Pay Factor for individual quality characteristics. The pay adjustment will be computed by multiplying a Composite Pay Factor for the LOT by the bid price per ton.

337-12.2 FC-9.5 and FC-12.5: Meet the requirements of 334-8.

337-12.3 FC-5: Meet the requirements of 334-8 with the following exceptions:

1. Pay factors will be calculated for asphalt binder content and the percentages passing the 3/8 inch, the No. 4, and the No. 8 sieves only.

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2. Table 337-5 replaces Table 334-8.
3. Table 337-6 replaces Table 334-9.
4. The Composite Pay Factor equation in 334-8.3 is replaced with the following:

CPF = [(0.20 x PF 3/8 inch) + (0.30 x PF No. 4) + (0.10 x PF No. 8) + (0.40 x PF AC)]

Table 337-5 Small Quantity Pay Table for FC-5		
Pay Factor	1-Test Deviation	2-Test Average Deviation
Asphalt Binder Content (%)		
1.05	0.00-0.25	0.00-0.18
1.00	0.26-0.50	0.19-0.35
0.90	0.51-0.60	0.36-0.42
0.80	>0.60	>0.42
3/8 inch Sieve (%)		
1.05	0.00-3.25	0.00-2.30
1.00	3.26-6.50	2.31-4.60
0.90	6.51-7.50	4.61-5.30
0.80	>7.50	>5.30
No. 4 Sieve (%)		
1.05	0.00-2.50	0.00-1.77
1.00	2.51-5.00	1.78-3.54
0.90	5.01-6.00	3.55-4.24
0.80	>6.00	>4.24
No. 8 Sieve (%)		
1.05	0.00-1.50	0.00-1.06
1.00	1.51-3.00	1.07-2.12
0.90	3.01-3.50	2.13-2.47
0.80	>3.50	>2.47

Table 337-6 Specification Limits for FC-5	
Quality Characteristic	Specification Limits
Asphalt Binder Content (%)	Target ± 0.45
Passing 3/8 inch sieve (%)	Target ± 6.00
Passing No. 4 sieve (%)	Target ± 4.50
Passing No. 8 sieve (%)	Target ± 2.50

337-12.4 Payment: Payment will be made under:

Item No. 337- 7- Asphaltic Concrete Friction Course - per ton.

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SECTION 338
VALUE ADDED ASPHALT PAVEMENT

338-1 Description.

Construct value added asphalt pavement consisting of asphalt concrete structural course and asphalt concrete friction course, subject to a three year warranty period after final acceptance of the Contract in accordance with 5-11.

For purposes of this Specification, the Responsible Party, as designated herein, is responsible for performance of the value added asphalt pavement including continued responsibility for performing all remedial work associated with pavement distresses exceeding threshold values determined in accordance with this Section, and as to which notice was provided to the Responsible Party.

The work specified in this Section will not be paid for directly, but will be considered as incidental to other Contract items.

338-2 Materials and Construction Requirements.

Meet the following requirements:

Hot Bituminous Mixtures - Plant, Methods and Equipment.....Section 320
Hot Bituminous Mixtures - General Construction Requirements.....Section 330
Superpave Asphalt Concrete.....Section 334
Asphalt Concrete Friction Courses.....Section 337

338-3 Responsible Party.

Prior to any value added asphalt pavement being placed on the project, the Contractor shall designate a Responsible Party to accept responsibility for maintaining the value added asphalt pavement, when remedial work is required. When the scope of the asphalt work is only milling and resurfacing, and there is no construction of the embankment, subgrade or base below the pavement included in the Contract, the Responsible Party may be either the Contractor or the Department approved subcontractor performing the value added asphalt pavement work. When the construction of the embankment, subgrade or base below the pavement is included in the Contract, in addition to the construction of the asphalt concrete structural course and asphalt concrete friction course, the Contractor shall be considered as the Responsible Party.

When the Responsible Party is a subcontractor, the subcontractor must be pre-qualified with the Department in the category of asphalt, and such designation must be made to the Department by the Contractor. The proposed subcontractor must execute and submit to the Department a form, provided by the Department, prior to or concurrent with the Contractor's request to sublet any value added asphalt pavement work, stipulating that the subcontractor assumes all responsibility as the Responsible Party for the value added asphalt pavement within the three-year warranty period. Failure to timely designate the Responsible Party will result in the Contractor being the Responsible Party unless otherwise agreed to in writing by the Department.

Upon final acceptance of the Contract in accordance with 5-11, the Contractor's responsibility for maintenance of all the work or facilities within the project limits of the Contract will terminate in accordance with 5-11; with the sole exception that the obligations set

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forth in this Section for value added asphalt pavement will continue thereafter to be the responsibility of the Responsible Party as otherwise provided in this Section.

338-4 Statewide Disputes Review Board.

The Statewide Disputes Review Board in effect for this Contract will resolve any and all disputes that may arise involving administration and enforcement of this Specification. The Responsible Party and the Department acknowledge that use of the Statewide Disputes Review Board is required, and the determinations of the Statewide Disputes Review Board for disputes arising out of this Specification will be binding on both the Responsible Party and the Department, with no right of appeal by either party.

Meet the requirements of 8-3.

338-5 Pavement Evaluation and Remedial Work.

338-5.1 General: The Department's Pavement Condition Survey Program, along with observations by the Engineer, will be used as the basis for determining the extent and the magnitude of the pavement distresses occurring on the project. In the event the level of distress exceeds any of the threshold values defined below, remedial work as described in 338-5.5 by the Responsible Party will be required.

The Department will monitor the pavement for distresses and may require remedial action at any time. For evaluation purposes, the project will be subdivided into LOTs of 0.1 mile per lane. When the segment is less than 0.1 mile, the segment will be called a partial LOT. For purposes of threshold values and remedial work, partial lots and lots will be treated as lots. The Department may conduct a Pavement Condition Survey of the value added pavement following the final acceptance of the project, and at intermediate times throughout the warranty period with findings provided when considered by the Department to be the obligation of the Responsible Party.

The final survey, if determined by the Engineer to be necessary, will be conducted before the end of the warranty period with results provided to the Responsible Party for those conditions exceeding contract threshold values requiring remedial action that the Department believes to be an obligation of the Responsible Party. The Department will be responsible for all costs associated with the surveys.

If the survey findings, intermediate or final, are to be disputed by the Responsible Party, written notification must be submitted to the Engineer within 30 calendar days of the date of receipt of the information from the Department.

During the warranty period, the Responsible Party may monitor the project using nondestructive methods and may participate with the Department in the Pavement Condition Surveys upon request. The Responsible Party shall not conduct any coring, milling or other destructive methods without prior approval by the Engineer.

338-5.2 Category 1 Pavement: For purposes of this Specification, Category 1 pavement is defined as mainline roadways, access roads and frontage roads with a design speed of 55 mph and greater.

Threshold values and associated remedial work for Category 1 value added asphalt pavement are specified in Table 338-1.

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Table 338-1 Category 1 Pavements		
Type of Distress	Threshold Values	Remedial Work
Rutting (1)	Depth > 0.25 inch	Remove and replace the distressed LOT(s) to the full depth of all layers and to the full lane width (2)
Ride (3)	RN < 3.5 IRI > 110 inches/mile	Remove and replace the friction course layer for the full length and the full lane width of the distressed LOT(s)(4)
Settlement/Depression(5)	Depth ≥ 1/2 inch	Propose the method of correction to the Engineer for approval prior to beginning remedial work
Cracking (6)	Cumulative length of cracking > 30 feet for Cracks > 1/8 inch	Remove and replace the distressed LOT(s) to the full depth of all layers, and to the full lane width (7)
Raveling and/or Delamination affecting the Friction Course (8)	Any length	Remove and replace the distressed area(s) to the full distressed depth and the full lane width for the full distressed length plus 50' on each end
Pot holes and Slippage Area(s) (8)	Observation by Engineer	Remove and replace the distressed area(s) to the full distressed depth and the full lane width for the full distressed length plus 50' on each end
Bleeding (9)	Loss of surface texture due to excess asphalt, individual area ≥ 10 sf.	Remove and replace the distressed area(s) to the full distressed depth and the full lane width for the full distressed length plus 50' on each end

(1) Rutting: Rut depth to be determined by Laser Profiler in accordance with the Flexible Pavement Condition Survey Handbook. For any LOT that cannot be surveyed by Laser Profiler, the rut depth will be determined manually in accordance with the Flexible Pavement Condition Survey Handbook, with the exception that the number of readings per LOT will be one every 20 feet. For a partial LOT, a minimum of three measurements not exceeding 20 feet apart will be made. When the average of the measurements obtained manually exceeds 0.30 inch or if any individual measurement exceeds 0.6 inch, remedial work will be required.
(2) Remedial Work for Rutting: The Contractor may propose removal and replacement of less than the full depth of all layers by preparation and submittal of a signed and sealed engineering analysis report, demonstrating the actual extent of the distressed area(s). Remedial work must be performed in accordance with Table 338-1 unless approved otherwise by the Engineer.
(3) Ride: Ride Number (RN) and International Roughness Index (IRI) to be established by Laser Profiler in accordance with FM 5-549. Use RN Warranty Threshold for projects that used RN for construction acceptance and International Roughness Index (IRI) Warranty Threshold for projects that used IRI for construction acceptance.
(4) If the deficient ride is due to underlying asphalt layers; base, subgrade, or embankment which were constructed by the Responsible Party, propose the method of correction to the Engineer for approval prior to beginning the remedial work.
(5) Settlement/Depression: Depth of the settlement/depression to be determined by a 6 foot manual straightedge.
(6) Cracking: Beginning and ending of 1/8 inch cracking will be determined as the average of three measurements taken at one foot intervals. The longitudinal construction joint at the lane line will not be considered as a crack.
(7) Remedial Work for Cracking: The Contractor may propose removal and replacement of less than the full depth of all layers by preparation and submittal of a signed and sealed engineering analysis report, demonstrating the actual extent of the distressed area(s). Remedial work must be performed in accordance with Table 338-1 unless approved otherwise by the Engineer.
(8) Raveling, Delamination, Pot holes, Slippage: As defined and determined by the Engineer in accordance with the examples displayed at the following URL: https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/Pavement.shtm
(9) Bleeding: Bleeding to be defined and determined by the Engineer in accordance with the examples displayed at the following URL: https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/Pavement.shtm

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338-5.3 Category 2 Pavement: For purposes of this Specification, Category 2 pavement is defined as mainline roadways, access roads and frontage roads with a design speed less than 55 mph, approach transition and merge areas at toll booths, ramps, acceleration and deceleration lanes (including tapers), turn lanes, parking areas, rest areas, weigh stations, and agricultural inspection stations.

Threshold values and associated remedial work for Category 2 value added asphalt pavement are specified in Table 338-2.

Table 338-2
Category 2 Pavements

Type of Distress	Threshold Values	Remedial Work
Rutting(1)	Measured by Laser Profiler: See Table 338-1	See Table 338-1
	Manual Measurement: Avg. Depth > 0.4 inch	Remove and replace 1.5 inch(1a) the full lane width for the area plus 50 feet
Cracking	Cumulative length of cracking > 300 feet for Cracks > 1/8 inch	See Table 338-1
Surface Deterioration (2)	See Table 338-1	See Table 338-1
Settlement/Depression(3)	Depth ≥ 1/2 inch	See Table 338-1

(1) Rutting: Rut depth to be determined by Laser Profiler in accordance with the Flexible Pavement Condition Survey Handbook. For any LOT that cannot be surveyed by the Laser Profiler, the rut depth will be determined manually in accordance with the Flexible Pavement Condition Survey Handbook, with the exception that the number of readings per LOT will be one every 20 feet. For partial LOT, minimum of three measurements not exceeding 20 feet apart will be checked. When the average of the measurements obtained manually exceeds 0.40 inch, or if any individual measurement exceeds 0.6 inch, remedial work will be required.
(1a) If pavement has an open graded friction course, remove and replace 2.0 inches.
(2) Surface Deterioration: As used in Table 338-2, Surface Deterioration includes Raveling and/or Delamination affecting the Friction Course; Pot holes; Slippage Area(s); and Bleeding; all as defined and footnoted in Table 338-1.
(3)Settlement/Depression: Depth of the settlement/depression to be determined by a 6 foot manual straightedge.

338-5.4 Category 3 Pavement: For purposes of this Specification, Category 3 pavement is defined as bicycle paths, walking paths, median crossovers, shoulders and other areas as determined by the Engineer.

Threshold values and associated remedial work for Category 3 value added asphalt pavement are specified in Table 338-3.

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Table 338-3 Category 3 Pavements		
Type of Distress	Threshold Values	Remedial Work
Rutting	N/A	N/A
Cracking	Cumulative length of cracking > 500 feet for Cracks > 1/8 inch	See Table 338-1
Surface Deterioration (1)	See Table 338-1	See Table 338-1
Settlement/Depression(2)	Depth ≥ 1/2 inch	See Table 338-1

(1) Surface Deterioration: As used in Table 338-3, Surface Deterioration includes Raveling and/or Delamination affecting the Friction Course; Pot holes; Slippage Area(s); and Bleeding; all as defined and footnoted in Table 338-1. Raveling of FC-5 for Category 3 Pavements is excluded from this requirement.

(2) Settlement/Depression: Depth of the settlement/depression to be determined by a 6-foot manual straightedge.

338-5.5 Remedial Work: The Responsible Party will perform all necessary remedial work described within this Section at no cost to the Department. If the pavement distresses exceed threshold values and it is determined that the cause of the distress is due to the embankment, subgrade, base or other activities performed by the Contractor, the Responsible Party will be responsible for performing all remedial work associated with the pavement distress. Should an impasse develop in any regard as to the need for remedial work or the extent required, the Statewide Disputes Review Board will render a final decision by majority vote.

Remedial work will not be required if any one of the following conditions is found to apply:

a. Determination that the pavement thickness design as provided by the Department is deficient. The Department will make available a copy of the original pavement thickness design package and design traffic report to the Responsible Party upon request. The Responsible Party is responsible for performing all remedial work associated with the pavement distress if the pavement design is provided by the Contractor.

b. Determination that the Accumulated ESALs (Number of 18 Kip Equivalent Single Axle Loads in the design lane) has increased by 25% or more than the Accumulated ESALs used by the Department for design purposes for the warranty period for the pavement design life. In calculating ESALs, the average annual daily traffic (AADT) will be obtained from the Department's traffic count data and the T24 (percent heavy trucks during a 24 hour period) will be obtained from the Department's traffic classification survey data.

c. Determination that the deficiency was due to the failure of the existing underlying layers that were not part of the Contract work.

d. Determination that the deficiency was the responsibility of a third party or its actions, unless the third party was performing work included in the Contract.

e. Determination that raveling of open-graded friction course (FC-5) in a turn lane, turn out, or median cross over was caused by turning movements and not a materials or construction issue.

If a measured distress value indicates remedial action is required per Table 338-1, Table 338-2 and/or Table 338-3, the Responsible Party must begin remedial work within 45 calendar days of notification by the Department or a ruling of the Statewide Disputes Review Board. The Disputes Review Board will determine the allowable duration for the completion of the remedial work, but not to exceed six months.

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In the event remedial action is necessary and forensic information is required to determine the source of the distress, the Department may core and/or trench the pavement. The Responsible Party will not be responsible for damages to the pavement as a result of any forensic activities conducted by the Department.

As applicable to distress criteria for rutting, ride and cracking for Category 1 and Category 2 pavements, when two LOTs requiring remedial action are not separated by three or more LOTs not requiring remedial action, the remedial work shall be required for the total length of all such contiguous LOTs, including the intermediate LOTs not requiring remedial action.

Additionally, for Category 1 and Category 2 pavements, where such areas of remedial action are required due to raveling, slippage or bleeding are separated by less than 1,000 feet, the remedial work will be required for the entire area contiguous to the distressed areas, including intermediate areas otherwise requiring no remedial action.

The Responsible Party has the first option to perform all remedial work that is determined by the Department to be their responsibility. If, in the opinion of the Engineer, the problem poses an immediate danger to the traveling public and the Responsible Party cannot provide temporary mitigation for the defect within 4 hours of written notification and restore the pavement to its original design condition within 72 hours of written notification, the Engineer has the authority to have the remedial work performed by other forces. Temporary mitigation includes the use of traffic control systems such as barricades, drums, or other approved devices to secure the area including lane closures if necessary, and constructing temporary repairs making it safe for the roadway user until the defect can be restored to its original design condition. The Responsible Party is responsible for all incurred costs of the work performed by other forces should the problem (remedial work) be determined to be the responsibility of the Responsible Party. Remedial work performed by other forces does not alter any of the requirements, responsibilities or obligations of the Responsible Party.

The Responsible Party must complete all remedial work to the satisfaction of the Engineer. Any disputes regarding the adequacy of the remedial work will be resolved by the Statewide Disputes Review Board. Approval of remedial work does not relieve the Responsible Party from continuing responsibility under the provisions of this Specification.

Notify the Engineer in writing prior to beginning any remedial work. Meet the requirements of the Specifications when performing any remedial work. Perform all signing and traffic control in accordance with the current edition of the Department's Standard Plans. Provide maintenance of traffic during remedial work at no additional cost to the Department. Lane closure restrictions listed in the original Contract will apply to remedial work. Written requests to obtain permission for lane closures for either forensic investigation or remedial work must be made to the Engineer 48 hours in advance of any lane closures. Do not perform any lane closures until written permission is given by the Engineer.

If remedial work necessitates a corrective action to overlying asphalt layers, pavement markings, signal loops, adjacent lanes, roadway shoulders, or other affected Contract work, perform these corrective actions using similar products at no additional cost to the Department.

338-6 Responsible Party's Failure to Perform.

Should the Responsible Party fail to timely submit any dispute to the Statewide Disputes Review Board, fail to satisfactorily perform any remedial work, or fail to compensate the Department for any remedial work performed by the Department and determined to be the Responsible Party's responsibility in accordance with this Specification, the Department will

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suspend, revoke or deny the Responsible Party's certificate of qualification under the terms of Section 337.16(d)(2), Florida Statutes, for a minimum of six months or until the remedial work has been satisfactorily performed (or full and complete payment for remedial work performed by others made to the Department), whichever is longer. Should the Responsible Party choose to challenge the Department's notification of intent for suspension, revocation or denial of qualification and the Department's action is upheld, the Responsible Party will have its qualification suspended for an additional minimum of six months.

The remedial work is not an obligation of the Contractor's bond required by Section 337.18, Florida Statutes.

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SECTION 339
MISCELLANEOUS ASPHALT PAVEMENT

339-1 Description.

Construct asphalt pavement in areas where vehicular traffic does not travel, such as pavement under guardrail, bicycle paths, median pavement, sidewalks, etc.

Also, chemically treat the underlying soil to prevent plant growth.

339-2 Materials.

Meet the following requirements:

Hot Bituminous Mixtures .....Section 320
Herbicide..... 7-1.7

For the pavement, use any plant-mixed hot bituminous mixture meeting the requirements of a mix design verified by the Engineer, except do not use open-graded friction course (FC-5). For bicycle paths, use a mixture that produces a finished pavement which will not distort or maunder bicycle or mower wheel loads.

In general, the Engineer will accept the mixture on the basis of visual inspection with no further testing required.

339-3 Foundation and Soil Treatment.

Shape the soil in areas where pavement is to be constructed, to a surface true to the lines, grades and typical sections shown in the Plans. Compact the soil to a firm state.

Immediately before placing the pavement, uniformly apply a pre-emergent herbicide in accordance with the requirements of 7-1.7, to the foundation soil. Ensure that the herbicide carries an approved label for use under paved surfaces, and that herbicide is applied in accordance with directions on the label.

Prevent damage to any adjacent vegetation during herbicide application. Replace, at no expense to the Department, any plants damaged as the result of soil treatment outside designated areas.

339-4 Placing Mixture.

Uniformly place the hot bituminous mixture by machine or hand methods at the rate of spread or dimensions indicated in the Plans or as otherwise directed by the Engineer. If posts are to be constructed within the pavement area, the Contractor may cut holes for installation through the completed pavement. After completing installation of posts and compaction of the backfill material, patch the area around each post with fresh hot bituminous mixture.

If directed by the Engineer, place miscellaneous asphalt pavement prior to placement of the final surface course.

339-5 Compacting Mixture.

Uniformly compact the hot bituminous mixture with lightweight rollers or vibratory compactors as directed by the Engineer. The Contractor may use hand tamps for compaction in areas which are inaccessible to other compaction equipment.

The Engineer will not require a specific density.

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339-6 Surface Requirements.

Provide a finished surface that is reasonably smooth, of uniform texture, and shaped so as to drain without ponding of water.

Upon completion of the pavement, shape the surface of the adjacent earth to match the pavement edges.

339-7 Method of Measurement.

For the work specified under this Section (including the pertinent provisions of Sections 320 and 330), the quantity to be paid for will be the weight of the mixture in tons. For each pay item, the pay quantity will be based on the quantity placed on the project, limited to 110% of the adjusted plan quantity for the pay item. The adjusted plan quantity will be determined by dividing the original plan quantity (including any Engineer approved quantity revisions) by the design G_{mm} stated in 334-1.4, then multiplying it by the tonnage-weighted average G_{mm} of the mixes used on the project for the pay item. The plan quantity will be determined based on a spread rate of 100 pounds per square yard per inch of design thickness of asphalt placed over the area shown in the Plans.

Prepare and submit a Certification of Quantities to the Engineer in accordance with 9-2.1.2.

339-8 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including shaping and compacting the foundation, soil sterilization treatment, furnishing of the bituminous material used in the mixture, and shaping of adjacent earth surfaces.

Payment will be made under:

Item No. 339- 1- Miscellaneous Asphalt Pavement - per ton.

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SECTION 341
ASPHALT MEMBRANE INTERLAYER

341-1 Description.

Construct an asphalt membrane interlayer composed of a separate application of asphalt binder covered with a single application of aggregate. Obtain asphalt binder from a plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 916.

341-2 Materials.

Meet the following requirements:

Bituminous Material (PG 76-22 Asphalt Binder)*.....Section 916

Coarse Aggregate Cover Material (Size No. 6 stone, slag, or gravel) .....
.....Section 901

*Use products listed in the Department's Approved Product List (APL).

341-3 Equipment.

341-3.1 Power Broom: Provide a power broom for cleaning the existing pavement capable of removing all loose material from the surface.

341-3.2 Spreading Equipment: Provide a self-propelled aggregate spreader that can be adjusted to accurately apply the cover material at the specified rate and that spreads the material uniformly.

341-3.3 Rollers: Provide self-propelled, pneumatic-tired traffic type rollers equipped with at least 7 smooth-tread, low-pressure tires, and capable of carrying a gross load of at least 8 tons. Maintain a minimum tire inflation pressure of 90 psi, or as specified by the manufacturer, such that in no two tires the air pressure varies more than 5 psi. Load the traffic roller as directed by the Engineer.

341-3.4 Mixing Equipment: Use mixing equipment for asphalt binder designed for that purpose and capable of producing and maintaining a homogeneous mixture of asphalt cement at the specified temperature.

341-3.5 Pressure Distributor: Use a pressure type distributor to apply asphalt binder capable of maintaining a homogeneous mixture of asphalt cement at the specified temperature and consistently apply the material in a uniform manner.

341-4 Contractor's Quality Control.

Provide the necessary quality control of the asphalt binder, and interlayer construction in accordance with the Contract requirements. If the rate of application varies by more than 5% from the rate set by the Engineer in accordance with 341-6, immediately make all corrections necessary to bring the spread rate into the acceptable range. The Engineer may take additional measurements at any time. The Engineer will randomly check the Contractor's measurement to verify the spread rate.

341-5 Construction Procedure.

341-5.1 Preparation of Surface: Prior to application of the asphalt binder, clean the existing pavement as specified in 300-5.

341-5.2 Application of Asphalt Binder: Apply the asphalt binder only under the following conditions:

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1. The air temperature is above 50ºF and rising.
2. The pavement is absolutely dry.
3. The wind conditions are such that cooling of the asphalt binder will not be so rapid as to prevent good bonding of the aggregate.

Uniformly apply the asphalt binder, at the rate of 0.6 to 0.8 gal/yd^2, as directed by the Engineer. Use an application rate corrected to 60ºF, in accordance with 300-9.3. Determine the rate of application after each application operation.

341-5.3 Application of Cover Material: Immediately after application of the asphalt binder, uniformly spread the cover material at a rate of 0.26 and 0.33 ft^3/yd^2. The Engineer will set the exact rate. Determine the application rate at the beginning of each day's production, and as needed to control the operation, a minimum of twice per day. Maintain an application rate such that the pavement is covered uniformly with aggregate, and is one aggregate layer thick. For the cover material, use aggregate that is reasonably free of any adherent coatings and that does not contain excessive moisture. Immediately after the application of cover material, check the surface to ensure a uniform distribution of cover material and a smooth surface.

Do not separate the application of the asphalt binder and the application of the cover material by more than 300 feet, unless approved by the Engineer.

341-5.4 Rolling: In order to ensure maximum embedment of the aggregate, cover the entire width of the mat immediately by traffic rollers. For the first coverage, provide a minimum of three traffic rollers in order to accomplish simultaneous rolling in echelon of the entire width of the spread.

After initial rolling, immediately correct all portions of the completed surface, that the Engineer deems defective (not properly covered by aggregates, fat spots, excessive free aggregate, etc.).

Following the first coverage, make additional coverages with traffic rollers as directed by the Engineer.

341-5.5 Traffic Control: For the normal sequence of construction operations, place the first course of asphalt concrete overlay over the membrane prior to opening to traffic.

341-6 Unacceptable Asphalt Membrane Interlayer.

If the asphalt membrane interlayer is unacceptable due to incorrect blending, application rate, or not meeting the requirements of this Section, or damaged prior to placement of the asphalt concrete layer, remove and replace it as directed by the Engineer at no additional cost to the Department. Do not apply excessive amounts of asphalt binder.

341-7 Placement of Asphalt Concrete Overlay.

Ensure that the thickness and temperature of the initial layer of asphalt concrete placed on top of the asphalt membrane interlayer are such that the overlay bonds to the interlayer and the underlying layer without voids or excessive binder. Core the asphalt overlay as directed by the Engineer to evaluate the binder and aggregate spread rates, as well as the effectiveness of the asphalt concrete overlay in producing a well-bonded interlayer.

341-8 Method of Measurement.

341-8.1 Asphalt Membrane Interlayer: The quantity to be paid for will be plan quantity, in square yards, completed and accepted.

341-8.2 Bituminous Material (Asphalt Binder-Interlayer): The quantity will be the volume, in gallons, determined as provided in 300-9.

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341-8.3 Submittal of Certification of Quantities for Bituminous Material: Prepare and submit a Certification of Quantities to the Engineer in accordance with 9-2.1.2.

341-9 Basis of Payment.

341-9.1 Asphalt Membrane Interlayer: Price and payment will be full compensation for all work specified in this Section, including furnishing cover materials, handling, spreading, rolling, bituminous material, and other incidental work necessary to complete this item.

341-9.2 Payment Items: Payment will be made under:

Item No. 341- 1- Asphalt Membrane Interlayer - per square yard.

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SECTION 346
STRUCTURAL PORTLAND CEMENT CONCRETE

346-1 Description.

Use a Department-approved concrete mix design composed of a mixture of portland cement, aggregate, water, admixtures, and supplementary cementitious materials. Deliver the portland cement concrete to the site of placement in a freshly mixed, unhardened state.

Obtain concrete from a plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105. If the concrete production facility's Quality Control (QC) Plan is suspended, the Contractor is solely responsible to obtain the services of another concrete production facility with an accepted QC Plan or await the reacceptance of the concrete production facility's QC Plan prior to the placement of any further concrete on the project. There will be no changes in the Contract Time because of the suspension, as described. Bear all delay costs and other costs associated with the concrete production facility's QC Plan acceptance or reacceptance.

346-2 Materials.

346-2.1 General: Meet the following requirements:

Coarse Aggregate	Section 901
Fine Aggregate*	Section 902
Portland Cement and Blended Cement	Section 921
Water	Section 923
Admixtures**	Section 924
Supplementary Cementitious Materials	Section 929
Materials for Concrete Repair**	Section 930
Non-Shrink Grout*	Section 934

*Use only silica sand except as provided in 902.

**Use products listed on the Department's Approved Product List (APL).

Do not use materials containing hard lumps, crusts, or frozen matter, or that is contaminated with materials exceeding the specified limits in the above listed Sections.

346-2.2 Types of Cement: Unless a specific type of cement is designated in the Contract Documents, use Type I, Type IL, Type IP, Type IT, Type IS, Type II, or Type III cement in all classes of concrete. Use Type IL, Type IT, or Type II for all mass concrete elements.

Use only the types of cements designated for each environmental classification in structural concrete as shown in Table 346-1. A mix design for a more aggressive environment may be used in a less aggressive environmental condition.

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Table 346-1 Cement Use by Environmental Classification			
Component	Slightly Aggressive Environment	Moderately Aggressive Environment	Extremely Aggressive Environment (1)
Bridge Superstructures			
Precast Superstructure and Prestressed Elements	Type I or Type III	Type I, Type IL, Type II, Type III, Type IP, or Type IS	Type II, Type IL, Type III (2), Type IT or Ternary Blend
Cast in Place	Type I	Type I, Type IL, Type II, Type IP, or Type IS	Type II, Type IL, Type IT or Ternary Blend
Bridge Substructures, Drainage Structures, and other Structures			
All Elements	Type I or Type III	Type I, Type IL, Type II, Type IP, or Type IS	Type II, Type IL, Type IT or Ternary Blend

Notes:
(1) Cements used in a more aggressive environment may also be used in a less aggressive environment.
(2) Type III cement may be used in an Extremely Aggressive Environment for precast superstructure and prestressed elements when the ambient temperature at the time of concrete placement is 60°F and below.

346-2.3 Supplementary Cementitious Materials: Supplementary cementitious materials (SCMs) are required in all classes of concrete specified in Table 346-3. Nonreinforced concrete Class I (Seal) and Class I (Pavement), are exempted, and Class II when used in slightly aggressive environments.

The quantity of portland cement that is replaced with SCMs must be on an equal weight replacement basis of the total cementitious materials in accordance with Table 346-2. When using Type IP, IS or IT blended cements, the total quantity of SCMs, including the blended cement added separately at the concrete plant shall meet the requirements of Table 346-2.

346-2.3.1 Highly Reactive Pozzolans: Materials that have a very high degree of pozzolanic reactivity due to their very fine particle sizes, including silica fume, metakaolin and ultrafine fly ash.

346-2.3.2 Binary Concrete Mixes: Concrete mixes containing portland cement and one SCM.

346-2.3.3 Ternary Concrete Mixes: Concrete mixes containing portland cement and any two SCMs.

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Table 346-2
Cementitious Materials Concrete Mix Proportions (%)
(Environmental classification is extremely aggressive, unless otherwise noted)

Application	Portland Cement	Coal Ash Type F	Slag	Highly Reactive Pozzolans (4 and 5)		
				Silica Fume	Metakaolin	Ultra-Fine Fly Ash
General Use	50-82	18-50				
	51-79	18-40		3-9		
	63-77	15-25			8-12	
	63-77	15-25				8-12
	30-45	10-20	45-60			
	30-50		50-70			
	36-43		50-55	7-9		
	33-42		50-55		8-12	
	33-42		50-55			8-12
Precast / Prestressed	70-85 (1)	15-30 (1)				
	50-82	18-50				
	51-79	18-40		7-9		
	63-77	15-25			8-12	
	63-77	15-25				8-12
	30-40	10-20	50-60			
	30-50		50-70			
	36-43		50-55	7-9		
	33-42		50-55		8-12	
	33-42		50-55			8-12
Drilled Shaft	50-82	18-50				
	38-42		58-62			
	30-40	10-20	50-60			
Mass Concrete	50-82 (2)	18-50 (2)				
	50-65 (3)	35-50 (3)				
	66-78	15-25		7-9		
	63-77	15-25			8-12	
	63-77	15-25				8-12
	30-40	10-20	50-60			
	30-50		50-70			
	36-43		50-55	7-9		
	33-42		50-55		8-12	
	33-42		50-55			8-12

(1) Slightly Aggressive and Moderately Aggressive environments.
(2) For Concrete with Core Temperature T≤165°F.
(3) For Concrete with Core Temperature T≥165°F.
(4) A minimum concrete Surface Resistivity (SR) value of 29 kΩ-cm is required.
(5) Highly reactive pozzolans may be used below the specified ranges to enhance strength and workability when it is not required by the Contract Documents. A minimum concrete Surface Resistivity (SR) value is not required.

346-2.4 Aggregates: Produce all concrete using Size No. 57, 67 or 78 coarse aggregates. Use Size No. 8, and Size No. 89 alone, only when approved by the Engineer.

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Use Size No. 4 or larger blended with smaller size coarse aggregate as two components.

346-2.4.1 Optimized Aggregate Gradation: Improve the aggregate packing density at the Contractor's option, by adding an intermediate-size coarse aggregate in accordance with FM 5-621 to produce combined aggregate gradation of fine, intermediate, and coarse aggregate sizes for the concrete mixes.

346-2.4.2 Lightweight fine aggregate (LWFA) for internal curing: At the Contractor's option, use LWFA to reduce the early-age concrete cracking by replacing some of normal fine aggregate with saturated LWFA.

346-2.5 Admixtures: Ensure admixtures are used in accordance with the manufacturer's recommendations and meeting the requirements of Section 9.2, Volume II of the Materials Manual.

346-3 Classification of Concrete.

346-3.1 General: The classifications of concrete are designated as Class I (Seal), Class I (Pavement), Class II, Class II (Bridge Deck), Class III, Class IV, Class IV (Drilled Shaft), Class V, Class VI, and Class VII. The 28-day specified minimum compressive strength, maximum water to cementitious materials ratio and target slump of each class are detailed in Table 346-3. The required air content for all classes of concrete is less than or equal to 6.0%.

For purposes of this Specification the concrete is further classified as follows:

1. Conventional Concrete: The target slump is described in Table 346-3 with a tolerance of ± 1.5 inches.
2. Increased Slump Concrete: The maximum target slump is 7 inches with a tolerance of ± 1.5 inches when a Type F, G, I or II admixture is used.
3. Slip-form Concrete: The target slump is 1.5 inches with a tolerance of ± 1.5 inches. For Class I (Pavement), meet the requirements of Section 350.
4. Flowing Concrete: Request Engineer's authorization to use flowing concrete for cast-in-place applications. The target slump is 9 inches with a tolerance of ± 1.5 inches.
5. Self-Consolidating Concrete (SCC): Request Engineer's authorization to use SCC for cast-in-place applications The minimum target slump flow is 22.5 inches with a tolerance of ± 2.5 inches.

346-3.2 Concrete Class Substitutions: The Engineer may allow the substitution of a higher class concrete in lieu of the specified class concrete when the substituted concrete mixes are included as part of the QC Plan, or for precast concrete, the Precast Concrete Producer QC Plan. The substituted higher class concrete must meet or exceed the requirements of the specified class concrete.

When the average compressive strength is less than the specified minimum compressive strength of the higher class mix design, notify the Engineer. Acceptance is based on the requirements in Table 346-3 for the specified class concrete.

346-3.3 Acceptance Requirements: The specified minimum 28-day strengths, maximum water to cementitious materials ratio (w/cm), and target slumps for each class of concrete are given in Table 346-3. For lightweight concrete, acceptance requirements also include the hardened density specified in the Contract Documents.

The calculation of the water to cementitious materials ratio (w/cm) is based on the total mass of cementitious materials including portland cement and any SCMs used in the mix.

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Table 346-3 Compressive Strength, w/cm, and Slump of Concrete Classes			
Class of Concrete	28-day Specified Minimum Compressive Strength (f'c) (psi)	Maximum Water to Cementitious Materials Ratio (pounds per pounds)	Target Slump Value (inches)
I (Seal)	3,000	0.53	8
I (Pavement) (1) (5)	3,000	0.50	1.5 or 3
II (3)	3,400	0.53	3 (2)
II (Bridge Deck)	4,500	0.44	3 (2)
III	5,000	0.44	3 (2)
IV	5,500	0.41(4)	3 (2)
IV (Drilled Shaft)	4,000	0.41	8.5
V	6,500	0.37(4)	3 (2)
VI	8,500	0.37(4)	3 (2)
VII	10,000	0.37(4)	3 (2)

Notes:
(1) Meet the requirements of Section 350.
(2) For increased slump concrete, flowing concrete, SCC and slip form concrete meet the requirements of 346-3.1.
(3) For precast three-sided culverts, box culverts, endwalls, inlets, manholes and junction boxes, the target slump value and air content will not apply. The maximum allowable slump is 6 inches, except as noted in (2). The Contractor is permitted to use concrete meeting the requirements of ASTM C478 (4,000 psi) in lieu of the specified Class II concrete for precast endwalls, inlets, manholes and junction boxes.
(4) When silica fume or metakaolin is required, the maximum water to cementitious material ratio will be 0.35. When ultrafine fly ash is used, the maximum water to cementitious material ratio will be 0.30.
(5) If 28-day strength is 2,500 or greater, concrete may be accepted if 28-day compressive strength is reached by 56 days.

346-3.4 Acceptance of concrete at 56 days: Use concrete mix designs meeting the specified compressive strength at 56 days at the Contractor's option. Submit the request to the Engineer for approval. After the Engineer's approval, notify the concrete producer to initiate the mix design approval process at least 90 days prior to the anticipated concrete placement.

346-3.5 Durability for Concrete Construction:

346-3.5.1 Minimum Cementitious Materials Content: Ensure that the produced concrete meets the minimum amount of cementitious materials content in Table 346-4.

Table 346-4 Minimum Amount of Total Cementitious Materials Content (pounds per cubic yard of concrete)			
Concrete Class	Environmental Classification		
	Extremely Aggressive	Moderately Aggressive	Slightly Aggressive
I (Seal) (1), I (Pavement) (1), and II,	470		
II (Bridge Deck), III (2), IV, IV (Drilled Shaft), V, VI and VII	600	550	510

Notes:
(1) Request the use of concrete mixes with a lower amount of total cementitious materials content at the Contractor's option. The mix design must meet the requirements of Section 9.2 Volume II of the Materials Manual.
(2) When precast three-sided culverts, box culverts, endwalls, inlets, manholes or junction boxes require a Class III concrete, minimum cementitious materials content may be reduced to 470 pounds per cubic yard.

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346-3.5.2 Chloride Content Limits: Use the following maximum allowable chloride content limits for the concrete application and/or exposure environment shown:

Table 346-5
Chloride Content Limits for Concrete Construction

Application/Exposure Environment		Maximum Allowable Chloride Content, (pounds per cubic yard of concrete)
Non-Reinforced Concrete		No Test Needed
Reinforced Concrete	Slightly Aggressive Environment	0.70
	Moderately or Extremely Aggressive Environment	0.40
Prestressed Concrete		0.40

Suspend concrete placement immediately for every mix design if chloride test results exceed the limits of Table 346-5 until corrective measures are made. Submit an Engineering Analysis Scope in accordance with 6-4 by a Specialty Engineer knowledgeable in the areas of corrosion and corrosion control, to determine if the material meets the intended service life of the structure on all concrete produced from the mix design failing chloride test results to the previous passing test results.

346-3.5.3 Surface Resistivity Test: Ensure that the concrete meets or exceeds a Sr value of 29 kΩcm at 28 days or 56 days if specified, when a highly reactive pozzolan is specified in the Contract Documents.

346-4 Special Types of Concrete.

346-4.1 Drilled Shaft Concrete: Notify the Engineer at least 48 hours before placing drilled shaft concrete. Obtain slump loss test results demonstrating that the drilled shaft concrete maintains a slump of at least 5 inches throughout the concrete elapsed time before drilled shaft concrete operations begin.

Perform the slump loss test at the anticipated ambient temperature for drilled shaft placements greater than 30 cubic yards and an elapsed time of greater than five hours.

Obtain slump loss test results from an approved laboratory or from a field demonstration. Slump loss test results for drilled shafts requiring 30 cubic yards of concrete or less and a maximum elapsed time of five hours or less may be done in a laboratory. Obtain all other slump loss test results in the field.

The concrete elapsed time is defined in Section 455. Obtain the Engineer's approval for use of slump loss test results including elapsed time before concrete placement begins.

Test each load of concrete for slump to ensure that it is within the limits of this Section. Initially cure acceptance cylinders for 48 hours before transporting them to the laboratory.

If the elapsed time during placement exceeds the slump loss test data, submit an Engineering Analysis Scope in accordance with 6-4 by a Specialty Engineer knowledgeable in concrete foundations, to determine if the shaft is structurally sound and free from voids. At the direction of the Engineer, excavate the drilled shaft for inspection. Obtain approval from the Engineer before placing any additional shafts.

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346-4.2 Mass Concrete: When the Contract Documents designate any structure as mass concrete, use a Specialty Engineer to develop and administer a Mass Concrete Control Plan (MCCP). Develop the MCCP in accordance with Section 9.4 Volume II of the Materials Manual. Provide the Specialty Engineer a list of all concrete elements identified. Use a sequential identification code for each element indicating the bridge or structure number, location and type of element, least dimension size, and environmental exposure.

Record core and differential temperatures for all structures included in the MCCP and monitor only the elements specified therein. Ensure that the concrete core temperatures do not exceed the maximum allowable temperature of 180°F and that the differential temperatures between the element core and surface do not exceed the maximum allowable temperature differential of 35°F. Submit the MCCP to the Engineer for approval at least 21 calendar days prior to the first anticipated mass concrete placement.

Do not place concrete until the proposed MCCP has been approved. Any modifications must be submitted as addenda to the original MCCP and must be approved in writing by the Engineer.

Install temperature measuring sensors and recording devices for all mass concrete elements in accordance with the MCCP. Do not add local additional insulation or external sources of heat around the surface sensors that affect the temperature readings.

Ensure that, prior to the first concrete placement of each concrete element the Specialty Engineer or approved designee personally inspects the installation of the temperature measuring devices and verifies that the temperature data acquisition equipment is properly functioning. The Specialty Engineer shall be available for immediate consultation during the monitoring period of any mass concrete element.

Use temperature data acquisition equipment to record temperature readings in accordance with the MCCP.

Within three workings days of the completion of temperature recording for each concrete element, submit the Mass Concrete Field Report in accordance with Section 9.4, Volume II of the Materials Manual.

For a group of elements, the Engineer may approve a monitoring reduction if the first element placed does not exceed either the maximum temperature or maximum temperature differential. Request written approval from the Engineer at least 14 calendar days prior to the anticipated date of the intended reduced monitoring. If approved, monitoring of the recorded temperatures is not required for the remaining elements meeting all of the following requirements:

1. All elements have the same dimensions.
2. All elements have the same concrete mix design.
3. All elements have the same insulation R value and active cooling measures (if used).
4. Ambient temperatures during concrete placement for all elements are within minus 10°F of the ambient temperature during placement of the initial element.
5. Use the same temperature control measures used for the initial monitored element and keep them in place for at least the same length of time as for the initial element.

Resume monitoring of the temperatures for all elements if directed by the Engineer.

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Instrumentation and temperature monitoring are not required for miscellaneous drilled shafts supporting sign, signal, lighting or Intelligent Transportation System (ITS) structures when the as built diameter is six feet or less, and the total cementitious materials content of the concrete mix design is less than or equal to 752 pounds per cubic yard.

Monitoring of the recorded temperatures is not required for any mass concrete substructure element meeting all of the following requirements:

1. The minimum cross-sectional as-built dimension of the element is six feet or less.
2. Insulation with an R-value of at least 2.5 must be provided for at least 72 hours following the completion of concrete placement.
3. The environmental classification of the concrete element is slightly aggressive or moderately aggressive.
4. The concrete mix design meets the mass concrete proportioning requirements of 346-2.3.
5. The total cementitious material content of the concrete mix design is less than or equal to 752 pounds per cubic yard.
6. Temperature of the concrete is 95°F or less at placement.

Implement immediate corrective action as directed by the Specialty Engineer when either the core temperature or the temperature differential of any mass concrete element exceeds its maximum allowable value. The approval of the MCCP shall be revoked.

Submit an Engineering Analysis Scope in accordance with 6-4 for approval, which addresses the structural integrity and durability of any mass concrete element that is not cast in compliance with the approved MCCP, or which exceeds the allowable core temperature or temperature differential.

Submit all analyses and test results requested by the Engineer for any noncompliant mass concrete element. Submit a revised MCCP and do not place any mass concrete elements until a revised MCCP has been approved in writing by the Engineer.

The Department will not provide compensation for additional costs or loss of time due to additional analyses, tests, or other impacts on production caused by not monitoring the recorded temperatures.

346-4.3 Flowing Concrete and Self-Consolidating Concrete (SCC): Use Flowing concrete or SCC when shown in the Contract Documents or to facilitate concrete placement in structures of complex geometric shape or highly reinforcement.

Perform a field demonstration mockup using an approved mix design. Submit the mockup design to the Engineer for approval including the location of the sawcut.

Cast a partial or full-scale mockup(s) and demonstrate through the successful production the ability to produce and place flowing concrete or SCC.

The design, production, and evaluation product must meet the following requirements:

1. Use the proposed mix design(s).
2. Produce the mockup(s) at the jobsite, using the intended placement and curing methods, such as the use of ready-mix trucks, pumps, chutes, hopper, consolidation equipment, etc. The mockup shall contain reinforcing steel, mass concrete cooling pipes if required during construction, and other embedded items typical of the cast element.
3. Meet the requirements of the plastic properties including the cutoff time.

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4. Meet the hardened properties and durability requirement when specified in the Contract Documents.

5. Concrete will be produced in the proposed concrete plant(s).

6. Concrete plant(s) representative(s) must be present during mockup demonstration.

7. Notify the Engineer at least 7 days prior to mockup production.

8. If the production of the structural element that will be represented in the mockup requires concrete from multiple concrete plants, the concrete from each plant must be represented in the mockup.

9. Sawcut the mockup's entire cross-section. Inspect and report for voids, honeycombing, and rock pockets, mix segregation, and other inclusions developed during placement of the concrete.

10. Determine the Coarse Aggregate Index of concrete in accordance with FM 5-617.

11. Complete the demonstration of a successful mockup prior to the beginning of concrete placement operations.

Based on the inspection results of the field demonstration mockup, the acceptance of using flowing concrete or SCC in the structural element or section of the element is at the Engineer's discretion.

The required mockup demonstration may be omitted at the Contractor's request. Submit documentation indicating successful experience of furnishing and placing flowing concrete or SCC on similar Department projects. Such documentation must list projects by date of completion, name or project reference number, structural elements or type of unit placed, quantity of concrete furnished, names and experience of personnel, and contact information for verification.

346-4.4 Lightweight Concrete: Submit the fresh and hardened concrete density for mix design approval. The hardened density is the equilibrium density in ASTM C567. Ensure that the hardened density of the mix design is within ± 2 lb/ft^3 of the hardened density specified in the Contract Documents.

During production, the freshly mixed concrete density must be within ± 3 lb/ft^3 of the approved mix design fresh density.

346-5 Sampling and Testing Methods.

Perform concrete sampling and testing in accordance with the following methods:

Table 346-7
Concrete Sampling and Testing Methods

Description	Method
Slump of Hydraulic Cement Concrete	ASTM C143
Air Content of Freshly Mixed Concrete by the Pressure Method (1)	ASTM C231
Air Content of Freshly Mixed Concrete by the Volumetric Method (1)	ASTM C173
Making and Curing Test Specimens in the Field (2)	ASTM C31
Compressive Strength of Cylindrical Concrete Specimens(3)	ASTM C39
Obtaining and Testing Drilled Core and Sawed Beams of Concrete	ASTM C42
Density of Structural Lightweight Concrete	ASTM C567
Initial Sampling of Concrete from Revolving Drum Truck Mixers or Agitators	FM 5-501

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Table 346-7 Concrete Sampling and Testing Methods	
Description	Method
Low Levels of Chloride in Concrete and Raw Materials	FM 5-516
Density (Unit Weight), Yield and Air Content (Gravimetric) of Concrete	ASTM C138
Temperature of Freshly Mixed Portland Cement Concrete	ASTM C1064
Sampling Freshly Mixed Concrete (4)	ASTM C172
Static Segregation of Self-Consolidating Concrete using Column Techniques	ASTM C1610
Slump Flow of Self-Consolidating Concrete	ASTM C1611
Relative Viscosity of Self-Consolidating Concrete	ASTM C1611
Visual Stability Index of Self-Consolidating Concrete	ASTM C1611
Passing Ability of Self-Consolidating Concrete by J-Ring	ASTM C1621
Rapid Assessment of Static Segregation Resistance of Self-Consolidating Concrete Using Penetration Test	ASTM C1712
Aggregate Distribution of Hardened Self-Consolidating Concrete	FM 5-617
Hardened Visual Stability Index of Self-Consolidating Concrete	AASHTO R 81
Fabricating Test Specimens with Self-Consolidating Concrete	ASTM C1758
Concrete Resistivity as an Electrical Indicator of its Permeability	AASHTO T 358
(1) The Department will use the same type of meter for Verification testing as used for QC testing. When using pressure type meters, use an aggregate correction factor determined by the concrete producer for each mix design to be tested. Record and certify test results for correction factors for each type of aggregate at the concrete production facility. (2) Provide curing facilities that have the capacity to store all QC, Verification, and Resolution cylinders simultaneously for the initial curing. Cylinders will be delivered to the testing laboratory in their molds. The laboratory will remove the specimens from the molds and begin final curing. (3) Lightweight concrete also includes hardened specimen density. The ASTM C567 may be used in lieu of ASTM C39 to verify the density. (4) Take the test sample from the middle portion of the batch in lieu of collecting and compositing samples from two or more portions, as described in ASTM C172.	

346-6 Quality Control.

346-6.1 General: Perform QC activities to ensure materials, methods, techniques, personnel, procedures and processes utilized during production meet the specified requirements. For precast/prestressed concrete operations, ensure that the QC testing is performed by the producer.

Accept the responsibility for QC inspections on all phases of work. Ensure all materials and workmanship incorporated into the project meet the requirements of the Contract Documents.

346-6.2 Concrete Mix Design: Provide concrete that has been produced in accordance with a Department approved mix design, in a uniform mass free from balls and lumps.

For slump target values in excess of 6 inches, including flowing concrete and SCC, utilize a grate over the conveyance equipment to capture any lumps or balls that may be present in the mix. The grate must cover the entire opening of the conveyance equipment and have an opening that is a maximum of 2-1/2 inches in any one direction. Remove the lumps and balls from the grate and discard them. Discharge the concrete in a manner satisfactory to the Engineer. Perform demonstration batches to ensure complete and thorough placements in complex elements, when requested by the Engineer.

Do not place concretes of different compositions such that the plastic concretes may combine, except where the Plans require concrete with a surface resistivity value of

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29 kΩcm or below and one with higher than 29 kΩ-cm values in a continuous placement. Produce these concretes using separate mix designs. For example, designate the mix with calcium nitrite as the original mix and the mix without calcium nitrite as the redesigned mix. Ensure that both mixes contain the same cement, coal ash or slag, coarse and fine aggregates and admixtures. Submit both mixes for approval as separate mix designs, both meeting all requirements of this Section. Ensure that the redesigned mix exhibits plastic and hardened qualities which are additionally approved by the Engineer as suitable for placement with the original mix. The Engineer will approve the redesigned mix for commingling with the original mix and for a specific project application only. Alternately, place a construction joint at the location of the change in concretes as approved by the Engineer.

346-6.3 Delivery Certification: Ensure that an electronic delivery ticket is furnished with each batch of concrete before unloading at the placement site. The delivery ticket may be proprietary software or in the form of an electronic spreadsheet, but shall be printed. Ensure that the materials and quantities incorporated into the batch of concrete are printed on the delivery ticket. Include the following information on the delivery ticket:

1. Arrival time at jobsite,
2. Time that concrete mix has been completely discharged,
3. Number of revolutions upon arrival at the jobsite,
4. Total gallons of water added at the jobsite,
5. Additional mixing revolutions when water is added,
6. Total number of revolutions.

Items (3) through (6) do not apply to non-agitating concrete transporting vehicles.

Ensure the batcher responsible for production of the batch of concrete signs the delivery ticket, certifying the batch of concrete was produced in accordance with the Contract Documents.

Sign the delivery ticket certifying that the design mix maximum specified water to cementitious materials ratio was not exceeded due to any jobsite adjustments to the batch of concrete, and that the batch of concrete was delivered and placed in accordance with the Contract Documents.

346-6.4 Plastic Property Tolerances: Reject concrete with slump or air content that does not fall within the specified tolerances, except as noted below, and immediately notify the concrete production facility that an adjustment of the concrete mixture is required.

If a load does not fall within the tolerances, test each subsequent load and the first adjusted load. If failing concrete is not rejected or adjustments are not implemented, the Engineer may reject the concrete and terminate further production until the corrections are implemented.

At the Contractor's risk, water may be added at the placement site immediately after completion of the initial slump or slump flow test, either to correct a low slump or slump flow, or to increase the concrete workability, provided the addition of water does not exceed the water to cementitious materials ratio as defined by the mix design.

After adding water at the placement site depending on the type of concrete, perform the following tests:

1. Except for SCC, perform a slump test to confirm the concrete is within the slump tolerance range. If the slump is outside the tolerance range, reject the load.
2. For SCC, perform a slump flow and rapid assessment of static segregation resistance. Do not reject SCC exceeding the high-end slump flow tolerance if it has passed the rapid assessment of static segregation resistance test. Reject the load if the slump flow

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is below the low-end tolerance. As an exception, the Engineer may accept the concrete if the rejection compromises the structural integrity of the element or produces other detrimental effects. Minimum vibration may be needed in accordance with Section 400.

If an adjustment is made at the concrete production facility, perform a slump test on the next load to ensure the concrete is within the slump tolerance ranges.

Except for SCC, do not place concrete represented by slump test results outside of the tolerance range. Include water missing from the water storage tanks upon arrival at the project site in the jobsite water added.

Do not allow concrete to remain in a transporting vehicle to reduce slump.

346-7 Mixing and Delivering Concrete.

346-7.1 General Requirements: Operate all concrete mixers at speeds and volumes per the manufacturer's design or recommendation as stipulated on the mixer rating plate.

346-7.2 Transit Truck Mixing: Produce a completely uniform mixed concrete in a truck mixer for a minimum of 70 revolutions at the mixing speed designated by the truck manufacturer.

` Prior to starting the discharge of the concrete at the jobsite, when water is added, record the added quantity and mix the concrete 30 additional drum mixing revolutions. Do not make more than two mix adjustments. Seek approval from the Engineer prior to using a central mixer and depositing the batch into a truck mixer.

346-7.2.1 Transit Time: Ensure compliance with Table 346-8 between the initial introduction of water into the mix and completely discharging all the concrete from the truck. Reject concrete exceeding the maximum transit time. The Engineer may approve an extension of the transit time which will be identified on the approved mix design.

Table 346-8	
Maximum Allowable Transit Time	
Non-Agitator Trucks	Agitator Trucks
45 minutes	60 minutes
75 minutes (1)	90 minutes (1)
Note: (1) When a water-reducing and retarding admixture (Type D, Type G, or Type II) is used.	

346-7.2.2 Placement Time: All the concrete in a load must be in its final placement position a maximum of 15 minutes after the transit time or cutoff time has expired unless a time extension is approved by the Engineer. As an exception, the Engineer may accept concrete that exceeds the transit time or cutoff time if the load passes the slump or slump flow tests. Place concrete in continuous manner in accordance with Section 400.

For Class IV (Drilled Shaft) mixes, placement time may be extended provided the slump loss time of the first concrete placed is not exceeded throughout the elapsed time.

The Engineer may perform Independent Verification (IV) testing to verify the plastic and hardened properties of the concrete when a time extension is granted.

346-7.3 On-site Batching and Mixing: Use a mixer of sufficient capacity to prevent delays that may be detrimental to the quality of the work. Ensure that the accuracy of batching equipment is in accordance with requirements of this Section.

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346-7.4 Concreting in Cold Weather: Do not mix or place concrete when the air temperature is below 40ºF. Protect the fresh concrete from freezing in accordance with Section 400. The requirements of concreting in cold weather are not applicable to precast concrete mixing and placement operations occurring in a temperature controlled environment.

346-7.5 Concreting in Hot Weather: Hot weather concreting is defined as the production, placing and curing of concrete when the concrete temperature at placing exceeds 85ºF but is 100ºF or less.

Unless the specified hot weather concreting measures are in effect, reject concrete exceeding 85ºF at the time of placement. Concrete pavement slab replacement mix designs are exempt from this requirement. Regardless of special measures taken, reject concrete exceeding 100ºF. Predict the concrete temperatures at placement time and implement hot weather measures to avoid production shutdown.

346-7.6 Sample Location: Obtain acceptance samples from the point of final placement.

Where concrete buckets are used to discharge concrete directly to the point of final placement or into the hopper of a tremie pipe, samples will be obtained from the discharge of the bucket. When the concrete is discharged directly from the mixer into the bucket and the bucket is discharged within 20 minutes, samples may be obtained from the discharge of the mixer.

Where conveyor belts, troughs, pumps, or chutes are used to transport concrete directly to the point of final placement or into the hopper of a tremie pipe, samples will be obtained from the discharge end of the entire conveyor belt, trough, pump, or chute system.

Where concrete is placed in a drilled shaft or other element using a tremie pipe and a concrete pump, samples will be obtained from the discharge of the pump line at the location of the tremie hopper.

For all other placement methods, prior to each placement, obtain Department approval for sampling at the discharge of the mixer in lieu of sampling at the point of final placement. Submit the sampling correlation procedure to the Engineer for approval prior to the placement of the concrete. Once the comparative sampling correlation is approved by the Engineer, apply this correlation to the plastic properties tolerances for samples obtained from the discharge of mixer.

Where a concrete pump is used to deposit concrete directly into a drilled shaft which is a wet excavation without the use of a tremie, or other applications as approved by the Engineer, ensure the discharge end of the pump line remains immersed in the concrete at all times after starting concrete placement.

346-8 Plastic Concrete Sampling and Testing.

QC tests include air content, temperature, slump, and preparing cylinders for testing at later dates with the following exceptions:
with the following exceptions:

For Class I (Pavement), the air content testing is not required.

For Lightweight concrete, tests also include the plastic density (unit weight).

For SCC, QC tests also include slump flow in lieu of slump, visual stability index, and rapid assessment of static segregation.

In addition, calculate the water to cementitious materials ratio in accordance with FM 5-501 for compliance to the approved mix design.

Ensure that each truck has a rating plate and a valid mixer identification card issued by the Department. Ensure that the revolution counter on the mixer is working properly, and

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calibration of the water dispenser has been performed within the last twelve months. Reject any concrete batches that are delivered in trucks that do not have mixer identification cards. Remove the mixer identification card when a truck mixer is discovered to be in noncompliance and the mixer deficiencies cannot be repaired immediately. When the mixer identification card is removed for noncompliance, make note of the deficiency or deficiencies found, and forward the card to the District Materials and Research Engineer who has Producer QC Plan acceptance authority.

Perform plastic concrete tests on the initial delivery from each plant of each concrete design mix each day. Ensure QC technicians meeting the requirements of Section 105 are present and performing tests throughout the placement operation. Ensure a technician is present and performing tests throughout the placement operation at each placement site. If a project has multiple concrete placements at the same time, identify the technicians in the QC Plan to ensure minimum sampling and testing frequencies are met. Ensure that the equipment used for delivery, placement and finishing meets the requirements of this Specification.

When a truck designated for QC testing arrives at the discharge site, a subsequent truck may also discharge once a representative sample has been collected from the QC truck and while awaiting the results of QC testing. Reject non-complying loads at the jobsite. Ensure that corrections are made on subsequent loads. Immediately cease concrete discharge of all trucks if the QC truck has failing test. Perform plastic properties tests of concrete on all trucks prior to the first corrected truck and the corrected truck. When more than one truck is discharging into a pump simultaneously, only the truck designated for QC testing may discharge into the pump to obtain a representative sample of concrete from the QC truck only.

Furnish sufficient concrete of each design mix as required by the Engineer for verification (VT) testing. When the Engineer's VT test results do not compare with the QC plastic properties test results, within the limits defined by the Independent Assurance (IA) checklist comparison criteria, located in Materials Manual Chapter 5, disposition of the concrete will be at the option of the Contractor.

On concrete placements consisting of only one load of concrete, perform initial sampling and testing in accordance with this Section. The acceptance sample and plastic properties tests may be taken from the initial portion of the load.

If any of the QC plastic properties tests fail, reject the remainder of that load, and any other loads that have begun discharging, terminate the LOT and notify the Engineer. Make cylinders representing that LOT from the same sample of concrete.

Following termination of a LOT, obtain samples from a new load, and perform plastic properties tests until the water to cementitious materials ratio, air content, temperature and slump comply with the Specification requirements. Initiate a new LOT once the testing indicates compliance with Specification requirements.

Suspend production when any five loads in two days of production of the same design mix are outside the specified tolerances. Increase the frequency of QC testing to one per load to bring the concrete within allowable tolerances. After production resumes, obtain the Engineer's approval before returning to the normal frequency of QC testing.

If concrete placement stops for more than 90 minutes, perform initial plastic properties testing on the next batch and continue the LOT. Cylinders cast for that LOT will represent the entire LOT.

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When the Department performs Independent Verification (IV), the Contractor may perform the same tests on the concrete at the same time. The Department will compare results based on the Independent Assurance (IA) Checklist tolerances.

346-9 Acceptance Sampling and Testing.

346-9.1 General: Perform plastic properties tests in accordance with 346-8 and cast a set of three QC cylinders, for all structural concrete incorporated into the project. Take these acceptance samples randomly as determined by a random number generator acceptable to the Department. The Department will independently perform VT plastic properties tests and cast a set of VT cylinders. The VT cylinders will be the same size cylinder selected by the Contractor, from a separate sample from the same load of concrete as the Contractor's QC sample.

For each set of QC cylinders verified by the Department, cast two additional cylinders from the same sample, and identify them as the quality control resolution (QR) test cylinders. The Department will also cast two additional verification resolution (VR) test cylinders from each VT sample. All cylinders will be clearly identified as outlined in the Sample/LOT Numbering System instructions located on the State Materials Office website. Deliver the QC samples, including the QR cylinders to the final curing facility in accordance with ASTM C31. Concurrently, the Department will deliver the VT samples, including the VR cylinders, to their final curing facility.

Test the QC laboratory cured samples for compressive strength at the age of 28 days, in a laboratory meeting and maintaining at all times the qualification requirements listed in Section 105.

Ensure the QC testing laboratory input the compressive strength test results into the Department's Materials Acceptance and Certification (MAC) system within 24 hours after testing. Notify the Engineer when results cannot be inputted into MAC.

The Department will compare the VT sample compressive strength test results with the corresponding QC sample test results.

346-9.2 Sampling Frequency: As a minimum, sample and test concrete of each mix design for water to cementitious materials ratio, air content, temperature, slump and compressive strength once per LOT as defined by Table 346-9. The Engineer will randomly verify one of every four consecutive LOTs of each mix design based on a random number generator. The Department may perform Independent Verification (IV) testing to verify compliance with specification requirements. All QC activities, calculations, and inspections will be randomly confirmed by the Department.

Table 346-9
Sampling Frequency

Class Concrete [(1)]	LOT Size
I (Seal)	Each seal placement
I (Pavement)	According to Section 350
II, II (Bridge Deck), III, IV, V, VI, VII	50 cubic yards, or one day's production, whichever is less
IV (Drilled Shaft)	50 cubic yards, or one day's production, whichever is less [(2)]

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Table 346-9 Sampling Frequency	
Class Concrete [1]	LOT Size
I (Seal)	Each seal placement
(1) For any class of concrete used for roadway concrete barrier, the lot size is defined as 100 cubic yards, or one day's production, whichever is less. (2) Start a new LOT when there is a gap of more than two hours between the end of one drilled shaft placement and the beginning of the next drilled shaft placement.	

346-9.2.1 Reduced Frequency for Acceptance Tests: Except for Class I (Pavement), the LOT size may represent 100 cubic yards when produced with the same mix design at the same concrete production facility for the same prime Contractor and subcontractor on a given Contract. As an exception, the requirements for the precast/prestressed production facility will only include the same mix design at the same concrete production facility. The reduced testing frequency of Class I (Pavement) is described in the Section 350.

Submit strength test results indicating that the two following criteria are met:

1. The average of the acceptance compressive strengths is equal to or greater than the specified minimum compressive strength (f′c) plus 2.33 standard deviations minus:

   a. 500 psi, if f′c is 5,000 psi or less.

   b. 0.10 f′c, if f′c is greater than 5,000 psi.

2. Every average of three consecutive strength test equals or exceeds the f′c plus 1.34 standard deviations.

Base calculations on a minimum of ten consecutive strength test results for a Class IV or higher; or a minimum of five consecutive strength results for a Class III or lower.

The average of the consecutive compressive strength test results, based on the class of concrete, can be established using historical data from a previous Department project. The tests from the previous Department project must be within the last calendar year or may also be established by a succession of samples on the current project. Only one sample can be taken from each LOT. Test data must be from a laboratory meeting the requirements of Section 105. Obtain Department approval before beginning reduced frequency LOTs.

If at any time a strength test is not verified or the average strength of the previous ten or five consecutive samples based on the class of concrete from the same mix design and the same production facility does not conform to the above conditions, return to the frequency represented by the LOT as defined in Table 346-9. Notify the Engineer that the initial frequency is reinstated. In order to reinitiate reduced frequency, submit a new set of strength test results.

346-9.3 Strength Test Definition: The strength test of a LOT is defined as the average compressive strength tests of at least two companion cylinders cast from the same sample of concrete and tested at the same age.

346-9.4 Acceptance of Concrete: The Engineer will accept the concrete of a given LOT when the compressive strength test results are verified and meets the minimum specified compressive strength in Table 346-3. Ensure that the hardened concrete strength test results are obtained in accordance with 346-9.3.

The process of concrete compressive strength verification and acceptance consists of the following steps:

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1. Verification of QC and VT data.
2. Resolution of QC and VT data if needed.
3. Structural Adequacy determination.

Do not discard a cylinder strength test result based on low strength (strength below the specified minimum strength as per the provisions of this Section).

When one of the three QC cylinders from a LOT is lost, missing, damaged or destroyed, determination of compressive strength will be made by averaging the remaining two cylinders. If more than one QC cylinder from a LOT is lost, missing, damaged or destroyed, the Contractor will core the structure at no additional expense to the Department to determine the compressive strength. Prior to coring, obtain Engineer's approval for coring the structure and its proposed coring location. Acceptance of LOT may be based on VT data at the discretion of the Engineer.

For each QC and each QR cylinder that is lost, missing, damaged or destroyed, payment for that LOT will be reduced by $750.00 per 1,000 psi of the specified design strength [Example: loss of two Class IV (Drill Shaft) QC cylinders that has no VT data will require the element to be cored and a pay reduction will be assessed (4,000 psi / 1,000 psi) x $750 x 2 = $6,000]. This reduction will be in addition to any pay adjustment for low strength.

346-9.4.1 Small Quantities of Concrete: When a project has a total plan quantity of less than 50 cubic yards, that concrete will be accepted based on the satisfactory compressive strength of the QC cylinders. Submit certification to the Engineer that the concrete was batched and placed in accordance with the Contract Documents. Submit a QC Plan for the concrete placement operation in accordance with Section 105. The Engineer may perform IV testing as identified in 346-9 and evaluate the concrete in accordance with 346-9.7.

346-9.5 Verification: The results of properly conducted test by QC and VT laboratories on specimens prepared from the same sample of concrete are not to differ by more than 14%.

$$\text{Difference (\%)} = \text{ABS}\left(\frac{\text{QC}-\text{VT}}{\text{QC}}\right)100$$

Where:

Difference (%) is the absolute percentage difference between QC and VT average compressive strength.

The procedure consists of verifying if the QC and VT compressive strengths data meet the established comparison criteria:

1. When the difference between the average compressive strength of QC and the average compressive strength of VT is less than or equal to 14%, the QC test results are upheld and verified. The Engineer will accept at full pay only LOTs of concrete represented by plastic property results which meet the requirements of the approved mix design and strength test results which equal or exceed the respective specified minimum strength.
2. When the difference between the average compressive strength of QC and the average compressive strength of VT data exceeds 14%, the compressive strength results are not verified and the Engineer will initiate the resolution procedure.

Maintain the QR and VR cylinders for a minimum of 30 days following the testing date of the specified strength.

346-9.6 Resolution: The Engineer will perform the resolution process to identify the reliability of the compressive strength results when the difference between the average compressive strength of QC and the average compressive strength of VT data exceeds 14% as described in 346-9.5(2).

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The Engineer will estimate the 28-day strengths (VR_{28} and QR_{28}) for the VR and QR cylinders using the following equation:

$$\text{Estimated 28-Day Compressive Strength (psi)} = \left(\frac{\text{Average Strength at (t) days}}{\text{-17.8 + 46.3[ln (t)] } - \text{ 3.3[ln (t)]}^2}\right)100$$

Where:

(t) is the elapsed number of days from concrete placement to the resolution cylinders testing.

ln (t) is the natural logarithm of (t).

The Engineer will compare:

1. The VT sample results with the VR_{28} cylinders results.
2. The QC sample results with the QR_{28} cylinders results.

Comparison results must not be greater than 17.5%. Core samples of the hardened concrete may be required.

$$V_D\ (\%) = \text{ABS}\left(\frac{VT - VR_{28}}{VT}\right)100$$

$$Q_D\ (\%) = \text{ABS}\left(\frac{QC - QR_{28}}{QC}\right)100$$

Where:

V_D (%) is the absolute percentage difference between VT and VR_{28}.

Q_D (%) is the absolute percentage difference between QC and QR_{28}.

Perform the resolution with the concrete compressive strength data at 56 days in lieu of the 28 days when the acceptance of concrete is at 56 days.

The resolution procedure will use the above equations. The Engineer will determine through the resolution procedure whether the QC strength test results or the VT strength test are deemed to be the most accurate, LOTs will then be considered to be verified.

The Engineer will inform the QC and VT laboratories within three calendar days of the acceptance compressive strength test to transport their QR and VR cylinders to the resolution laboratory. The QC and VT laboratories will transport their own hold cylinders to the resolution testing laboratory within three calendar days after the Engineer notifies the Contractor that a resolution procedure is required. In addition, the Engineer will ensure that the QR and VR cylinders are tested within 14 calendar days of the acceptance strength tests.

The Engineer will determine the most accurate strength test result to represent the four or fewer consecutive LOTs as follows:

1. When both results meet the established comparison criteria, both are deemed accurate and the QC strength will represent the LOTs. The Department will pay for cost of the resolution testing.
2. When only the QC result is within the established comparison criteria, the QC strength is deemed as most accurate and will represent the LOTs. The Department will pay for the cost of the resolution testing.
3. When only the VT result is within the established comparison criteria, the VT strength is deemed as most accurate and will represent the LOTs. The Department will assess a $1,000 pay reduction for the cost of the Resolution Investigation.
4. When both results are outside the established comparison criteria, the Engineer, with input from the DMO, will determine if any Department IA evaluations are

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required and which test results are most accurate. The Department will pay for the cost of the resolution testing.

When the Engineer cannot determine which strength test results are the most accurate, the concrete represented by the four consecutive LOTs will be evaluated based on the QC data.

The results of the resolution procedure will be forwarded to the Contractor within five working days after completion of the investigation.

346-9.7 Structural Adequacy: The Engineer will evaluate the structural adequacy for verified concrete that does not meet the minimum specified compressive strength of Table 346-3.

For structural adequacy, with standard molded and cured compressive strength cylinders, the compressive strength of concrete is satisfactory provided that the two following criteria are met:

1. The average compressive strength does not fall below the specified minimum compressive strength by more than:

a. 500 psi if the specified minimum compressive strength is equal to or less than 5,000 psi.

b. 10% of the specified minimum compressive strength if the specified minimum compressive strength is greater than 5,000 psi.

2. The average compressive strength with the previous two LOTs is equal to or exceeds the specified minimum compressive strength. This condition only applies if there are two or more previous LOTs to calculate the average.

The Engineer will consider the concrete for a given LOT as structurally adequate and coring will not be allowed when a concrete compressive strength test result falls below the specified minimum strength but has met the above conditions.

346-9.7.1 Lightweight concrete: The Engineer may require an Engineering Analysis Scope in accordance with 6-4 to establish structural and durability adequacy when the lightweight concrete plastic density (unit weight) is outside of the specified tolerances.

346-10 Investigation of Low Compressive Strength Concrete.

When a verified concrete compressive strength test result falls below the specified minimum strength, and does not meet the structural adequacy described in 346-9.7, perform one of the following options:

1. Submit an Engineering Analysis Scope in accordance with 6-4 to establish structural and durability adequacy. When the scope is approved by the Engineer, submit an Engineering Analysis Report (EAR) in accordance with 6-4 that includes a full structural analysis. If the results of the structural analysis indicate adequate strength to serve its intended purpose with adequate durability, and is approved by the Engineer, the Contractor may leave the concrete in place subject to the requirements of 346-11, otherwise, remove and replace the LOT of concrete in question at no additional expense to the Department.

2. At the Engineer's discretion, obtain drilled core samples as specified in this Section to determine the in-place strength of the LOT of concrete in question, at no additional expense to the Department. The Engineer will determine whether to allow coring of the in-place concrete or require an engineering analysis based on the compressive strength of the test cylinders.

346-10.1 Coring for Determination of Structural Adequacy: Core strength test results obtained from the structure will be accepted by both the Contractor and the Department as the in-place strength of the LOT of concrete in question. The core strength test results will be used in

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lieu of the cylinder strength test results for determination of structural adequacy. The Department will calculate the strength value to be the average of the compressive strengths of the three individual cores. This will be accepted as the actual measured value.

Obtain and test the cores in accordance with ASTM C42.The Engineer will select the size and location of the drilled cores so that the structure is not impaired and does not sustain permanent damage after repairing the core holes. Obtain the Engineer's written approval before taking any concrete core sample. Notify the Engineer 48 hours prior to taking core samples.

Sample three undamaged cores taken from the same approximate location where the questionable concrete is represented by the low strength concrete test cylinders. Repair core holes after samples are taken with a product in compliance with Section 930 or 934 and meeting the approval of the Engineer. Report the test results to the Engineer within two calendar days of testing the core samples.

The Engineer, with input from the DMO, will consider the concrete as structurally adequate, in the area represented by core tests at the actual test age, if the average compressive strength of cores does not fall below the specified minimum compressive strength (f'c) by more than:

a. 500 psi when the f'c is equal to or less than 5,000 psi.
b. 10% of the f'c when the f'c is greater than 5,000 psi.

The Engineer may also require the Contractor to perform additional testing as necessary to determine structural adequacy of the concrete.

346-11 Pay Adjustments for Low Compressive Strength Concrete.

346-11.1 General: For any LOT of concrete failing to meet the f'c as defined in 346-3, 346-9, and satisfactorily meeting all other requirements of the Contract Documents, including structural adequacy, the Engineer will individually reduce the price of each low strength LOT in accordance with this Section.

346-11.2 Basis for Pay Adjustments: The Engineer will determine payment reductions based on the 28-day compressive strength, represented by either acceptance compressive strength or correlated cores strength test results based on the following criteria:

1. When the acceptance compressive strength test result falls below the specified minimum compressive strength, but no more than the limits established in 346-9.7 below the specified minimum strength, do not core hardened concrete for determining pay adjustments. Use the acceptance compressive strength test results.

2. When the acceptance compressive strength test result falls below the specified minimum compressive strength by more than the limits established in 346-9.7, the structure may be cored for determination of structural adequacy as directed by the Engineer. Use the result of the 28-day correlated core compressive strength or the acceptance compressive strength test, whichever is less.

A price adjustment will be applied to the certified invoice price the Contractor paid for the concrete or the precast product.

The Engineer will relate the strength at the actual test age to the 28-day strength for the design mix represented by the cores using appropriate strength time correlation equations.

In precast concrete operations, excluding prestressed concrete, ensure that the producer submits acceptable core sample test results to the Engineer. The producer may elect to use the products in accordance with this Section. Otherwise, replace the concrete in question at no additional cost to the Department. For prestressed concrete, core sample testing is not allowed

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for pay adjustment. The results of the cylinder strength tests will be used to determine material acceptance and pay adjustment.

346-11.3 Calculating Pay Adjustments: The Engineer will determine payment reductions for low strength concrete accepted by the Department. The 28-day strength is represented by either cylinders or correlated cores strength test results in accordance with 346-11.2.

Reduction in Pay is equal to the reduction in percentage of concrete compressive strength below the specified minimum strength:

$$\text{Reduction in Pay (\%)} = \left(\frac{\text{f'c} - \text{28 day Strength}}{\text{f'c}}\right) 100$$

For the elements that payments are based on the per foot basis, the Engineer will adjust the price reduction from cubic yards basis to per foot basis, determine the total linear feet of the elements that are affected by low strength concrete samples and apply the adjusted price reduction accordingly.

Use the concrete compressive strength data at 56 days in lieu of the 28 days when the acceptance of concrete is at 56 days.

For 28-day Class I pavement concrete, if the 56-day strength meets or exceeds the 28-day strength requirement, no reduction in pay will be made. If the 56-day strength is less than the 28-day strength requirement, but is at least within 500 psi of the 28-day strength requirement, reduction in pay is equal to the reduction in percentage of concrete compressive strength below the specified minimum strength:

$$\text{Reduction in Pay (\%)} = \left(\frac{\text{f'c} - \text{56 day Strength}}{\text{f'c}}\right) 100$$

346-12 Pay Reduction for Plastic Properties.

A rejected load in accordance with 346-6.4 is defined as the entire quantity of concrete contained within a single ready-mix truck or other single delivery vehicle regardless of what percentage of the load was placed. If concrete fails a plastic properties test and is thereby a rejected load but its placement continues after completion of a plastic properties test having a failing result, payment for the concrete will be reduced.

The pay reduction for cast-in-place concrete will be twice the certified invoice price per cubic yard of the quantity of concrete in the rejected load.

The pay reduction for placing a rejected load of concrete into a precast product will be applied to that percentage of the precast product that is composed of the concrete in the rejected load. The percentage will be converted to a reduction factor which is a numerical value greater than zero but not greater than one. The precast product payment reduction will be twice the Contractor's billed price from the producer for the precast product multiplied by the reduction factor.

If the Engineer authorizes placement of the concrete, even though plastic properties require rejection, there will be no pay reduction based on plastic properties failures; however, any other pay reductions will apply.

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SECTION 347
PORTLAND CEMENT CONCRETE - CLASS NS

347-1 Description.

The requirements of this Section are applicable to concrete designated as nonstructural portland cement concrete, (Class NS) hereinafter referred to as concrete. Use concrete composed of a mixture of portland or blended cement, aggregates, water; and where specified chemical admixtures, or supplementary cementitious materials. Deliver concrete to placement site in a freshly mixed, unhardened state. Ensure the concrete is placed and cured in a manner to ensure that the strength and durability of the concrete is maintained.

347-2 Materials.

347-2.1 General: Ensure all materials used in concrete are free from detrimental matter and deleterious reaction.

Meet the following requirements:

Portland Cement..... Section 921 or ASTM C150
Blended Cement..... Section 921 or ASTM C595
Coarse Aggregate*..... Section 901 or ASTM C33
Fine Aggregate*..... Section 902 or ASTM C33
Water..... Section 923 or ASTM C1602
Admixtures for Concrete*.....Section 924
.....or ASTM C494 and ASTM C260
Supplementary Cementitious Materials..Section 929
.....or ASTM C618 and ASTM C989

* Recycled Asphalt Pavement (RAP) may replace up to 20% of the total aggregate in the design mix. Use RAP from a Department approved stockpile.

347-3 Production, Mixing and Delivery.

347-3.1 Concrete Production Requirements: Obtain concrete from a plant that is currently on the Department's Nonstructural Concrete Production Facility Listing. Producers seeking inclusion on the list must contact the local District Materials Office for approval.

When Volumetric Mixers are used, deliver concrete in accordance with the Volumetric Mixer Standards of the Volumetric Mixer Manufacturers Bureau (VMMB) VMMB 100-01.

Substitution of structural concrete in lieu of non-structural concrete may be used if approved by the Engineer. If structural concrete is used in lieu of non-structural concrete, obtain the concrete from a production facility meeting the requirements of Section 346. Acceptance is based on the requirements of Section 347.

The Engineer may disqualify any concrete production facility for non-compliance with Specification requirements.

347-3.2 Delivery: The maximum allowable mixing, agitation, and placement time of concrete is 120 minutes.

347-3.3 Small Quantities of Concrete: With approval of the Engineer, small quantities of concrete, less than 3 cubic yards placed in one day and less than 0.5 cubic yards placed in a single placement may be accepted using a pre-bagged mixture.

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347-4 Certification and Acceptance.

347-4.1 General: Furnish a delivery ticket with each batch of concrete before discharging concrete at the placement site. Ensure the delivery ticket includes material quantities incorporated into the batch, sources of materials, batch adjustments, batch size, time loaded, time discharged, and the allowable jobsite water addition.

Ensure the batcher responsible for producing the concrete signs the delivery ticket, certifying that the batch was produced in accordance with the Contract Documents.

Record water added at the jobsite. Sign the delivery ticket certifying that the concrete was placed in accordance with the Contract Documents.

Acceptance by the Department will be by certification on the delivery ticket signed by the batcher and the Contractor. Certify that the concrete meets a minimum compressive strength of 2,500 psi at 28 days. The Engineer may verify the strength of the concrete.

347-4.2 Remedial Action: Delineate, remove to the full depth and width, and replace, at no cost to the Department, concrete that has:

1. Any cracking greater than 1/4 inch in vertical displacement.

2. Any spalling or flaking off of the surface layer that exposes the rough, pitted aggregate surface in excess of 10 square inches.

3.Any intersecting cracks visible in the hardened concrete (regardless of size) in sidewalk, ditch pavement, slope pavement, traffic separator, or curb and gutter.

4. Any uncontrolled cracks that appear during the life of the Contract unacceptable to the Engineer.

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SECTION 350
CEMENT CONCRETE PAVEMENT

350-1 Description.

Construct Portland cement concrete pavement in one course, on a prepared subgrade or base. Use either the fixed-form or the slip-form method of construction. When reinforced cement concrete pavement is specified or required, use concrete reinforced with steel bars or welded wire reinforcement, in accordance with details shown in the Plans. The Engineer may require a demonstration of equipment and paving operations.

If any uncontrolled cracks appear during the life of the Contract, remove and replace the cracked concrete at no expense to the Department. Investigate and implement immediate effective solutions to eliminate further cracks, in consultation with, and subject to the approval of the Engineer.

350-2 Materials.

Meet the following requirements except as modified herein:

Concrete	Section 346
Grinding Concrete Pavement	Section 352
Curing Materials*	Section 925
Embedded Items	Section 931
Joint Seal	Section 932

*Use products listed on the Department's Approved Product List (APL).

Provide concrete with a minimum 28-day compressive strength of 3,000 psi and maximum water to cementitious materials ratio of 0.50.

For concrete pavement placed using the slip-form method of construction, utilize concrete with a target slump of 1.5 inches plus or minus 1 inch. For concrete pavement placed by hand in constructed forms, utilize concrete with a target slump of 3 inches plus or minus 1.5 inches. Air content testing for concrete pavement mixes is not required.

350-3 Equipment.

350-3.1 General: Ensure the equipment and tools used have the capability of handling materials and performing all parts of the work and meet the following requirements:

To be of such capacity that the paver operates continuously and at a constant rate of production, with starting and stopping held to a minimum.

When equipment operates on the side forms, use scraping devices to clean accumulations from the top of the forms and wheels.

The forms will be a rigid material and mortar tight. Ensure that the alignment and grade of all forms are in accordance with the contract documents, prior to the placing of concrete.

350-3.2 Slip-Form Paver: Use a self-propelled slip-form paving system consisting of a slip-form paver and if needed, a concrete spreader to distribute, strike-off, consolidate, and screed the freshly placed concrete in one complete pass to produce a dense and homogeneous pavement requiring minimal hand finishing. The slip-form paving machine must extrude concrete into a shape using attached molding components consisting of a profile pan and side forms. The slip-form paving machine must be equipped with the following components:

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1. Automatic controls to regulate line and grade from either or both sides of the machine.

2. Vibrators to consolidate the concrete for the full width and depth of the course placed in a single pass and designed and constructed so no spreading or slumping of the concrete occurs.

3. A positive interlock system to stop all vibration and tamping elements when forward motion of the machine stops.

For finishing small areas of concrete pavement, the Contractor may use alternative finishing equipment if approved by the Engineer. This equipment must produce equivalent results including adequate consolidation by internal vibration and an acceptable finish.

350-3.3 Vibratory Equipment: Consolidate the concrete for the full width and depth of concrete in a single pass of an approved internal vibrator system. Operate internal vibrators within a frequency range of 4,000 to 8,000 vibrations per minute (vpm). The Engineer may authorize lowering the minimum vibration frequency to 3,500 vpm for isolated sections of paving such as super elevations.

Do not operate vibrators in a manner to cause segregation, either a downward displacement of large aggregate particles or an accumulation of laitance on the surface of the concrete. Reduce the vibrator frequency when forward motion of the paver is decreasing.

Stop vibrators whenever forward motion of the paver is stopped.

For internal vibrators, set the depth of penetration at the paver screed pan or below while passing above any dowels and dowel baskets. Use an operating position locking device so that no part of the vibrating unit will be in contact with reinforcing steel or tie bars while paving.

Meet the manufacturer’s recommendations for the horizontal spacing of the vibrators or 16 inches from center to center of the vibrators, whichever is less.

Ensure that the longitudinal axis of the vibrator body is mounted approximately parallel to the direction of paving.

Use vibrators that meet or exceed the following specifications at the manufacturer's design frequency of 8,000 vpm:

1. Amplitude (peak to peak) 0.070 inches.

2. Centrifugal force 1,200 pounds.

350-3.4 Vibratory Monitoring Equipment: All projects with concrete paving over 15,000 square yards in area, or 1 mile in length, must use an electronic vibrator monitoring device displaying the operating frequency of each individual internal vibrator.

Use a monitoring device with a readout display visible to the paver operator and the Engineer while paving. Display all vibrator frequencies with manual or automatic sequencing among all individual vibrators. Record the clock time, station location, paver track speed, and operating frequency of individual vibrators. Provide an electronic record of the data to the Engineer daily for the first 3 days of paving and weekly thereafter. The Engineer may adjust the frequency submission if necessary.

If the electronic monitoring and recording devices fail to operate properly, immediately check the vibrators manually. If the vibrators are functioning properly, paving may continue. Correct the malfunction within 3 days.

350-3.5 Curing Compound Application Equipment: Use equipment for applying membrane curing compound that is self-propelled and capable of uniformly applying the curing

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compound at the specified rate. Use mechanical spray equipment that continuously stirs the curing compound, by effective mechanical means. Thoroughly atomize the curing compound during the spraying operation so that the finished surface of the fresh concrete will not be marred. Cover the entire surface of the pavement and, with slip-form type paving, the vertical faces by a single pass of the machine. Only use spray nozzles that are equipped with appropriate wind guards to ensure uniform application.

Power-spray equipment may be used to apply curing compound to areas where it is impracticable to operate the self-propelled equipment.

350-4 Subgrade Preparation.

Complete the construction of the subgrade for a distance of at least 500 feet ahead of the paving operation. Maintain the finished subgrade in a smooth, compact condition. Restore any areas which are disturbed prior to placing the concrete. Do not place concrete on a frozen subgrade.

Uniformly moisten the subgrade surface ahead of the paving operations with no standing water.

350-5 Setting Forms.

For straight forms, use only steel forms intended for concrete pavement. For curved work, use forms approved by the Engineer.

Clean forms and apply a release agent in accordance with the manufacturer's recommendations before use.

Align and grade so that the forms rest firmly, throughout their entire length, upon the subgrade surface. Join forms neatly and tightly. Brace the form to resist the pressure of the placed concrete and equipment operating on them. Obtain the Engineer's approval of the alignment and grade of all forms before and immediately prior to the placing of concrete.

350-6 Protection from Weather.

Protect unhardened concrete from effects of inclement weather. Cease production and paving operations in rain. The following will apply during paving in cold and hot weather:

1. During the cold weather paving, do not mix or place concrete when the air temperature is below 40ºF. Protect the fresh concrete from freezing in accordance with Section 400 until the concrete reaches a minimum compressive strength of 1,500 psi.

2. During paving in hot weather, cool the aggregates and mixing water as necessary to maintain the concrete temperature at not more than 100ºF at time of placement with the protective covering.

350-7 Placement Widths.

The Contractor may construct the pavement either in lanes as determined by the longitudinal joints shown in the Plans, or for the full width of the pavement in one operation. Construct the pavement to the full width of the lane or slab in a single construction operation. When constructing pavement in separate lanes, do not deviate the junction line from the true line shown in the Plans by more than 1/2 inch at any point.

350-8 Delivery Certification.

Ensure that a printed delivery ticket is furnished with each batch of concrete before unloading at the placement site. Include the following information on the delivery ticket:

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1. Mix design number.
2. Time all materials are introduced into mixer.
3. Cubic yards in this load.

At the end of each day's production provide a summary listing all the daily ticket numbers along with the materials and quantities incorporated into each load, water to cementitious materials ratio, and the signature of the plant operator attesting to the accuracy and conformance of each load delivered to the project.

350-9 Sampling and Testing Methods.

350-9.1 General: Meet the requirements of 346-8 and 346-9, with the exception of air content.

350-9.2 Sampling Frequency for Quality Control Tests: Sample and test concrete of each design mix for temperature and compressive strength tests once per LOT.

A LOT is defined as the concrete placement of 2,000 square yards or one day's production, whichever is less. The LOT must be of the same type of placement method, such as slip form or formwork methods. Partial LOTs of less than 500 square yards will be combined with the previous LOT for testing and acceptance purposes.

350-9.2.1 Reduced Frequency for Quality Control Tests: The LOT size for reduced testing frequency of Class I (Pavement) may represent a maximum production quantity of 4,000 square yards, provided that the submitted historical compressive strength test results meet the requirements as described below:

1. The average of the acceptance compressive strengths is equal to or greater than 2,500 psi plus 2.33 standard deviations.
2. Every average of three consecutive strength test equals or exceeds the 3,000 plus 1.34 standard deviations.

Base calculations on a minimum of five consecutive compressive strength results. The average of the consecutive compressive strength test results can be established using historical data from a previous Department project. The tests from the previous Department project must be within the last calendar year or may also be established by a succession of samples on the current project. Only one sample can be taken from each LOT. Test data must be from sample(s) tested by a laboratory meeting the requirements of Section 105. Obtain Department approval before beginning reduced frequency LOTs.

If at any time a compressive strength test is not verified or the average compressive strength of the previous five consecutive samples from the same mix design and the same production facility does not conform to the above conditions, return to the frequency represented by the LOT as defined in 350-9.2. Notify the Engineer that the initial frequency is reinstated. To reinitiate reduced frequency, submit a new set of strength test results.

350-9.2.2 Sampling Frequency for Verification: The Engineer will verify one of every four consecutive LOTs, randomly selected, for each mix design in accordance with 346-8.

The Engineer may perform additional independent verifications tests. All QC activities, calculations and inspections may be randomly confirmed by the Engineer. The Engineer may obtain additional samples for informational purposes.

350-10 Striking-off, Consolidating, and Finishing Concrete.

350-10.1 General Requirements: Immediately after placing the concrete, strike-off, consolidate, and finish it to produce a finished pavement in accordance with the cross-section,

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width, and surface finish required by the Contract Documents. After screeding while the concrete is plastic, correct all flaws such as cavities, blemishes, marks, or scratches that will not be removed by grinding.

Provide a concrete surface true to grade, cross slope and superelevation, and free of irregularities. If the Engineer permits adding water to assist the finishing operations, apply water as a fog spray by means of approved spray equipment.

350-10.2 Hand Methods: Use hand methods in areas of narrow width or irregular dimensions, where operation of a slip-form paver is impracticable or when using fixed form paving.

350-10.2.1 Strike-off and Screeding: Use a portable screed of an approved design, constructed either of metal or of other suitable material shod with metal, to strike-off and screed the concrete. Use a screed that is sufficiently rigid to retain its shape and is at least 2 feet longer than the maximum width of the strip to be screeded.

350-10.2.2 Consolidation: Use hand-operated spud-type vibrators to consolidate.

350-10.3 Work Bridges: Provide work bridges or other devices necessary for access to the pavement surface for the purpose of inspection, finishing, straightedging, and performing corrective work.

350-10.4 Cross Slope: Control the cross slope using a level with a minimum length of 4 feet or a digital measuring device approved by the Engineer. Make this level or measuring device available at the jobsite at all times during paving operations.

Measure the cross slope at a minimum frequency of one measurement every 100 feet. When the difference between the measured cross slope and the design cross slope exceeds plus or minus 0.2% for travel lanes (including auxiliary lanes) or plus or minus 0.5% for shoulders, make any necessary corrections immediately to bring the cross slope for subsequent paving into the acceptable tolerance.

Upon approval of the Engineer, the frequency of the cross-slope measurements may be reduced to one measurement every 200 feet during paving operations when the cross slope is consistently within the acceptable tolerance.

350-11 Final Finish.

350-11.1 Finishing: Use a burlap drag that consists of two layers of medium weight burlap with the trailing edge of the lower layer extending approximately 2 inches behind the upper layer. Support the burlap drag in a manner so that a length of at least 3 feet of burlap is in contact with the pavement.

Except in areas where using hand methods to construct the pavement, support the lead end of the burlap drag by a traveling bridge. Maintain the drag clean and free from encrusted mortar. Replace the burlap with new material as necessary.

Apply a broom or burlap finish to areas constructed using hand methods.

350-11.2 Edging: After applying the final finish, but before the concrete has become nonplastic, carefully round the edges to a 1/4 inch radius on each side of transverse expansion joints and construction joints and along any structure extending into the pavement. Produce a well-defined and continuous radius, and obtain a smooth, dense mortar finish. Completely remove all concrete from the top of the joint filler.

350-12 Curing.

350-12.1 General: After completing the finishing operations and as soon as the concrete has hardened sufficiently to not mar the surface, cure the entire surface and, when the slip-form

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method is used, cover and cure the edges of the newly placed concrete. Do not leave freshly placed concrete exposed for more than 30 minutes without applying curing protection. Failure to provide sufficient curing materials to adequately cure the concrete in place in a timely manner may result in the suspension of paving operations.

Continuously cure the freshly placed concrete for a period of 72 hours, exclusive of any periods when the temperature of the surface of the concrete falls below 50ºF.

350-12.2 White-Pigmented Curing Compound: Uniformly apply a Type 2 white-pigmented curing compound meeting the requirements of Section 925 to the surfaces to be cured, including the edges of slip-form produced paving, in a single coat of continuous film, at the minimum rate of 1 gallon per 200 square feet.

During application, thoroughly mix the compound in accordance with the manufacturer's recommendation.

Do not apply curing compound during periods of rainfall. Do not apply curing compound to the inside faces of joints to be sealed. Should the film become damaged from any cause within the required curing period, repair the damaged portions immediately with additional compound. If using forms, upon their removal, immediately coat the sides of the slabs exposed to provide a curing treatment equal to that provided for the surface.

350-12.3 Removal of Forms: Do not remove forms from freshly placed concrete for at least 12 hours after placement. Remove forms carefully so as to avoid damage to the pavement. After removing the forms, immediately cure the sides of the slab in the same manner as the surface of the pavement.

350-13 Joints.

350-13.1 General: Construct joints at the locations and in accordance with the details shown in Standard Plans, Indexes 350-001 and 370-001 and the Contract Documents.

350-13.2 Longitudinal Joints: Construct longitudinal construction joints in accordance with the details shown in the Plans. Construct longitudinal lane-tie joints within the limits of the pavement placed, in accordance with the details shown in the Plans by sawing a groove in the surface of the hardened concrete.

350-13.2.1 Tie Bars: Place deformed steel tie bars at the required depth, parallel to the finished surface, at right angles to the joint and at the uniform spacing required in the Plans. Place them in the plastic concrete using approved equipment, or rigidly support them on the subgrade by approved devices capable of preventing displacement prior to placing of the concrete. Do not paint or coat the bars with any material before placing them in the concrete.

Use Grade 40 reinforcing steel when placing tie bars along a longitudinal construction joint by inserting bars with a 90 degree bend in the edge of the plastic concrete. When the concrete hardens, straighten the bar and replace any bar broken while being straightened in an approved manner.

Do not insert steel tie-bars into the unsupported side of the freshly formed slab. The Contractor may place tie-bars into position prior to extrusion from the paver by insertion through a temporary support form placed against the form slab, or by other means approved by the Engineer. Use a method that results in placement of the tie-bars at the specified locations without damaging or disrupting the plastic concrete.

350-13.3 Transverse Joints:

350-13.3.1 Load-Transfer Devices: Provide dowel load-transfer devices in all transverse joints. Firmly hold dowel bars in a position parallel to the surface in the longitudinal direction of the pavement and the centerline of the slab depth, by approved steel supports and

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spacers. Allow the dowels to be free to move in one slab as the concrete contracts and expands. Wait a minimum of 7 days before coating one-half of the dowel with a petroleum based lubricant grease to inhibit bonding to the concrete. Provide a cap for the free end of expansion joint dowels. Use dowel bars coated in accordance with 931-2.3.

Ensure that the bars are straight, round, smooth, and free from burrs or other deformations detrimental to the free movement of the bar in the concrete. Provide a cap for the free end of expansion joint dowels.

Position each dowel such that:

1. Fits final deviation from parallel to the surface of the pavement does not exceed 1/2 inch.

2. Final deviation from parallel to the longitudinal centerline of the pavement does not exceed 1/2 inch.

3. Final deviation from being centered on the joint does not exceed 2 inches, and at no point in its length does it deviate from the surface of the pavement as shown in the Plans in excess of 1 inch. Confirm the position of dowel bars by suitable means acceptable to the Engineer.

350-13.3.2 Transverse Construction Joints: Construct transverse construction joints at the end of all pours and at other locations where the paving operations are stopped for 30 minutes or longer. Do not place construction joints within 7 1/2 feet of any other transverse joint or within 7 1/2 feet of either end of a section of pavement. If sufficient concrete has not been placed to form a slab at least 7 1/2 feet long, remove the excess concrete, back to the last preceding joint. Form the joints in place, in a plane perpendicular to the profile and centerline of the pavement. Saw or form construction joints, in a manner similar to contraction joints, so that a groove will be formed for holding the joint sealing compound.

Check all joints with a straightedge before the concrete has become non-plastic. Make corrections as necessary if one side of the joint is higher than the other, or the entire joint is higher or lower than the adjacent slabs.

350-13.3.3 Transverse Contraction Joints: Construct transverse contraction joints at the interval in accordance with the Standard Plans, Index 350-001.

Ensure that the sawing equipment does not damage the pavement and saw the transverse contraction joints as soon as the pavement has hardened to the degree that tearing and raveling are not excessive and before uncontrolled shrinkage cracking begins.

Accomplish the joint sawing in two steps. Make the initial cut 1/8 inch wide by a depth at least 1/3 of the pavement thickness and as soon as possible but in no case longer than 24 hours after placing the concrete. Upon approval of the Engineer, the Contractor may extend initial saw cutting time to avoid raveling at joint due to sawing too soon or reduce initial saw cutting time to avoid slab cracking due to sawing too late. Make a second saw cut, to provide the joint dimensions indicated in the Plans, just prior to final grinding and sealing the joint.

Repair any uncontrolled cracks at no expense to the Department by removing and replacing the pavement across the full width of all affected lanes or shoulders and to the nearest transverse joint in each direction.

350-13.3.4 Transverse Expansion Joints: Form transverse expansion joints using preformed joint filler, and provide them with dowel load transfer, in accordance with the details shown on the Standard Plans, or in the Plans.

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Form the joints during the placing of the concrete, by securely staking a metal bulkhead accurately in place at the joint location or by other methods which will securely brace and support the joint filler. Where using approved devices to keep the expansion joint filler and dowels securely in place, the Engineer will not require a bulkhead. For concrete pavement using the Special Select soil base option, protect all transverse expansion joints at the bottom and side edges by a sheet metal strip as specified in 931-2.1 and as shown in the Contract Documents.

Cut the filler to the crown and shape of the slab cross-section and extend it to the subgrade. After installation, ensure that the top is not less than 1 inch, and not more than 1.25 inches, below the finished surface. Furnish the joint filler in lengths not less than the lane widths being poured, except that the Engineer will not require lengths greater than 12 feet. Where more than one section is allowed and used in a joint, securely lace or clip the sections together.

Place the filler normal to the pavement surface. Stake the assembly into position in such a way as to hold the assembly securely in position throughout construction. Ensure that the assembly is true to the line prescribed, subject to a tolerance of 1/4 inch in the width of the slab. Obtain the Engineer's approval of the assembly and its installation before placing any concrete against it. Obtain the Engineer's approval of the cross-section and length of the stakes.

When laying the pavement in partial width slabs, place transverse joints in the succeeding slab in line with the like joints in the first slab. In the case of widening existing pavement, place transverse joints in line with like joints in the existing pavement or as otherwise shown in the Plans.

350-13.4 Expansion Joints Around Structures at Manholes, Meter Boxes and other Projections: Form expansion joints by placing premolded expansion joint material around all structures and features projecting through, into or against the pavement. Ensure that such joints are 3/4 inch in width.

350-13.4.1 Bridge Approach Expansion Joints: Construct in accordance with Standard Plans, Index 370-001.

350-13.5 Cleaning Joints and Cracks:

350-13.5.1 Cleaning Joints in New Pavement:

350-13.5.1.1 Sawed Joints: Immediately after the final saw cut, completely remove the resulting slurry from the joint and the immediate area by flushing with a pressure washer and by using other tools as necessary.

1. After flushing, blow out the joints with compressed air.
2. Patch all spalled edges with an epoxy compound.
3. Immediately prior to joint seal installation, clean the joints using compressed air to remove all traces of debris and dust within and on the joint surfaces.

350-13.5.1.2 Non-Sawed Joints: Thoroughly clean joints which require sealing of all foreign material for the full depth of the seal installation.

With the exception of slurry removal due to sawing, meet the cleaning requirements as specified for sawed joints.

350-13.5.2 Cleaning Joints in Existing Pavement: Remove all existing joint-sealing material and foreign material for the full depth of the new joint seal by sawing, wire brushing, sandblasting, or other methods approved by the Engineer.

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Remove any existing sealant or parting strip material below the tape or backer rod bond breaker and replace it with additional bond breaker. When conditions require removal and replacement with additional bond breaker below the new joint seal, obtain the Engineer's approval of the type of bond breaker and its installation procedure. Perform cleaning by any method or combination of methods, as detailed in the Plans.

Flush the joint with a pressurized jet of water, and use other tools as necessary, to remove loose remnants and debris.

After flushing, blow out the joints with compressed air. After the flushed joints have dried, sandblast the joint faces to thoroughly remove all foreign material. Perform sandblasting in two passes, once for each face.

Patch all spalled edges with an epoxy compound.

Immediately prior to joint seal installation, clean the joints using compressed air to remove all traces of debris and dust within and on the joint surfaces.

350-13.5.3 Cleaning Random Cracks in Existing Pavement: Do not begin cleaning random cracks in existing pavement until all other concrete pavement repairs have progressed to the point where those operations will not adversely affect the installation of the new seal.

Cut the random cracks to be repaired and sealed into grooved joints to the depth and width detailed in the Plans. Clean the joints in accordance with 350-13.5.2.

350-13.6 Sealing Joints and Cracks: Clean joints in accordance with 350-13.5 prior to final grinding and sealing.

When using silicone and non-silicone sealants in the transverse and longitudinal joints, respectively, use the silicone sealants first to prevent contamination at the intersection of the joint faces. Remove non-silicone sealant 1 foot in each direction from the transverse joints and replace it with silicone sealant.

350-13.6.1 Hot-Poured Type Sealant: When the Plans require hot poured sealant for specific joints, fill the joint thoroughly, without trapping air, ensuring the sealant is recessed 1/4 inch below the pavement surface Control the pouring rate to avoid spilling of sealant onto the adjacent pavement surface. If any spilling of sealant occurs, immediately remove and clean the entire surplus amount from the pavement surface. Place the poured material when the ambient air temperature is 50ºF or greater.

Use an indirect heating or double boiler type heating kettle that uses oil as a heat transfer medium, for hot poured sealer. Use a heating kettle that has a thermostatically controlled heat source, a built-in automatic agitator, and thermometers installed to indicate both the temperature of the melted sealing material and that of the oil bath.

350-13.6.2 Low Modulus Silicone Sealant: Use low modulus silicone sealant of either Type A non-sag (non-self-leveling), or Type B and/or Type C (self-leveling silicone sealant). Install and tool the sealant as necessary until firm contact is achieved and appropriately formed with the joint faces as specified.

Provide the required depth of recess above the sealant surface and below the pavement surface. Install the silicone sealant at ambient air temperatures above 40ºF.

350-14 Surface Requirements.

Produce, by grinding in accordance with Section 352, a pavement surface that is true to grade and uniform in appearance with a longitudinal line type texture.

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350-15 Thickness Determinations.

350-15.1 General: After completing the concrete pavement, including any corrective work to meet ride requirement, determine the thickness by core boring or non-destructive testing. The Engineer will select the locations for testing and make the determination of thickness. Sample locations will be taken at various offsets from the centerline such that each test represents an area not exceeding 2,500 square yards. Provide traffic control, non-destructive equipment, coring equipment, and operator to obtain the samples.

350-15.1.1 Core Borings: Drill cores from the pavement and measure thickness in accordance with ASTM C174 to determine the actual thickness. Replace the portions of the pavement removed by the borings at no expense to the Department.

350-15.1.2 Non-destructive Testing: Measure the thickness of the pavement in accordance with ASTM C1383 using the impact-echo method. The initial thickness measurement will be validated by having a core boring taken at that the same location in accordance with 350-15.1.1. If the results from the impact-echo test vary by plus or minus 0.15 inches from the core boring, then the non-destructive test method cannot be used on the pavement. In such case, the core boring will be used for acceptance of that LOT of concrete. The Engineer has the option to verify the accuracy of the results at any time.

350-15.2 Method of Calculating Average Thickness: The Engineer will determine the average thickness of the pavement by using the following method of calculation:

1. Areas of pavement which are left in place, but for which no payment will be made, will not be taken into account.
2. The specified thickness plus 1/2 inch will be considered in the calculation when the thickness of the pavement is more than 1/2 inch greater than the specified thickness.
3. The average thickness for the entire job will be calculated as a unit.

350-16 Deficient Thickness.

350-16.1 General: The Department will not pay for any pavement which is more than 1/2 inch less than the specified thickness. When the pavement contains no longitudinal construction joint, the Department will not pay for the area of such pavement that is the product of the full width of the strip placed as a unit times the sum of the distances each way from the short core or cores to the cores on each side which show measurements within the tolerance limits. When the pavement contains longitudinal construction joints, for the width, the Department will use the width between longitudinal construction joint and the edge of pavement.

350-16.2 Deficient Pavement Requiring Removal: The Engineer will evaluate areas of pavement found deficient in thickness by more than 1/2 inch and if, in his judgment, the deficiency is enough to seriously impair the anticipated service life of the pavement, remove such areas and replace them with concrete of the thickness shown in the Plans. The Department will not pay for the area of pavement removed or for the materials or labor involved in its removal. When removing a section of pavement, remove the full length between transverse joints and the full lane width. Grind replaced sections in accordance with 350-14.

350-16.3 Deficient Pavement Left in Place: If the Engineer determines that the deficiency will not seriously impair the anticipated service life of the pavement, the pavement may be left in place, at no compensation.

350-16.4 Additional Borings: If the number of cores taken is not sufficient to indicate the thickness of the pavement, additional boring locations may be requested, with prior approval from the Engineer at no cost to the Department.

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350-17 Pay Reductions for Low Compressive Strength Concrete.

Payment reductions for low compressive strength concrete will be assessed in accordance with Section 346. The payment reductions of 346-12 do not apply.

350-18 Opening Pavement to Traffic.

Construct an earth berm along longitudinal free edges of the pavement within 36 hours, when newly placed concrete pavement is constructed on a granular base of an erodible material. Build the berm to the full height of the pavement and at least 18 inches wide. Sufficiently compact the berm to prevent underwash of the pavement. Maintain the berm until the final shoulders are complete.

Keep the pavement closed to traffic, including construction operations until one of the following has been met:

1. Fourteen calendar days after placement of the concrete.
2. Test cylinders, made in accordance with ASTM C31 and tested in accordance with ASTM C39, indicate a compressive strength of at least 2,000 psi (cure these test cylinders in a manner identical to the corresponding section of pavement).
3. Provide a strength-maturity relationship curve as outlined by FM 3-C1074 for opening to traffic determined during design mix verification. Use the maturity method specified in this Section to:

    a. Determine if the concrete has achieved 2,000 psi and can be opened to traffic.

    b. Verify the strength of the last slab of each day's placement.

Fabricate three test cylinders for strength and maturity curve correlation testing. The compressive strength cylinders and maturity curve correlation testing will be performed at the first day of production or at the discretion of the Engineer.

350-19 Method of Acceptance.

Acceptance will be based on compressive strength of cylinders at placement in accordance with Section 346 and pavement thickness in accordance with 350-15.

350-20 Method of Measurement.

350-20.1 Concrete Pavement: The quantities to be paid for will be the plan quantity, in square yards, of plain cement concrete pavement and of reinforced cement concrete pavement, omitting any areas not allowed for payment under the provisions of 350-16.3 and adjusted for average thickness as provided herein.

For purposes of payment, the average thickness of pavement will determine the final pay quantities for this pavement as follows:

The area of pavement represented by the difference between the calculated average thickness and the specified thickness will be converted into equivalent square yards of specified thickness pavement, and the quantity thereby obtained will be added to, or deducted from, the quantity of pavement to be paid for, subject to the limitation that the maximum average of over-thickness permitted in the adjustment of the quantity of pavement to be paid for will be 1/2 inch.

Where the Plans call for cement concrete pavement that is to be covered with asphalt concrete surface course, payment will be made for the total thickness of the combination as plain cement concrete pavement. In such cases, price and payment will also include all costs of the asphalt concrete surface course constructed in accordance with Section 334.

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Reinforcing steel, placed and accepted, will be measured and paid for as provided in Section 415.

350-20.2 Joints and Cracks: For cleaning and sealing joints in new or existing concrete pavement, the quantity to be paid will be the length in feet, as determined by field measurement along the joints. Payment for the joints between concrete pavement and curb will be made under Section 520.

For cleaning and sealing random cracks in existing concrete pavement, the quantity to be paid will be the length in feet, as determined by field measurement along the cracks.

350-20.3 Bridge Approach Expansion Joint: The quantity to be paid for will be plan quantity, in feet of bridge approach expansion joint installed in accordance with Standard Plans, Index 370-001, calculated across the pavement at right angles to the centerline of the roadway pavement, completed and accepted.

350-21 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section, including any preparation of the subgrade not included in the work to be paid for under another Contract item; all transverse and longitudinal joint construction, including tie-bars and dowel bars; the furnishing of test specimens; repair of core holes; and all incidentals necessary to complete the work.

Payment will be made under:

Item No. 350- 3-	Plain Cement Concrete Pavement - per square yard.
Item No. 350- 4-	Reinforced Cement Concrete Pavement - per square yard.
Item No. 350- 5-	Cleaning and Sealing Joints - per foot.
Item No. 350- 6-	Cleaning and Sealing Random Cracks - per foot.
Item No. 350- 30-	Cement Concrete Pavement for Roundabout Apron - per square yard.

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SECTION 352
GRINDING CONCRETE PAVEMENT

352-1 Description.

Grind existing concrete pavement in the areas designated on the Plans.

Grind new concrete pavement the full width of the travel lanes. Do not grind shoulders or roundabout aprons unless indicated in the Plans or required to promote drainage.

352-2 Equipment.

Provide a power driven self-propelled machine that is specifically designed to grind portland cement concrete pavement with diamond-impregnated grinding blades. Provide, operate, and maintain in working condition all necessary equipment to ensure performance of the work in the allotted time. Use equipment of the size, shape, and dimensions that does not restrict the movement of traffic in areas outside the designated limits of construction. The equipment will be of a size that can cut or plane at least 3 feet wide or as approved by the Engineer. Use equipment that is capable of grinding specified surfaces without causing spalls at cracks, joints, or other locations. The equipment will be capable of removing any slurry or residue resulting from the grinding operation.

352-3 Construction Methods.

Schedule and proceed with the construction operation in a manner that produces a uniform finished surface. Grind in a manner that eliminates joint or crack faults while providing positive lateral drainage by maintaining a constant cross-slope between grinding extremities in each lane. Grind transition, auxiliary or ramp lane as required from the mainline edge to provide positive drainage and an acceptable riding surface.

Grind parallel to the centerline until the pavement surfaces of adjacent sides of transverse joints and cracks are in the same plane. Grind the concrete pavement to eliminate the faulting at joints and cracks, maintain the overall smoothness within the limits specified, and texture over the majority of the pavement surface. Take all necessary precautions to minimize the number of minor depressions in the first place and only resolve to grind such areas if necessary. Continue grinding if accumulated total areas of minor depressions exceed 30% of the total area of a 0.1 mile section or if directed by the Engineer. Maintain the cross slope of the pavement as shown in the Plans.

Establish and obtain the Engineer’s approval for a means to continuously remove grinding residue.

Remove solid residue from pavement surfaces before traffic action or wind blows such residue. Do not allow residue to flow across lanes or shoulders used by public traffic or into gutters or other drainage facilities. Do not allow the discharge of any residue runoff into adjacent rivers, streams, lakes, ponds, or other bodies of water.

352-4 Final Surface Finish.

After the curing period, use a grinding process that produces a pavement surface that is true to grade and uniform in appearance with a longitudinal line type texture. Provide a line type texture that contains parallel longitudinal corrugations that present a narrow ridge with a corduroy type appearance. Provide a surface finish with the peaks of the ridges approximately 1/32 inch higher than the bottoms of the grooves and with approximately 60 evenly spaced grooves per foot.

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Grind to produce areas of uniform and neat surface appearance, beginning and ending at lines perpendicular to the pavement centerline.

352-5 Acceptance Testing for Surface Tolerance.

Test the pavement surface for smoothness with a 10 foot long straightedge, a 10 foot long rolling straightedge, or a California Type Profilograph while the Engineer observes the operations as described below. For pavement surfaces not meeting the smoothness requirements, provide corrective work and retesting to ensure conformity approved by the Engineer.

1. Testing with a 10 foot straightedge: Use this straightedge for longitudinal profiling, parallel to centerline, within 15 feet of a bridge approach or existing pavement which is being joined. Use it for all transverse profiling of cross slopes, approaches, and as otherwise directed with respect to (2) or (3) below.

Furnish and operate a 10 foot straightedge. When portland cement concrete pavement abuts bridge approaches or pavement not under this Contract, ensure that the longitudinal slope deviations of the finished pavement do not exceed 1/8 inch in 10 foot length.

Produce transverse slope deviations of the finished pavement that do not exceed 1/8 inch with the straightedge laid in a direction perpendicular to the centerline.

2. Testing with a 10 foot rolling straightedge: Use this straightedge for longitudinal profiling of short pavement sections up to 250 feet long, including mainline and non-mainline sections on tangent sections and on horizontal curves with a centerline radius of curve less than 1,000 feet and the pavement within the superelevation transition of such curves, turn lanes, ramps, tapers, and other non-mainline pavements as directed.

Furnish and operate the straightedge. Provide and operate a 10 foot rolling straightedge of a design acceptable to the Engineer, able to accurately measure surface irregularities exceeding 1/8 inch in a 10 foot effective length of the straightedge.

When tested with a straightedge, ensure that the finished pavement profile provides a uniform surface with no deviation greater than 1/8 inch in a 10 foot length. Perform the profiling in lines parallel to the centerline, at not more than 4 foot transversal spacing, and extending across the transverse joints.

The Contractor may confine checking through traffic lanes with the straightedge to joints and obvious irregularities as directed.

3. Testing With A California Type Profilograph:

a. General: Use the profilograph on all longitudinal profiling of mainline full width pavement lanes longer than 250 feet and as otherwise directed.

The following terms are defined:

1. Profilograph: A longitudinal profile testing apparatus used to measure a pavement's surface profile deviations.

2. Profile Trace or Profilogram: A surface profile record generated along the individual wheel paths using a profilograph. Such a record is analyzed to determine the rate of roughness (or smoothness) and to identify changes in the longitudinal pavement surface elevation that exceed a specified threshold along the pavement length traversed by the profilograph.

3. Profile Index (PI): A profile measurement is a series of numbers representing elevation relative to a specified reference. A Profile Index (PI) is a summary value calculated from these numbers above and below a blanking band over a specified length of pavement.

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4. Blanking Band: A band of 0.2 inch uniform height with its longitudinal center positioned optimally between the highs and the lows of the profilogram depicting at least 100 ft of pavement.

b. Equipment: Furnish, calibrate, and operate an electronic California Type Profilograph device in accordance with FM 5-558.

c. Surface Test: Produce a riding surface meeting the requirements of FM 5-558 and having a Profile Index meeting the requirements herein. Start and terminate the profile 15 feet from each bridge approach or existing pavement, which is being joined.

Take at least two pavement profile traces with bump option turned on. Locate the position of the profiles in the traffic wheel paths. Take the profiles in the direction of the traffic and parallel to and approximately 3 feet from the outside edges of each traffic lane. The Contractor may take additional profiles to define the limits of an out-of-tolerance surface variation.

Upon completion of each day's testing, submit the profilograms to the Engineer for review to determine the pavement section in compliance with these requirements. The Engineer will retain those profilograms meeting these requirements. The Engineer will return profilograms with deficiencies to the Contractor for use to correct section deficiencies. The Engineer will retain the corrected profilograms, along with the deficient profilograms, for comparison purposes of the circumstances between the two profilograms.

Ensure that pavement tested meets the Profile Index requirements and is applicable to the profilogram for each profile trace:

1. Ensure that pavement on tangent alignment and horizontal curves having a centerline radius of curve 2,000 feet or more has a Profile Index of 5 inches per mile or less.

2. Ensure that pavement on horizontal curves having a centerline radius of curve 1,000 feet or more but less than 2,000 feet and pavement within the superelevation transition of such curves has a Profile Index of 7 inches per mile or less.

3. Ensure that the pavement riding surfaces have all deviations in excess of 0.3 inch in 25 feet removed.

The Engineer will evaluate the pavement in 0.1 mile consecutive sections. Grind all areas represented by individual points having deviations in excess of 0.3 inch in 25 feet or less pavement length, until such points do not exceed 0.3 inch.

After removing all individual deviations in excess of 0.3 inch in 25 feet, perform additional grinding as necessary to reduce the Profile Index to the specified requirements.

Surface smoothness tests with a California Type Profilograph on bridges are specified in 400-15. Ensure that the pavement within 15 feet of a bridge approach (or existing pavement which is being joined) complies with the testing requirements of a 10 foot straightedge.

Visually inspect transverse joints and random cracks to ensure that the adjacent surfaces are in the same plane. Where misalignment of the planes of the surfaces on adjacent sides of the joints or cracks is in excess of 1/16 inch, grind the pavement until the surfaces are flush.

352-6 Surface Corrections.

After the curing period, test the surface for pavement surface smoothness in accordance with 352-5. Plainly mark all variations from the required tolerances. Where pavement surfaces

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do not meet the smoothness requirements, the Engineer will require corrective work and retesting to ensure conformity.

Eliminate high spots exceeding 1/8 inch in 10 feet, but not in excess of 0.3 inch in 25 feet, by grinding either with an approved machine or with a carborundum brick and water. Do not use bush-hammering or other destructive means for removing irregularities. As directed by the Engineer, retexture corrected high areas to give skid resistance comparable to the surrounding area.

Operate all milling, cutting, or grinding equipment to produce a reasonably uniform finished surface without spalling the pavement joints within corrected areas. The Engineer will not require extra grinding to eliminate minor depressions in order to provide 100% texturing of the pavement surface. Maintain the cross slope of the pavement as shown in the Plans. Repair all joint seals destroyed by grinding at no expense to the Department.

Remove and replace any area of pavement which, after grinding, still shows a deviation in excess of the allowable tolerance. Ensure that the area removed and replaced is the full length between transverse joints and the full width of the lane involved. Replace any area of concrete pavement with concrete that meets the requirements of Sections 353.

Bear the costs of all surface corrections required and of all required removal and replacement of defective surface concrete. If the grinding operation removes more than a total length of 100 consecutive feet of the grooves, then re-groove the entire width of the pavement for the deficient area.

352-7 Method of Measurement.

The quantity to be paid for will be the plan quantity, in square yards, completed and accepted.

352-8 Basis of Payment.

Price and payment will be full compensation for all work and materials specified in this Section, including furnishing all labor, materials, tools, equipment, testing, and incidentals and for doing all work involved in grinding existing or new concrete pavement, removing residue, and cleaning the pavement, including necessary disposal of residue, and furnishing any water or air used in cleaning the pavement.

Pay adjustments based on the surface smoothness will be made in accordance with Table 352-1.

Table 352-1
Profile Index Pay Factors

Average Profile Index (inches/mile) per 0.1 mile Section		
Curvature Radius ≥2,000 ft	1,000 ft ≤ Curvature Radius < 2,000 ft	Pay Factor
PI ≤ 2	PI ≤ 4	1.05
2 < PI ≤ 5	4 < PI ≤7	1.00
PI > 5	PI > 7	Corrective work required

The Pay Factor will be based on the initial measured average Profile Index, prior to any corrective work. The Pay Factor will be applied to the bid price for Grinding Concrete Pavement.

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The Pay Adjustment will be computed by multiplying the Pay Factor times the unit bid price for grinding concrete pavement times the plan surface area of grinding concrete pavement. The Pay Adjustment will apply to the total area of the 0.1 mile section for the lane width represented by the profilograms for the average Profile Index.

Payment will be made under:

Item No. 352- 70- Grinding Concrete Pavement - per square yard.

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SECTION 353
CONCRETE PAVEMENT SLAB REPLACEMENT

353-1 Description.

Replace the existing defective area of concrete pavement with portland cement concrete free of any uncontrolled cracks. Repair the damaged area of adjacent slabs, caused by slab removal at no cost to the Department. When using the maturity method, submit a strength-maturity relationship curve as determined by FM 3-C 1074 for opening to traffic during design mix verification.

353-2 Materials.

Meet the following requirements:

Portland Cement Concrete* .....Section 346
Curing Materials .....Section 925
Epoxy Compounds.....Section 926
Dowel Bar Assembly** .....Section 931
Post-Installed Anchor Systems for Structural
Applications in Concrete Elements.....Section 937
Accelerating Admixtures .....ASTM C494, Type C and E

*For concrete pavement slab replacement, the use of supplementary cementitious materials is optional.

**Concrete pavement containing only dowel bars will be considered non-reinforced concrete.

353-3 Composition of Concrete.

353-3.1 Mixture Proportions: Designate the actual proportions to be used to produce a concrete with a minimum 28 day compressive strength of 3,000 psi.

Prior to producing concrete, submit the design mix for approval on a form acceptable to the Department. Provide a mix design that will produce a concrete with a minimum compressive strength of 1,600 psi, designated for opening to traffic, at the time period specified in the Contract Documents. Perform the plastic property tests in accordance with Section 346 prior to the addition of the accelerator. Use mixes approved by the Department and obtain concrete from a plant that is currently on the Department's Production Facility listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.

Make necessary adjustment to the concrete mix-water to account for the amount of water in the accelerating admixture solution.

353-3.2 Delivery Certification: Submit a delivery ticket in accordance with Section 346.

353-3.3 Demonstration Slab: Prior to batching production concrete, demonstrate the ability to furnish replacement slabs by constructing a demonstration slab at the project site. Demonstrate production techniques for slab removal, dowel installation, concrete placement, finishing, slab curing, sample preparation and curing, and proper timing of joint sawing. Demonstrate the ability to achieve the required compressive strengths. Demonstrate proficiency to the Engineer the ability to determine when the concrete has achieved a compressive strength of 1,600 psi by testing concrete cylinders or by using the maturity-strength curve. Use cylinders to verify the concrete compressive strength at 28 days. Schedule construction of the demonstration slab at the time specified in the Contract Documents. If the Engineer determines

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that elements of the demonstration slab fail to meet requirements of the Contract Documents, propose adjustments to the construction processes and/or materials for the Engineer's approval.

The demonstration slab may be used in the final work with the approval of the Engineer. No slab replacements will be constructed until the demonstration slab is approved. The Engineer may require additional demonstration slabs until a demonstration slab conforms to the Contract Documents.

353-4 Batching and Mixing Concrete.

Obtain concrete that meets the requirements of Section 346 with the following additional requirements:

Add all the concrete ingredients, excluding the accelerator to the truck mixer at the plant.

Add the accelerator to the load at the job site and record the amount on the delivery ticket. Mix the concrete for 30 additional revolutions at mixing speed after the accelerator is added to the mixer.

Incorporate the accelerator into the concrete design mix in accordance with the recommendations of the admixture manufacturer. Do not exceed the manufacturer's written recommendations for the dosage rate of the accelerating admixture.

353-5 Test Requirements.

353-5.1 General: Perform concrete sampling and testing in accordance with Section 346, with the addition of density measurement testing is required. Perform the plastic property tests prior to the addition of the accelerator. Concrete strength determination can be done using test cylinders or by using the maturity method. If test cylinders are used, prepare after the addition of accelerator.

353-5.2 Verification of Maturity Curve Data: Develop a new maturity curve if any of the plastic properties or the density results exceed the tolerances specified in Table 353-1, for the initial sampling.

Table 353-1
Slump and Density Tolerances Prior to Accelerator Addition

Slump Tolerance	± 1.5 inches
Density Tolerance	± 3.0 lb/ft^3

Use either the maturity method in FM 3-C1074 or concrete cylinder testing to determine if the concrete has achieved 1,600 psi and can be opened to traffic. Use the maturity value or concrete cylinder test results to verify the strength of the last slab of each day's placement. Additional maturity meters or concrete cylinder testing may be used to open other locations to traffic prior to the last slab of each day, as needed, provided each location has achieved the minimum strength.

353-5.3 Cylinder Fabrication and Testing: If cylinders will be used for opening to traffic strength determination, fabricate three test cylinders for opening to traffic strength and three cylinders for 28 day strength after all materials, including the accelerator, are added. If the maturity method will be used for opening to traffic strength, fabricate three test cylinders for maturity curve correlation testing and three for 28 day strength.

The compressive strength cylinders and maturity curve correlation testing will be performed at the beginning of each production day, when the mix design is changed to another

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mix design, at the discretion of the Engineer for each remaining placement week, when a new maturity curve is required, or until terminated by the Engineer.

353-6 Concrete Slab Acceptance and Testing.

Reject any Concrete not meeting the plastic property requirements of Section 346. Concrete pavement slab replacement mix designs are exempt from the requirements for concreting in hot weather. Reject concrete pavement slab replacement mix designs exceeding 100°F. Acceptance will be based on achieving a 1,600 psi compressive strength prior to opening the slab to traffic, and a 28 day compressive strength of 3,000 psi. Determine opening to traffic strength using the maturity method or concrete cylinder testing, and determine 28 day strength using concrete cylinder testing.

Perform Quality Control (QC) tests for temperature, slump, and density, and prepare compressive strength cylinders once per LOT. A LOT is defined as one day's production.

The Engineer will evaluate the particular circumstances in each instance where a strength deficiency occurs. Strength deficiencies will be addressed in accordance with Section 346.

Lost quality control cylinders and payment reductions for low strength concrete will be addressed in accordance with Section 346.

Controlled cracks are cracks designed to occur at specific locations based on the pavement design. All other cracks in the pavement are uncontrolled cracks. Repair uncontrolled cracked slabs, which occur during the life of the contract, by removing and replacing the pavement across the full width of all affected lanes or shoulders and to the nearest transverse joint in each direction. Investigate and implement immediate effective solutions to eliminate further cracks, in consultation with, and subject to the approval of, the Engineer.

353-7 Placing, Striking Off, Consolidating and Finishing Concrete.

The requirements of Section 350 are applicable to this Section.

Perform straightedging while the concrete is still in plastic state after floating is completed and the excess water removed. Furnish and operate a 10 foot straightedge meeting the requirements of Section 350. Hold the straightedge in successive positions parallel to the road centerline, in contact with the surface, testing until the replacement slab is straight edged from one side to the other. Advance along the road in successive stages of not more than one-half the length of the straightedge. Fill any depressions immediately with freshly mixed concrete, consolidate, strike-off, and refinish. Cut down and refinish any high areas. Continue straightedge testing and surface correction until the entire surface conforms to the required grade and cross slope. Ensure that transverse slope deviations of the finished pavement do not exceed 1/8 inch with the straightedge laid in a direction perpendicular to the centerline. When Portland cement concrete pavement abuts bridge approaches or pavement not under this Contract, ensure that the longitudinal slope deviations of the finished pavement do not exceed 1/8 inch in 10 foot length. Produce a uniform, gritty textured final finish longitudinally along the pavement by dragging a broom or seamless strip of damp burlap, having at least 3 feet in contact with the pavement.

If the Engineer identifies a surface irregularity determined to be objectionable, straightedge with a 10 foot long straightedge and address all deficiencies in excess of 1/8 inch by grinding in accordance Section 352.

When required in the Contract Documents, produce a pavement surface that is true to grade and uniform in appearance with a longitudinal line type texture by grinding in accordance with Section 352.

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353-8 Curing.

Cure the slab as specified in Section 350, except for time and temperature restrictions. Use a Type I (with dye) or Type ID (clear with dye) curing compound and apply within 1/2 hour after completing the finishing operations. After the curing compound has been applied, cover the surface and exposed edges with two layers of white burlap-polyethylene curing blanket conforming to Section 925 or insulating blankets approved by the Engineer. Continue curing the slab until the concrete achieves the required 1,600 psi compressive strength.

353-9 Joints.

353-9.1 General: Construct transverse joints as specified in Section 350 and as shown in the Standard Plans, except that dowels bars are installed per this Section. Tie bars will not be placed along the longitudinal joints unless shown in the Contract Documents. Apply a bond breaker to all vertical faces of the adjacent slabs. Submit the proposed bond breaker and manufacturer's technical data to the Engineer for approval.

Clean and seal joints in accordance with Section 350.

353-9.2 Dowel Bars: Provide dowel bars in accordance with the details shown in the Contract Documents.

353-9.2.1 Dowel Bars at Transverse Joint Between two Replacement Slabs: Follow the requirements of 350-12 when providing dowel bars at a transverse joint between two freshly placed replacement slabs.

353-9.2.2 Dowel Bars at Transverse Joints Between Existing and Replacement Slabs: Follow the requirements of Section 350, except drill holes and install dowel bars into the sawed face or end of the existing slab. Develop load transfer between existing and freshly placed replacement slab. The dowels shall be free to move inside the replacement slab and epoxy-bonded into the existing slab.

353-9.2.3 Dowel Bar Installation: Install dowel bars in accordance with Section 416 except as modified herein. Position each dowel such that its final deviation from parallel to the surface of the pavement and parallel to the longitudinal centerline of the pavement does not exceed 1/2 inch. Position each dowel such that its final deviation from centered on the joint does not exceed 2 inches. Position each dowel such that at no point in its length does it deviate from the surface of the pavement as shown in the Plans in excess of 1 inch. Confirm the position of dowel bars by means acceptable to the Engineer, which may include non-destructive testing methods.

Use epoxy compounds in accordance with Section 937. Dispense the epoxy from a cartridge or from metered equipment that indicates the amount of each component material being dispensed.

Inject epoxy into the hole after cleaning and prior to dowel insertion. Start injection at the back of the hole to force the epoxy to move forward during dowel insertion. Twist the dowel a minimum of one full turn during the insertion to ensure that the epoxy surrounds the dowel. The injection process and viscosity of the epoxy shall be adequate to ensure that the space between the surface of the dowel and the inside of the hole is filled with epoxy.

Do not allow the epoxy to escape from the front of the hole after inserting the dowel in the hole. Use a 1/8 inch thick nylon or plastic grout retention disk to hold epoxy in the hole during dowel insertion.

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353-10 Protection and Opening to Traffic.

353-10.1 General: The requirements of Section 350 apply to this Section. Keep the placed slabs closed to traffic until the 1,600 psi compressive strength requirement is achieved. Submit documentation to the Engineer indicating that the required strength was achieved prior to opening to traffic. If documentation is not provided, the concrete will not be accepted. The Engineer may allow opening to traffic should the maturity equipment fail to provide a reading. Opening to traffic due to equipment failure does not constitute acceptance of the concrete.

Protect the pavement from all traffic, including construction vehicles, until the required strength has been obtained. The protective measures shall be arranged so as not to interfere with traffic lanes being utilized for required maintenance of traffic.

353-10.2 Maturity Method Testing: Use a maturity curve to estimate the strength of the concrete for opening to traffic for each day of production. Embed temperature sensors at mid-depth in the slab, at 6 inches from the leading edge of the transverse joint and at 6 inches from the longitudinal joint or at locations designated by the Engineer.

Develop a strength-maturity relationship curve using the Arrhenius maturity function with an activation energy of 33,500 J/mol as outlined in FM 3-C1074, in a laboratory with personnel qualified to perform the method. Compressive strength tests, as specified in FM 3-C1074, will be performed to produce a six point curve with points before and after the anticipated time for opening to traffic. Submit the mix design supporting data and the maturity curve to the Engineer for his approval.

Any changes of a material source or proportion in the concrete mixture will require a new maturity curve.

353-11 Method of Measurement.

The pay quantity for concrete pavement slab replacement, calculated using field-measured horizontal dimensions and thickness of the removed slab, will be the volume, in cubic yards, of calculated concrete volume placed and accepted.

The pay quantity for cleaning and sealing joints will be in accordance with Section 350.

353-12 Basis of Payment.

Price and payment for concrete pavement slab replacement, will be full compensation for all work specified in this Section and shall include demonstration slab construction, all joint construction, including tie bars and dowels, furnishing of test specimens, and all necessary incidentals.

Price and payment for cleaning and sealing joints will be made in accordance with Section 350.

Payment will be made under:

Item No. 353- 70- Concrete Pavement Slab Replacement - per cubic yard.

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SECTION 355
VALUE ADDED PORTLAND CEMENT CONCRETE PAVEMENT

355-1 Description.

Construct Value Added Portland Cement Concrete Pavement (Concrete Pavement), subject to a five year warranty period after final acceptance of the Contract in accordance with 5-11. This Section applies only to new pavements, including added lanes.

Submit each mix design to the Engineer at least 14 days prior to any paving work.

Perform all the associated work specified in this Section including continued responsibility for performing all remedial work associated with pavement distresses exceeding threshold values determined in accordance with this Section and as to which notice was provided to the Contractor.

The work specified in this Section will not be paid for directly, but will be considered as incidental to other Contract items.

355-2 Materials and Construction Requirements.

Meet the requirements of the following:

Portland Cement Concrete .....Section 346
Cement Concrete Pavement.....Section 350
Grinding Concrete Pavement.....Section 352

355-3 Statewide Disputes Review Board.

The Statewide Disputes Review Board in effect for this Contract will resolve any and all disputes that may arise involving administration and enforcement of this Specification. The Contractor and the Department acknowledge that use of the Statewide Disputes Review Board is required, and the determinations of the Statewide Disputes Review Board for disputes arising out of this Specification will be binding on both the Contractor and the Department, with no right of appeal by either party.

Meet the requirements of 8-3.

355-4 Pavement Evaluation and Remedial Work.

355-4.1 General: The Department's Pavement Condition Survey Program along with observations by the Engineer will be used as the basis for determining the extent and the magnitude of the pavement distresses occurring on the project. In the event the level of distress exceeds any of the threshold values defined below, remedial work as described in 355-5 by the Contractor will be required.

The Department will monitor the pavement for distresses and may require remedial action at any time. The Department may conduct a Pavement Condition Survey of the value added pavement following the final acceptance of the project, and at intermediate times throughout the warranty period with findings provided when considered by the Department to be the obligation of the Contractor.

The final survey, if determined by the Engineer to be necessary, will be conducted before the end of the warranty period with results provided to the Contractor for those conditions exceeding contract threshold values requiring remedial action that the Department believes to be an obligation of the Contractor. The Department will be responsible for all costs associated with the surveys.

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If the survey findings, intermediate or final, are to be disputed by the Contractor, written notification must be submitted to the Engineer within 30 calendar days of the date of receipt of the information from the Department.

During the warranty period, the Contractor may monitor the pavement using nondestructive methods and may participate with the Department in the Pavement Condition Surveys upon request. Do not conduct any coring, milling or other destructive methods without prior approval by the Engineer.

355-4.2 Distress Indicators: The Department will use Ride, Spalling and Cracking, as distress indicators in accordance with the Rigid Pavement Condition Survey Handbook to evaluate the Concrete Pavement. Ride Number (RN) will be established by Laser Profiler in accordance with FM 5-549. For ride evaluation purposes, the project will be subdivided into LOTs of 0.1 mile per lane and partial LOTs which are segments that are less than 0.1 mile. For the purposes of threshold values and remedial work, partial LOTs and LOTs will be treated as LOTs. **355-4.3 Threshold Values and Remedial Work:** Threshold values and associated remedial work for the Concrete Pavement are specified in Table 355-1.

Table 355-1
Concrete Pavement Threshold Values and Remedial Work

Type of Distress	Threshold Values	Remedial Work
Ride	Ride Number < 3. 50	Grind all deficient LOTs and partial LOTs in accordance with Section 352.
Spalling in the wheel path	Four areas in any Lane Mile exceeding 1 inch in width and exceeding 6 inches in length OR any single area exceeding 3 inches in width.	Full depth slab replacement for a minimum of 6 feet in length and the full width of the slab in accordance with Section 353.
Spalling outside the wheel path	Four areas in any Lane Mile exceeding 1-1/2 inches in width and 12 inches in length OR any single area exceeding 3 inches in width and 12 inches in length.	Full depth slab replacement for a minimum of 6 feet in length and the full width of the slab in accordance with Section 353.
Cracking	Four Cracks in any Lane Mile with width exceeding 1/8 inch OR any Crack exceeding 3/16 inch.	Full depth slab replacement for a minimum of 6 feet in length and the full width of the slab in accordance with Section 353.
Shattered Slab	Cracking patterns that divide the slab into three or more segments	Full slab replacement in accordance with Section 353.

355-5 Remedial Work.

Perform all necessary remedial work described in this Section at no cost to the Department. Should an impasse develop in any regard as to the need for remedial work or the extent required, the Statewide Disputes Review Board will render a final decision by majority vote.

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Remedial work will not be required if any one of the following conditions is found to apply:

1. Determination that the pavement thickness design as provided by the Department is deficient. The Department will make available a copy of the original pavement thickness design package and design traffic report to the Contractor upon request. The Contractor will be responsible for performing all remedial work associated with the pavement distress if the pavement design is provided by the Contractor.

2. Determination that the Accumulated ESALs (Number of 18 Kip Equivalent Single Axle Loads in the design lane) have increased by 25% or more than the Accumulated ESALs used by the Department for design purposes for the warranty period for the pavement design life. In calculating ESALs, the Average Annual Daily Traffic (AADT) will be obtained from the Department's traffic count data and the T24 (Percent Heavy Trucks during a 24 hour period) will be obtained from the Department's traffic classification survey data.

3. Determination that the deficiency was due to the failure of the existing underlying layers that were not part of the Contract work.

4. Determination that the deficiency was the responsibility of a third party or its actions, unless the third party was performing work included in the Contract.

If a measured distress value indicates remedial action is required per Table 355-1, begin remedial work within 45 calendar days of notification by the Department or a ruling of the Statewide Disputes Review Board. The Statewide Disputes Review Board will determine the allowable duration for the completion of the remedial work, but not to exceed 6 months.

If remedial action is necessary and forensic information is required, it is the responsibility of the Contractor to determine the source of the distress. The Contractor will not be responsible for damages to the pavement as a result of any forensic activities conducted at the discretion of the Engineer.

As applicable to distress criteria for ride, when two LOTs requiring remedial action or a partial LOT and a LOT are not separated by three or more LOTs not requiring remedial action, the remedial work shall be required for the total length of all such contiguous LOTs and partial LOTs, including the intermediate LOTs not requiring remedial action.

The Contractor has the first option to perform all remedial work, as determined by the Department. If, in the opinion of the Engineer, the problem poses an immediate danger to the traveling public and the Contractor cannot provide temporary mitigation for the defect within 4 hours of written notification and restore the pavement to its original design condition within 72 hours of written notification, the Engineer has the authority to have the remedial work performed by other forces. Temporary mitigation includes the use of traffic control systems such as barricades, drums, or other approved devices to secure the area including lane closures if necessary, and constructing temporary repairs making it safe for the roadway user until the defect can be restored to its original design condition. The Contractor is responsible for all incurred costs of the work performed by other forces should the problem (remedial work) be determined to be the responsibility of the Contractor. Remedial work performed by other forces does not alter any of the requirements, responsibilities or obligations of the Contractor.

Complete all remedial work to the satisfaction of the Engineer. Any disputes regarding the adequacy of the remedial work will be resolved by the Statewide Disputes Review Board. Approval of remedial work does not relieve the Contractor from continuing responsibility under the provisions of this Specification.

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Notify the Engineer in writing prior to beginning any remedial work. Meet the requirements of the Specifications when performing any remedial work. Perform all signing and traffic control in accordance with the Standard Plans. Provide maintenance of traffic during remedial work at no additional cost to the Department. Lane closure restrictions listed in the original Contract will apply to remedial work. Written requests to obtain permission for lane closures for either forensic investigation or remedial work must be made to the Engineer 48 hours in advance of any lane closures. Do not perform any lane closures until written permission is given by the Engineer.

If remedial work necessitates a corrective action to the pavement markings, adjacent lanes, or roadway shoulders, perform these corrective actions using similar products at no cost to the Department.

355-6 Failure to Perform.

Failure to timely submit any dispute to the Statewide Disputes Review Board, failure to satisfactorily perform any remedial work, or failure to compensate the Department for any remedial work performed by the Department and determined to be the Contractor's responsibility in accordance with this Specification, the Department will suspend, revoke or deny the Contractor's certificate of qualification under the terms of Section 337.16(d)(2), Florida Statutes, for a minimum of 6 months or until the remedial work has been satisfactorily performed (or full and complete payment for remedial work performed by others made to the Department), whichever is longer. Should the Contractor choose to challenge the Department's notification of intent for suspension, revocation or denial of qualification and the Department's action is upheld, the Contractor will have its qualification suspended for an additional minimum of 6 months.

The remedial work is not an obligation of the Contractor's bond required by Section 337.18, Florida Statutes.

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SECTION 370
BRIDGE APPROACH EXPANSION JOINTS

370-1 Description.

For concrete pavement using the asphalt base option, construct expansion joints in accordance with Standard Plans, Index 350-001. For concrete pavement using the special select soil base option, construct special expansion joints near the bridge approach slabs that consist of a section of reinforced concrete subslab supporting the roadway concrete pavement in accordance with the details shown in Standard Plans, Index 370-001 and the Contract Documents.

370-2 Materials.

Bar Reinforcement: Use bar reinforcing steel meeting the requirements of 931-1.1.

Concrete: For the expansion joint subslab, use concrete meeting the requirements of Section 347.

Galvanized Sheet Metal: Use galvanized sheet metal meeting the requirements shown in the Plans.

Seal: Use compression seals in accordance with Section 932 and Standard Plans, Index 370-001.

370-3 Construction Methods.

Construct the expansion joints in accordance with the applicable requirements of Sections 346, 347, 350, 415 and Standard Plans, Indexes 350-001 and 370-001.

370-4 Method of Measurement.

The quantity to be paid for will be plan quantity, in feet, calculated across the pavement at right angles to the centerline of the roadway pavement, completed and accepted.

370-5 Basis of Payment.

Price and payment will be full compensation for all work and materials specified in this Section or required for the expansion joint, including concrete subslab, sheet metal strip, reinforcing steel, compression seal and all additional excavation required.

Payment will be made under:

Item No. 370- 1- Bridge Approach Expansion Joint - per foot.

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SECTION 400
CONCRETE STRUCTURES

400-1 Description.

Construct concrete structures and other concrete members, with the exception of pavement and incidental concrete construction (which are specified in other Sections).

Refer to Section 450 for prestressed construction requirements additional to the requirements of this Section.

For precast concrete structures meet the requirements of Section 450 for inserts and lifting devices, handling, storage, shipping, and erection.

Obtain incidental precast products from a plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.

400-2 Materials.

Meet the following requirements:

Concrete ..... Sections 346 and 347
Penetrant Sealer .....Section 413
High Molecular Weight Methacrylate (HMWM)**
..... Section 413
Reinforcing for Concrete .....Section 415
Water.....Section 923
Curing Materials*,** .....Section 925
Epoxy Bonding Compounds** .....Section 926
Post Installed Anchor Systems**.....Section 937
Joint Materials**.....Section 932
Bearing Pads .....Section 932
Non-Shrink Grout** .....Section 934
Class 5 Applied Finish Coatings**.....Section 975
Galvanizing Compound** .....Section 562
Dowel Bar Assembly** .....Section 931
Filter Fabric**.....Section 985

*The Engineer will allow clean sand and sawdust for certain curing, when and as specified.

**Use products listed on the Department's Approved Product List (APL).

400-3 Depth of Footing.

Refer to Section 455, "D. SPREAD FOOTINGS".

400-4 Falsework.

400-4.1 Plans: At the Engineer's request, submit detailed plans for falsework or centering to the Department. The Contractor is responsible for results obtained by using these plans.

400-4.2 Design and Erection: Design and construct all falsework to provide the necessary rigidity and to support the loads without appreciable settlement or deformation. Use

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screw jacks or hardwood wedges to take up any settlement in the framework, either before or during the placing of concrete. If any weakness develops and the centering shows undue settlement or distortion, stop the work, remove any affected concrete, and strengthen the falsework before resuming work. Support falsework which cannot be founded on a satisfactory footing on piling. Space, drive, and remove the piling in an approved manner.

400-4.3 Camber: Provide camber to correct for settlement and deflection of falsework. Give bridges permanent camber only when shown in the Plans.

400-4.4 Bridge Deck Overhang Falsework for Steel I-Girders: Locate the lower contact point of bridge deck overhang falsework supporting screed rails within 6 inches above the bottom flange. If the lower contact point of the overhang falsework bears more than 6 inches above the bottom flange and/or if the deck overhang is 4 feet or greater, submit shop drawings and calculations to the Engineer in accordance with Section 5 and Chapter 11 of the Structures Design Guidelines (SDG). The deck overhang is measured from the centerline of the girder supporting the overhang falsework to the outside edge of the concrete deck.

400-5 Forms.

400-5.1 General: Provide forms, either of wood or metal, that are as follows: externally secured and braced where feasible; substantial and unyielding; of adequate strength to contain the concrete without bulging between supports and without apparent deviation from the neat lines, contours, and shapes shown in the Plans. Design forms to withstand the additional forces of vibration without apparent deviation from the desired shape or position. Assemble forms to be mortar-tight. If using lumber forms, construct them of dressed wood of uniform thickness. Use form liners on wooden forms where Class 3 surface finish is specified. Construct assembled forms to render a concrete surface of smooth, uniform finish. Make provisions to remove forms without injury to concrete surfaces. Remove blocks and bracing with the forms, and do not leave any portion of the forms in the concrete. Use the same form system for a type of work throughout.

400-5.2 Inspection and Approval: Do not place concrete in a form until the form has been inspected and approved. Although the Engineer inspects and approves the forms, the Contractor is responsible for obtaining satisfactory concrete surfaces, free from warping, bulging, or other objectionable defects. Pay special attention to the ties and bracing. Where the forms appear to be insufficiently braced or unsatisfactorily built, stop and correct defects to the satisfaction of the Engineer.

400-5.3 Non-metallic Form Materials:

400-5.3.1 Lumber: For all surfaces, use lumber that is not less than 3/4 inch in thickness, dressed, and free of knot holes, loose knots, cracks, splits, warps, and other defects. Proportion the spacing of studs, joists, and wales to exclude warps and bulges and to produce true and accurate concrete surfaces. Only use structurally sound lumber.

400-5.3.2 Form Liners: Use form liners of durable, abrasion resistant materials that are unaffected by water. Use liners with a hard surface texture capable of rendering concrete surfaces of a smooth, uniform texture, without grain marks, patterns, or blemishes. Use form liner material of sufficient thickness to eliminate the reflection of irregularities, undesirable patterns, and marks from the forms to the surfaces. Replace liners as necessary to produce a consistent concrete surface texture. Use form liners in large sheets and with true, tight-fitted joints which are logically located. Obtain the Engineer's approval of the layout of sheets. Do not use liners which have been patched. Use liner material of the same stock throughout.

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400-5.3.3 Plywood: The Contractor may use plywood of not less than 5/8 inch in thickness manufactured with waterproof glue or protected with an approved impervious coating. Do not use pieces with bulged plies or raveled, untrue edges.

400-5.4 Special Requirements:

400-5.4.1 Re-entrant Angles: Use chamfered forms for exterior concrete corners and filleted forms for interior concrete corners. Use chamfers and fillets that are 3/4 by 3/4 inch and are mill-dressed on all sides to uniform dimensions. The Contractor may use plastic or metal chamfers and fillets provided they perform satisfactorily in producing uniform, smooth concrete corner surfaces without honeycomb.

400-5.4.2 Handrails, Concrete Barriers, Traffic Railings, and Parapets: Construct in accordance with Section 521.

400-5.4.3 End-bent Caps: Do not place forms for end-bent caps until the embankment has been constructed to within 12 inches of the bottom of the cap. Place a mass of embankment that is sufficient to produce the subsidence, displacement, and settlement which may result from the construction of the total embankment.

400-5.4.4 Footings: Where footing concrete can be placed in dry excavation, the Contractor may omit cribs, cofferdams, and forms, subject to compliance with the following limitations and conditions:

1. Use this procedure only in locations not exposed to view from traveled roadways.
2. Obtain required elevations shown in the Plans.
3. Obtain neat line dimensions shown in the Plans.
4. Fill the entire excavation with concrete to the required elevation of the top of the footing.
5. The Engineer will determine the volume of footing concrete to be paid for from the neat line dimensions shown in the Plans.

400-5.5 Form Alignment, Bracing, and Ties: Construct forms in such manner that they may be adequately secured for alignment, shape, and grade. Use bracing systems, ties, and anchorages that are substantial and sufficient to ensure against apparent deviation from shape, alignment, and grade. Do not drive nails into existing concrete. Do not use bracing systems, ties, and anchorages which unnecessarily deface or mark, or have an injurious or undesirable effect on surfaces that will be a part of the finished surface.

If metal ties and anchorages are to remain in the concrete, construct them so as to permit the removal of metal to at least 1 inch beneath the finished surface of concrete. Use accessories for metal ties and anchorages that allow the removal of metal to the prescribed depth while leaving the smallest possible repairable cavity.

When using wire ties, cut or bend them back from the finished surface of the concrete a minimum of 1 inch. Do not use internal ties of wire when forming surfaces that are exposed to view.

400-5.6 Preparation and Cleaning: Meet the following requirements for the condition of forms at the time of beginning concrete casting:

1. Treat all forms with an approved form-release agent before placing concrete. Do not use material which adheres to or discolors the concrete.
2. Clean forms of all concrete laitance from previous use and all dirt, sawdust, shavings, loose wire ties and other debris.
3. Close and secure all inspection and cleanout holes.

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400-5.7 Stay-In-Place Metal Forms:

400-5.7.1 General: Utilization of stay-in-place metal forms is permitted in lieu of removable forms to form concrete bridge decks between beams and between the webs of individual box girders when designated in the Plans. Stay-in-place metal forms may be of the cellular, non-cellular or non-cellular with top cover sheet type. The flutes of non-cellular stay-in-place metal forms may be filled with polystyrene foam or concrete. When polystyrene foam is used to fill the forms, fill form flutes completely; do not allow any portion of the polystyrene foam to extend beyond the limits of the flutes. Ensure that the polystyrene foam remains in its required position within flutes during the entire concrete placement process. Do not use reinforcing supports or other accessories in such a manner as to cause damage to the polystyrene foam. Replace all damaged polystyrene foam to the satisfaction of the Engineer.

Apply polymer sheeting to stay-in-place metal forms in accordance with the requirements in the following table. Apply polymer sheeting to all faces and edges (including sheared edges) of support angles used on bridges with Moderately and Extremely Aggressive Superstructure Environmental Classifications (as shown in the Plans). No polymer sheeting is required for beam attachment straps or clips partially embedded in concrete, and for support angles used on bridges with a Slightly Aggressive Superstructure Environmental Classification. Use polymer sheeting materials and application methods as described herein.

Table 400-1
Polymer Sheeting Usage Requirements

Form Type		Superstructure Environmental Classification (as shown in Plans)		
		Slightly Aggressive	Moderately Aggressive	Extremely Aggressive
Non-cellular form with concrete filled flutes		No polymer sheeting required	Polymer sheeting required on bottom side[2]	Polymer sheeting required on bottom side[2]
Non-cellular form with polystyrene foam filled flutes		Polymer sheeting required on top side[1]	Polymer sheeting required on both sides[1,2]	Polymer sheeting required on both sides[1,2]
Non-cellular form with Top Cover Sheet	Top Cover Sheet	Polymer sheeting required on bottom side	Polymer sheeting required on bottom side	Polymer sheeting required on bottom side
	Non-cellular form	Polymer sheeting required on top side	Polymer sheeting required on both sides[2]	Polymer sheeting required on both sides[2]
Cellular form		No polymer sheeting allowed or required	Cellular form not permitted	Cellular form not permitted

1 Polymer sheeting not required on top side of form when foam filled flutes are used only at interior supports on continuous decks and the remainder of the flutes are concrete filled.
2 Polymer sheeting not required on bottom side of form located within box girders and U-beams.

Prior to using stay-in-place metal forms, submit detailed plans for approval of the forming system, including method of support and attachment and method of protecting the supporting structural steel components from welding effects. Submit design calculations for the forming system, which have been signed and sealed by the Specialty Engineer. Detail stay-in-place metal forms such that they in no way infringe upon the concrete

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outline of the slab shown on the Plans. Use stay-in-place metal forms that provide and maintain the dimensions and configuration of the original slab in regards to thickness and slope.

Do not weld stay-in-place metal form supports and connections to the structural steel components. Do not connect polymer coated angles or other hardware that support polymer coated metal forms to the beam attachment straps or clips by welding. Electrical grounding to steel reinforcing or fiber reinforced polymer (FRP) reinforcing is prohibited.

Protect structural steel components from damage by using a shield to guard against weld splatter, weld overrun, arc strikes, or other damaging effects of the welding process. Upon completion of welding, rest the metal form support flush on the supporting steel component. Should any weld spatter, weld overrun, arc strike, or other effects of the welding process be evident or occur to the structural steel component, immediately stop in-place welding of the metal form supports for the remainder of the work. In this event, weld all metal form supports off of the structure and erect the forms after prefabrication, or use an alternate approved method of attaching the form supports. Remove improper weldment, repair the supporting steel component for any improper welding. Perform all required verification and testing at no expense to the Department and to the satisfaction of the Engineer.

Do not use stay-in-place metal forms until the forming system has been approved by the Engineer. The Contractor is responsible for the performance of the stay-in-place forms.

Structures designed, detailed, and dimensioned for the use of removable forms: Where stay-in-place metal forms are permitted, the Contractor is responsible and shall obtain the approval of the Engineer for any changes in design, etc. to accommodate the use of stay-in-place forms. The Engineer will compute pay quantities of the various components of the structure which are paid on a cubic yard basis from the design dimensions shown in the Plans with no allowance for changes in deflection or dimensions necessary to accommodate the stay-in-place forms or concrete to fill the form flutes. The Engineer will limit pay quantities of other Contract items that the Contractor increases to accommodate the use of stay-in-place forms to the quantity required for the original plan design.

Submit all changes in design details of bridge structural members that support stay-in-place forms, showing all revisions necessary to enable the supporting components to withstand any additional weight of the forms and the weight of any extra concrete that may be required to fill the forms. Include with the design calculations a comparative analysis of the stresses in the supporting components as detailed on the Plans and as modified to support the forms. Use the identical method of analysis in each case, and do not allow the stresses in the modified components to exceed those of the component as detailed in the Plans. Include with the design the adjusted cambers for any changes in deflection over those shown on the original Plans. Modify the beams to provide additional strength to compensate for the added dead loads imposed by the use of stay-in-place forms. Obtain the additional strength by adding strands to the pre-stressed beams or by adding steel material to increase the section modulus of steel girders. Substantiate the added strength by the comparative calculations. Do not use stay-in-place forms until the forming system and all necessary design revisions of supporting members have been approved by the Engineer.

Structures designed, detailed, and dimensioned for the use of stay-in-place metal forms:

Prior to using stay-in-place metal forms, submit detailed plans for approval of the forming system (including method of support and attachment) together with

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design calculations. Include an analysis of the actual unit weight of the proposed forming system over the projected plan area of the metal forms. If the weight thus calculated exceeds the weight allowance for stay-in-place metal forms and concrete required to fill the forms shown on the Plans, then modify the supporting components to support the excess weight as specified by the Contractor's Specialty Engineer.

For all structures utilizing structural steel supporting components, paint the vertical sides of the top flange prior to installation of the stay-in-place metal forms in accordance with Section 560.

For non-polymer sheeting form surfaces, use zinc paint coating in accordance with Section 562 to all accessories cut from galvanized sheets, which are not embedded in concrete.

400-5.7.2 Design: Meet the following criteria for the design of stay-in-place bridge deck forms:

1. The maximum self weight of the stay in place metal forms, plus the weight of the concrete or expanded polystyrene required to fill the form flutes (where used), shall not exceed 20 psf.

2. Design the forms on the basis of dead load of form, reinforcement, and plastic concrete plus 50 pounds per square foot for construction loads. Use a unit working stress in the steel sheet of not more than 0.725 of the specified minimum yield strength of the material furnished, but not to exceed 36,000 psi.

3. Do not allow deflection under the weight of the forms, reinforcement, and plastic concrete to exceed 1/180 of the form span or 1/2 inch, whichever is less, for form spans of 10 feet or less, or 1/240 of the form span or 3/4 inch, whichever is less, for form spans greater than 10 feet. In all cases, do not use a total loading (psf) that is less than 20 plus the product of the deck thickness measured in inches times 12.5.

4. Use a design span of the form equal to the clear span of the form plus 2 inches. Measure the span parallel to the form flutes.

5. Compute physical design properties in accordance with requirements of the AISI Specifications for the Design of Cold Formed Steel Structural Members, latest published edition.

6. For all reinforcement, maintain the design concrete cover required by the Plans.

7. Maintain the plan dimensions of both layers of primary deck reinforcement from the top surface of the concrete deck.

8. Do not consider the permanent bridge deck form as lateral bracing for compression flanges of supporting structural members.

9. Do not use permanent steel bridge deck forms in panels where longitudinal deck construction joints are located between stringers.

10. Secure forms to the supporting members by means other than welding directly to the member.

400-5.7.3 Materials:

400-5.7.3.1 Metal Forms: Fabricate stay-in-place metal forms and supports from steel meeting the requirements of ASTM A653 having a coating designation G165. Do not use form materials that are less than 0.03 inch uncoated thickness.

400-5.7.3.2 Polymer Sheeting: Use polymer sheeting comprised of at least 85% ethylene acrylic acid copolymer capable of being applied to both G165 and G210 steel

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sheet as described in ASTM A742. Ensure that the polymer sheeting has a nominal thickness of 12 mils as manufactured and a minimum thickness of 10 mils after lamination to the steel sheet. Ensure that the polymer sheeting remains free of holes, tears and discontinuities and sufficiently flexible to withstand the forming process without any detrimental effects to bond, durability or performance. Ensure that the polymer sheeting is UV stabilized and contains antioxidants.

Ensure that the as-manufactured polymer sheeting (prior to application) has an Oxidative Induction Time (OIT) of 60 to 75 minutes at 170°C in air when tested according to ASTM D3895. Perform additional OIT tests on samples taken from the finished product (polymer sheeting applied to forms) resulting in a minimum OIT according to ASTM D3895 of 32 minutes at 170°C in air. Ensure that the polymer sheeting adheres to galvanized metal sufficient to prevent undercutting at penetrations made through the polymer sheeting or metal forms to the satisfaction of the Engineer. Ensure that edges subjected to shear cutting are coated by the form manufacturer with two coats of a compatible liquid coating repair material before delivery to the site. Ensure that steel used to produce polymer laminated metal forms is appropriately cleaned and prepared per NCCA (National Coil Coating Association) standard continuous coil coating practices. Ensure that pretreatment for use in conjunction with the manufacturer's polymer sheeting material is approved as compatible by the polymer sheeting manufacturer. Apply pretreatment in accordance with the polymer sheeting manufacturer's procedures. Apply polymer sheeting in accordance with the manufacturer's recommendations and procedures. Ensure that all steel has the polymer sheeting applied prior to fabrication of the stay-in-place forms and accessories.

Ensure that the screws to be used in the fastening of the stay-in-place laminated metal forms have a corrosion resistant cladding that will not have an adverse effect to the system due to the contact of dissimilar metals.

400-5.7.3.3 Certification: Submit a written certification from the manufacturer stating the product meets the requirements of this specification along with the delivery of the coated forms to the jobsite. Ensure that the certification conforms to the requirements of Section 6. Ensure that the manufacturer has a quality control program conforming to ISO 9001 2000 standards.

400-5.7.3.4 Polystyrene Foam: Use polystyrene foam comprised of expanded polystyrene manufactured from virgin resin of sufficient density to support the weight of concrete without deformation. Extrude the polystyrene foam to match the geometry of the flutes and provide a snug fit. Use polystyrene foam that has a density of not less than 0.8 pounds per cubic foot. Use polystyrene foam that has water absorption of less than 2.6% when tested according to ASTM C272. Submit a written certification from the manufacturer stating the product meets the requirements of this Specification along with the delivery of the product.

400-5.7.4 Construction: Install all forms in accordance with approved fabrication and erection plans.

Do not rest form sheets directly on the top of the stringer of floor beam flanges. Fasten sheets securely to form supports, and maintain a minimum bearing length of 1 inch at each end for metal forms. Place form supports in direct contact with the flange of the stringer or floor beam. Make all attachments for coated metal forms by bolts, clips, screws, or other approved means.

400-5.7.4.1 Form Galvanizing Repairs: For any permanent exposed steel where the galvanized coating has been damaged, thoroughly clean, wire brush, and paint it with

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two coats of galvanizing compound in accordance with Section 562 to the satisfaction of the Engineer. Do not touch up minor heat discoloration in areas of welds.

400-5.7.4.2 Polymer Sheeting Repairs: Inspect and identify areas for damage to the polymer sheeting and repair with liquid polymer coating similar and compatible with respect to durability, adhesion and appearance in accordance with ASTM A762, as furnished by the stay-in-place form manufacturer. Ensure that the inspection includes checking the polymer sheeting for cuts, tears, cracking, surface pits, peeling, dirt, grease, oil, stains, rust or bare areas. Reject any panels that show coating blistering, peeling or cracking. Repair all polymer sheeting damage according to the following:

1. Surface Preparation: Ensure that all surfaces to be repaired are clean and free of any deleterious substances. Remove all traces of dirt, soil, oil deposits, greases, and other surface contaminates in accordance with the polymer sheeting and coating manufacturer's written specifications prior to touch-up and recoating.

2. Application Procedures: Ensure that the liquid polymer repair coating is applied to a clean dry surface and in accordance with the manufacturer's written specifications. Apply the repair coating using a suitable paintbrush or other means acceptable to the Engineer. Apply a first coat of product to the surface at 2-4 mils in thickness. Let the first coat air dry. Apply a second coat to form a complete layer and increase the thickness, immediately after verifying the first coat is dry to the touch (15 - 25 minutes depending on the local air drying temperature and atmospheric conditions). Apply the second coat at the same coating thickness as the first at 2-4 mils. Ensure that the total dry film thickness of the two coats is not less than 6 mils. Apply additional coats in this same manner until desired coating thickness is achieved.

400-5.7.5 Placing of Concrete: Vibrate concrete to avoid honeycomb and voids, especially at construction joints, expansion joints, valleys and ends of form sheets. Use approved pouring sequences. Do not use calcium chloride or any other admixture containing chloride salts in the concrete.

400-5.7.6 Inspection: The Engineer will observe the Contractor's method of construction during all phases of the construction of the bridge deck slab, including the installation of the metal form system; location and fastening of the reinforcement; composition of concrete items; mixing procedures, concrete placement, and vibration; and finishing of the bridge deck. Should the Engineer determine that the procedures used during the placement of the concrete warrant inspection of the underside of the deck, remove at least one section of the metal forms in each span for this purpose. Do this as soon after placing the concrete as practicable in order to provide visual evidence that the concrete mix and the procedures are obtaining the desired results. Remove an additional section in any span if the Engineer determines that there has been any change in the concrete mix or in the procedures warranting additional inspection.

If, in the Engineer's judgment, inspection is needed to check for defects in the bottom of the deck or to verify soundness, sound the metal forms with a hammer as directed by the Engineer after the deck concrete has been in place a minimum of two days. If sounding discloses areas of doubtful soundness to the Engineer, remove the metal forms from such areas for visual inspection after the concrete has attained adequate strength. Remove metal bridge deck forms at no expense to the Department.

At locations where sections of the metal forms have been removed, the Engineer will not require the Contractor to replace the metal forms. Repair the adjacent metal forms and supports to present a neat appearance and to ensure their satisfactory retention and

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where they are polymer sheeted, coat all exposed surfaces of stay-in-place metal form system elements that are not coated or are damaged with a field applied liquid polymer coating as specified in 400-5.7.4.2. As soon as the form is removed, the Engineer will examine the concrete surfaces for cavities, honeycombing, and other defects. If irregularities are found, and the Engineer determines that these irregularities do not justify rejection of the work, repair the concrete as directed, and provide a General Surface Finish in accordance with 400-15. If the Engineer determines that the concrete where the form is removed is unsatisfactory, remove additional metal forms as necessary to inspect and repair the slab, and modify the method of construction as required to obtain satisfactory concrete in the slab. Remove and replace all unsatisfactory concrete as directed, at no expense to the Department.

If the method of construction and the results of the inspections as outlined above indicate that sound concrete has been obtained throughout the slabs, the amount of sounding and form removal may be reduced when approved by the Engineer.

Corrosion of assembly screws will not be considered a structural or aesthetic problem and is considered acceptable.

Provide the facilities for the safe and convenient conduct of the inspection procedures.

400-5.8 Stay-In-Place Concrete Forms:

400-5.8.1 General: Permanent stay-in-place precast reinforced concrete forms may be used in lieu of removable forms to form concrete bridge deck slabs subject to the conditions contained herein. Precast reinforced concrete stay-in-place forms are not permitted to construct a composite concrete deck. Do not use precast prestressed concrete stay-in-place forms to form any permanent bridge decks.

When detailed Plans for structures are dimensioned for the use of removable forms, provide additional slab thickness, elevation changes, changes in design, etc. to accommodate the use of stay-in-place forms, subject to the Engineer's approval. The Engineer will compute pay quantities of the various component members of the structure which are paid on a cubic yard basis from the design dimensions shown in the Plans with no allowance for changes in deflection and changes in dimensions necessary to accommodate the stay-in-place forms. The Engineer will limit pay quantities of other Contract items which are increased to accommodate the use of stay-in-place forms to the quantity required for the original plan design.

Prior to using stay-in-place forms, submit for approval detailed plans of the forming system and design calculations. Indicate on the plans the form panel sizes, placing patterns, type of mastic or felt bearing material and type and method of caulking between panels. Also, submit appropriate changes in design details of structural members supporting stay-in-place forms showing any revisions necessary to enable the supporting components to withstand the additional weight of the forms and perform equally as contemplated in the Plans. All calculations and details submitted shall be sealed by the Contractor's Engineer of Record. Modify the beams to provide additional strength to compensate for the added dead loads imposed by the use of stay-in-place forms. Obtain this strength by adding additional strands to prestressed girders or increasing the section modulus for steel girders. Do not use stay-in-place forms until the forming system and any necessary design revisions of supporting structural members have been approved by the Engineer. The Department is not responsible for the performance of the stay-in-place forms by its approval.

400-5.8.2 Materials: Construct permanent concrete forms of precast reinforced concrete with a Class 3 Surface Finish. As a minimum, use the same class of concrete and

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28-day minimum compressive strength as being used to construct the bridge deck. Use welded steel wire reinforcement meeting the requirements of Section 931.

400-5.8.3 Design: Use the following criteria for the design of permanent bridge deck forms:

1. Design the forms on the basis of deadload of form, reinforcement, and plastic concrete plus an unfactored live load of 50 psf for construction loads. Meet the AASHTO design requirements for service loads and ultimate loads as applicable.

2. Deflection under the weight of the forms, reinforcement, and the plastic concrete shall not exceed 1/180 of the form span or 1/2 inch, whichever is less. In all cases, do not use a loading that is less than 120 psf total.

3. Use a design span of the form equal to the clear span of the form between supports. Measure the span of concrete forms parallel to the centerline of the form panels.

4. Compute physical design properties of concrete forms in accordance with current AASHTO design procedures.

5. Ensure that all reinforcement contained in the cast-in-place concrete has the minimum cover shown in the Plans or not less than one inch, whichever is greater. Measure the minimum cover normal to the plane of the bottom of the cast-in-place concrete. For stay-in-place concrete forms with other than plane surfaces in contact with the cast-in-place concrete, such as regularly spaced geometrical shapes projecting above the plane of the bottom of the cast-in-place concrete, meet the following special requirements:

a. Space geometrical shapes projecting above the bottom plane of the cast-in-place concrete used to provide support for reinforcement no closer than 3 feet apart and of sufficient height to maintain the required concrete cover on the bottom mat of reinforcing bars.

b. Construct all other geometrical shapes projecting above the plane of the bottom of the cast-in-place concrete to provide a minimum vertical clearance of 3/4 inch between the closest surface of the projections and the secondary longitudinal reinforcing bars in the deck slab.

c. Do not allow a minimum horizontal distance from the surface of any transverse reinforcing bars to surfaces of the stay-in-place form of less than 1 1/2 inches.

For all reinforcement for the stay-in-place form panels, provide a minimum of 1 inch concrete cover except that, for construction in a salt or other corrosive environment, provide a minimum of 1 1/2 inches concrete cover.

6. Maintain the plan dimensions of both layers of primary deck reinforcement from the top surface of the concrete deck. Measure the minimum cover of the bottom mat of reinforcement normal to the top of the precast concrete form panel.

7. Do not consider the permanent bridge deck form as lateral bracing for compression flanges of supporting structural members.

8. Do not use permanent concrete bridge deck forms in panels where longitudinal deck construction joints are located between stringers.

9. Do not allow the maximum weight of the concrete form to exceed 40 pounds per square foot of form surface.

400-5.8.4 Construction: Install all forms in accordance with approved fabrication and erection plans.

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For concrete forms, provide a minimum bearing length of at least 1 1/2 inches but not exceeding 2 1/2 inches. Support concrete forms on the beams or girders by continuous layers of an approved mastic or felt bearing material that will provide a mortar tight uniform bearing. Use a mastic or felt bearing material that has a minimum width of 1 inch and a maximum width of 1 1/2 inches. Seal joints between concrete form panels with caulking, tape, or other approved method.

400-5.8.5 Placing of Concrete: Place the concrete in accordance with the requirements of 400-5.7.5. Immediately prior to placing the slab concrete, saturate concrete stay-in-place form panels with water.

400-5.8.6 Inspection: Inspect the concrete in accordance with the requirements of 400-5.7.6.

After the deck concrete has been in place for a minimum period of two days, inspect the forms for cracks and excessive form deflection, and test for soundness and bonding of the forms by sounding with a hammer as directed by the Engineer. Remove, for visual inspection, form panels found to be cracked that show evidence of leakage and form panels which have a deflection greater than adjacent panels by 1/2 inch or more which show signs of leakage. If sounding discloses areas of doubtful soundness to the Engineer, remove the form panels from such areas for visual inspection after the concrete has attained adequate strength. Remove permanent bridge deck form panels at no expense to the Department.

At locations where sections of the forms have been removed, the Engineer will not require the forms to be replaced. Repair the adjacent forms and supports to present a neat appearance and to ensure their satisfactory retention. As soon as the form is removed, the Engineer will examine the concrete surfaces for cavities, honeycombing, and other defects. If irregularities are found, and the Engineer determines that these irregularities do not justify rejection of the work, repair the concrete as directed and provide a General Surface Finish in accordance with 400-15. If the concrete where the form is removed is unsatisfactory, as determined by the Engineer, additional forms shall be removed as necessary to inspect and repair the slab, and modify the methods of construction as required to obtain satisfactory concrete in the slab. Remove and replace all unsatisfactory concrete as directed at no expense to the Department.

If the methods of construction and the results of the inspections as outlined above indicate that the Contractor has obtained sound concrete throughout the slabs, the Contractor may moderate the amount of sounding and form removal, when approved.

Provide all facilities for the safe and convenient conduct of the inspection procedures.

400-6 Underdrain and Weep Holes.

Provide weep holes in all abutments and retaining walls.

Provide a continuous underdrain for box culverts in accordance with Standard Plans, Index 400-289. Provide weep holes that are at least 3 inches in diameter and not more than 10 feet apart. Place the outlet ends of the weep holes just above the finish graded surface in front of abutments and retaining walls. Cover the inlet ends of all weep holes with galvanized wire mesh and a minimum of 2 cubic feet of clean, broken stone or gravel wrapped in Type D 3 filter fabric, to allow free drainage but prevent the fill from washing through.

400-7 Placing Concrete.

400-7.1Weather Restrictions:

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400-7.1.1 Concreting in Cold Weather: Do not place concrete when the air temperature at placement is below 40ºF.

Meet the air temperature requirements for mixing and placing concrete in cold weather as specified in Section 346. During the curing period, if NOAA predicts the ambient temperature to fall below 35ºF for 12 hours or more or to fall below 30ºF for more than 4 hours, enclose the structure in such a way that the air temperature within the enclosure can be kept above 50ºF for a period of 3 days after placing the concrete or until the concrete reaches a minimum compressive strength of 1,500 psi.

Assume all risks connected with the placing and curing of concrete. Although the Engineer may give permission to place concrete, the Contractor is responsible for satisfactory results. If the placed concrete is determined to be unsatisfactory, remove, dispose of, and replace the concrete at no expense to the Department.

400-7.1.2 Concreting in Hot Weather: Meet the temperature requirements and special measures for mixing and placing concrete in hot weather as specified in Section 346.

Spray reinforcing bars and metal forms with cool fresh water just prior to placing the concrete in a method approved by the Engineer.

Assume all risks connected with the placing and curing of concrete. Although the Engineer may give permission to place concrete, the Contractor is responsible for satisfactory results. If the placed concrete is determined to be unsatisfactory, remove, dispose of, and replace the concrete at no expense to the Department.

400-7.1.3 Wind Velocity Restrictions: Do not place concrete for bridge decks if the forecast of average wind velocity at any time during the planned hours of concrete placement exceeds 15 mph. Obtain weather forecasts from the National Weather Service “Hourly Weather Graph” for the city closest to the project site.

400-7.2 Lighting Requirements: Provide adequate lighting for all concrete operations conducted at night. Obtain approval of the lighting system prior to starting the concrete operations.

400-7.3 Inspections before Placing Concrete: Do not place concrete until the depth and character of the foundation and the adequacy of the forms and falsework have been approved by the Engineer. Do not deposit any concrete until all reinforcement is in place and has been inspected and approved by the Engineer.

400-7.4 Exposure to Water: Do not expose concrete other than seal concrete in cofferdams to the action of water before final setting. Do not expose such concrete to the action of salt or brackish water for a period of seven days after placing the concrete. Protect the concrete during this period by keeping salt or brackish water pumped out of cofferdams.

400-7.5 General Requirements for Placing Concrete: Deposit concrete as nearly as possible in its final position. Do not deposit large quantities at one point and then run or work it along the forms. Take special care to fill each part of the forms, to work coarse aggregate back from the face, and to force concrete under and around reinforcing bars without displacing them.

Use a method and manner of placing concrete that avoids the possibility of segregation or separation of aggregates. If the Engineer determines that the quality of concrete as it reaches its final position is unsatisfactory, remove it and discontinue or adjust the method of placing until the Engineer determines that the quality of the concrete as placed is satisfactory.

Use metal or metal-lined open troughs, chutes, or other means of concrete conveyance which have no aluminum parts in contact with the concrete. As an exception, chutes made of aluminum for ready mixed concrete trucks, no longer than 20 feet, may be used. This

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exception does not apply to any other means of concrete conveyance. Where steep slopes are required, use chutes that are equipped with baffles or are in short lengths that reverse the direction of movement. Where placing operations would involve dropping the concrete freely more than 5 feet, deposit it through pipes, troughs, or chutes of sheet metal or other approved material. Use troughs, chutes, or pipes with a combined length of more than 30 feet only with the Department's authorization. Keep all troughs, chutes, and pipes clean and free from coatings of hardened concrete by thoroughly flushing them with water after each run or more often if necessary.

Place concrete against supporting material that is moist at the time of concrete placement. If additional water is required, uniformly apply it ahead of the concrete placement as directed by the Engineer. Do not place concrete on supporting material that is frozen. The Contractor may use a moisture barrier in lieu of controlling the foundation grade moisture when approved by the Engineer.

400-7.6 Placing Concrete by Belt Conveyor: Place concrete by means of a belt conveyor system with written Department authorization. Remove conveyor belt systems which produce unsatisfactory results before continuing operations. Take concrete samples for assurance testing at the discharge end of the belt conveyor system. Make available to the Engineer the necessary platform to provide a safe and suitable place for sampling and testing. Remove any concrete placed in an unsatisfactory manner at no expense to the Department before continuing operations.

Use conveyor belt systems that do not exceed a total length of 550 feet, measured from end to end of the total assembly. Arrange the belt assembly so that each section discharges into a vertical hopper arrangement to the next section. To keep segregation to a minimum, situate scrapers over the hopper of each section to remove mortar adhering to the belt and to deposit it into the hopper. Equip the discharge end of the conveyor belt system with a hopper and a chute or suitable deflectors to cause the concrete to drop vertically to the deposit area.

In order to avoid delays due to breakdowns, provide stand-by equipment with an alternate power source prior to the beginning of the placement.

After the beginning of the placement, direct the discharge from the belt conveyor so that the concrete always falls on freshly placed concrete.

400-7.7 Placing Concrete by Pumping: In general, use concrete pumping equipment that is suitable in kind and adequate in capacity for the work proposed. Use a pump discharge line that has a minimum diameter of 4 inches. Use a pump and discharge lines that are constructed so that no aluminum surfaces are in contact with the concrete being pumped. Operate the pump to produce a continuous stream of concrete, without air pockets. When using cement slurry or similar material to lubricate the discharge line when pumping begins, collect such material at the point of discharge. Dispose of the collected slurry in areas provided by the Contractor. Control the pump discharge locations so that the placement locations of the various LOTs of concrete represented by strength test cylinders can be identified in the event the test cylinders indicate deficient strength. When concrete is placed by pumping, take all test samples of concrete at the end of the discharge line, except in accordance with the provisions of Section 346.

400-7.8 Consolidation: Consolidate the concrete by continuous working with a suitable tool in an acceptable manner, or by vibrating as set forth in 400-7.11. When not using vibrators, thoroughly work and compact all thin-section work with a steel slicing rod. Spade all faces, and flush the mortar to the surface by continuously working with a concrete spading implement.

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400-7.9 Obstructions: In cases where, because of obstructions, difficulty is encountered in puddling the concrete adjacent to the forms, bring the mortar content of the mix into contact with the interior surfaces by vibrating the forms. Produce the vibrations by striking the outside surfaces of the forms with wooden mallets or by other satisfactory means. In placing concrete around steel shapes place it only on one side of the shape until it flushes up over the bottom flange of the shape on the opposite side, after which place it on both sides to completion. After the concrete has taken its initial set, exercise care to avoid jarring the forms or placing any strain on the ends of projecting reinforcing bars.

400-7.10 Requirements for Successive Layers: Place concrete in continuous horizontal layers, approximately 20 inches thick. To avoid obtaining a plane of separation or a cold joint between layers, vibrate the concrete in accordance with 400-7.11.

400-7.11 Vibration of Concrete:

400-7.11.1 General: Consolidate all concrete except seal, steel pile jackets, and concrete for incidental construction by the use of mechanical vibrators.

Use minimal mechanical vibration of no more than 3 seconds per insertion for Self-Consolidating Concrete (SCC), when necessary to consolidate the concrete or to avoid obtaining a plane of separation or a cold joint between layers.

400-7.11.2 Vibrators: Provide adequate vibrators on the project that are approved by the Engineer before beginning concrete work. Generally, provide vibrators of the internal type. For thin sections, where the forms are especially designed to resist vibration, the Contractor may use external vibrators. Use a vibrator with a minimum frequency of 4,500 impulses per minute with sufficient intensity and duration to cause complete consolidation of the concrete without causing segregation of the materials. For vibrating thin, heavily reinforced sections, use heads of such size to secure proper vibration of the concrete without disturbance of either the reinforcing bars or the forms.

400-7.11.3 Number of Vibrators Required: Use a sufficient number of vibrators to secure the compaction of each batch before the next batch is delivered, without delaying the delivery. In order to avoid delays due to breakdowns, provide at least one stand-by vibrator, with an appropriate power source.

400-7.11.4 Method of Vibration: Use vibrators to consolidate properly placed concrete. Do not use them to move concrete about in the forms. Insert the vibrators in the surface of concrete at points spaced to ensure uniform vibration of the entire mass of the concrete. Insert the vibrator at points that are no further apart than the radius over which the vibrator is visibly effective. Allow the vibrator to sink into the concrete by its own weight, and allow it to penetrate into the underlying layer sufficiently so that the two layers are thoroughly consolidated together. After thoroughly consolidating the concrete, withdraw the vibrator slowly to avoid formation of holes.

400-7.11.5 Hand Spading: When necessary in order to secure well-filled forms, free from aggregate pockets, honeycomb, bubbles, etc., spade the concrete by hand, along the surfaces of the forms and in all corners, following the vibration.

400-7.12 Columns: Place concrete in columns in one continuous operation for each lift as shown in the Plans.

400-7.13 Slabs and Bridge Decks:

400-7.13.1 Bulkheads, Screed Rails, and Screeding Devices: Strike-off the concrete using an approved metal screed operating on rails or bulkheads. Use devices which do not contain aluminum parts. Prior to placing concrete, provide an approved screed capable of

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striking-off and screeding the surface of the slab or deck to the required shape. Set all necessary bulkheads and screed rails to the required grade. Use bulkheads, screed rails, and screeding devices that permit vertical profile adjustment to the grade, satisfactory for providing straight transverse slopes, differing transverse slopes broken as shown in the Plans and/or transverse slopes with changing grade along the longitudinal length of slab or deck. Locate the screed rails so the entire placement surface can be screeded to grade without using intermediate screed rails, unless approved otherwise by the Engineer.

Use a screed consisting of a truss or heavy beams that will retain it's shape under all working conditions, and a set of rotating drums with a diameter sufficient to carry a 2 inch mortar roll in front of and parallel to the axis of the drums, while making an initial pass. Adjust the drums to prevent mortar buildup forming behind the trailing edges of the drums. For long bridges, as defined in 400-15.2.5.1, provide a device that automatically smoothes the concrete surface to an untextured finish and that is attached to, and is moved by, the rolling drum screed. As an alternate to the drum type screed, a mechanical screed with a metal strike-off may be used. Equip the mechanical screed with mechanical vibrators to provide continuous uniform vibration to the entire length unless otherwise authorized by the Engineer. Small and irregularly shaped areas that cannot be mechanically screeded may be screeded in a manner approved by the Engineer.

400-7.13.2 Screed Demonstration: Subsequent to the placement of all reinforcing bars and prior to placing any slab or deck concrete, demonstrate that the proposed equipment and methods can finish the concrete to the specified grades while maintaining the specified cover over the reinforcement. Provide the demonstration over the entire length and width of the spans to be placed.

400-7.13.3 Screeding Operations: Perform concrete placement and screeding as independently controlled mechanical operations. Ensure that the passing of the screed and forward movement of the screeding equipment are independent of the movement of concrete placement equipment.

Level the concrete in front of the screed as near to the finished grade as possible to prevent the screed from rising off the rail and forming uneven ridges behind the screed. Pass the screed over the slab or deck as many times as necessary to obtain a satisfactory surface and provide a concrete surface true to grade and crown, and free of irregularities.

Do not add water to the concrete surface to assist in finishing operations unless specifically authorized by the Engineer. If the Engineer permits the addition of water, apply only a fog mist, above the concrete surface, by means of approved power driven spray equipment.

For long bridges, as defined in 400-15.2.5.1, do not manually or mechanically float the concrete surface or apply a texture by broom or any other device to the concrete surface produced by the screeding process. Correct isolated surface irregularities in accordance with 400-15.2.5.3.

400-7.13.4 Placing Operations: Select an approved concrete design mix which ensures complete placement of all slab or deck concrete between construction joints before initial set begins in the plastic concrete. On placements of 50 yd^3 or less, the minimum placement rate is 20 cubic yards per hour. On placements of greater than 50 cubic yards, the minimum placement rate is 30 cubic yards per hour.

The Engineer will not permit slab or deck placements until an acceptable plan for meeting the minimum placement rate is approved.

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400-7.13.5 Concrete Decks on Steel Spans: Where concrete decks are placed on steel spans, release the temporary supports under the bridge before placing any concrete.

400-7.13.6 Concrete Decks on T-Beams: For cast-in-place T-beam construction, cast the slabs and beams in one continuous operation. As an exception, where special shear anchorage or keys are provided for in the Plans or approved by the Engineer, the beams and slabs may be constructed in successive placements.

400-7.13.7 Diaphragms: Place concrete diaphragms at least 48 hours before the bridge deck slabs are placed unless otherwise indicated in the Plans.

400-7.13.8 Weather Protection: Provide an approved means of protecting unhardened concrete from rain. Position the protection system to shield the concrete from rain and running water. Provide a shield impervious to water over the slab or deck concrete, of sufficient size to protect all areas of slab or deck concrete subject to water damage, and include a means of intercepting and diverting water away from freshly placed concrete. Arrange the equipment so that the weather protection system can be erected over unhardened concrete. When there is a possibility of rain during concrete placement operations, place the weather protection system in stand-by readiness, capable of being deployed in a timely manner. Use the weather protection immediately when rain begins so that slab or deck concrete damage will not occur. Do not place concrete during rain.

Assume responsibility for damage to the slab or deck in the case of failure of the weather protection system.

400-7.14 Concrete Box Culverts: In general, place the base slab or footing of concrete box culverts, and allow them to set before constructing the remainder of the culvert. In this case, make suitable provision for longitudinal keys. Construct bottom slabs, footings, and apron walls as a monolith if practicable. Where transverse construction joints are necessary, place them at right angles to the culvert barrel, and make suitable provision for keys.

In the construction of box culverts having walls 6 feet or less in height, the sidewalls and top slab may be constructed as a monolith or may place the concrete in the walls and allow it to set before placing the top slab concrete.

Where the height of the box culvert walls exceed 6 feet, place the walls, and allow the concrete to set at least 12 hours before placing the top slab concrete. In such cases, form keys in the sidewalls.

When casting the walls and top slabs of box culverts as a monolith, ensure that any necessary construction joints are vertical. Design all construction joints with formed keys. Provide keys that are beveled as shown in the Plans or as directed, but do not allow the edge of the beveled material forming the key to be less than 1 1/2 inches from the edge of the concrete.

Construct each wingwall, if possible, as a monolith. Ensure that construction joints, where unavoidable, are horizontal and so located that no joints will be visible in the exposed face of the wing above the finished graded surface.

Precast box culvert sections may be used in lieu of cast-in-place box culvert construction provided the provisions in Section 410 are satisfied.

400-8 Seals.

400-8.1 General: Wherever practicable, dewater all foundation excavations, and deposit the concrete in the dry as defined in 455-15.2. Where conditions are encountered which render it impracticable to dewater the foundation before placing concrete, the Engineer may authorize the construction of a concrete foundation seal of the required size. Then, dewater the foundation, and place the balance of the concrete in the dry.

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When required to place seal concrete, the Contractor is responsible for the satisfactory performance of the seal in providing a watertight excavation for placing structural concrete. The Department will provide and pay for the seal concrete as an aid to the construction of the structure. Repair seal concrete as necessary to perform its required function at no expense to the Department.

400-8.2 Method of Placing: Carefully place concrete deposited under water in the space in which it is to remain by means of a tremie, a closed-bottom dump bucket of not less than 1 cubic yard capacity, or other approved method. Do not disturb the concrete after depositing it. Deposit all seal concrete in one continuous placement. Do not place any concrete in running water, and ensure that all form work designed to retain concrete under water is watertight.

400-8.3 Use of Tremie: Use a tremie consisting of a tube having a minimum inside diameter of 10 inches, constructed in sections having water-tight joints. Do not allow any aluminum parts to have contact with the concrete. Ensure that the discharge end is entirely seated at all times, and keep the tremie tube full to the bottom of the hopper. When dumping a batch into the hopper, keep the tremie slightly raised (but not out of the concrete at the bottom) until the batch discharges to the bottom of the hopper. Stop the flow by lowering the tremie. Support the tremie such as to permit the free movement of the discharge end over the entire top surface of the work and to permit its being lowered rapidly when necessary to choke off or retard the flow. Provide a continuous, uninterrupted flow until completing the work. Exercise special care to maintain still water at the point of deposit.

400-8.4 Time of Beginning Pumping: Do not commence pumping to dewater a sealed cofferdam until the seal has set sufficiently to withstand the hydrostatic pressure, and in no case earlier than 72 hours after placement of the concrete.

400-9 Construction Joints.

400-9.1 Location: Make construction joints only at locations shown in the Plans or in the placement schedule, unless otherwise approved in writing. If not detailed in the Plans or placement schedule, or in case of emergency, place construction joints as directed.

400-9.2 Provisions for Bond and Transmission of Shear: Use shear key reinforcement where necessary to transmit shear or to bond the two sections together.

400-9.3 Preparations of Surfaces: Before depositing new concrete on or against concrete which has hardened, re-tighten the forms. Roughen the surface of the hardened concrete in a manner that will not leave loosened particles, aggregate, or damaged concrete at the surface. Thoroughly clean the surface of foreign matter and laitance, and saturate it with water.

400-9.4 Placing Concrete: Continuously place concrete from joint to joint. Carefully finish the face edges of all joints which are exposed to view true to line and elevation.

400-9.5 Joints in Sea Water or Brackish Water: For concrete placed in sea water or brackish water, do not place any construction joints between points 2 feet below the mean low water elevation and 6 feet above the mean high water elevation.

400-9.6 Joints in Long Box Culverts: For long concrete box culverts, vertical construction joints may be placed at a spacing not less than 30 feet. When using transverse construction joints, ensure that longitudinal reinforcing is continuous through the joint and that the joint is vertical.

400-9.7 Crack Control Grooves in Concrete Bridge Decks: When the Plans require crack control grooves in the top surface of decks, either install a tooled “V” groove prior to initial concrete set or saw a groove using an early entry dry cut saw. When using an early entry dry cut saw, operate in accordance with the manufacturer’s recommendations. Commence

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sawing as soon as the concrete has hardened enough to permit standing on the surface without leaving visible tracks or impressions and before uncontrolled concrete cracks occur.

400-10 Expansion Joints.

400-10.1 General: After meeting the smoothness criteria in 400-15, construct expansion joints to permit absolute freedom of movement. Carefully remove all loose or thin shells of mortar likely to cause a spall with movement at a joint from all expansion joints as soon as possible.

400-10.2 Sealed Joints: Fill expansion joints with a preformed joint filler. Cut the filler to conform to the cross-section of the structure, and furnish it in as few pieces as practicable, using only a single piece in each curb section. Do not use small pieces that would tend to come loose. Prepare joints to be sealed and apply the sealer in accordance with approved manufacturer's directions.

400-10.3 Joint System Installation: Install expansion joints before or after the deck planing required by 400-15.2.5.5 following the manufacturer's instructions. When installed after deck planing, install the edge rail assemblies in the blockouts on a profile tangent between the ends of the deck and/or approach slab to within a plus 0 and minus1/4 inch variation.

When installed before deck planing, install the edge rail assemblies 3/8 inch, plus or minus 1/16 inch, below the top surface of the deck or approach slab to compensate for concrete removal during planing.

400-11 Contact and Bearing Surfaces.

400-11.1 Separation of Surfaces: In general, separate all contact surfaces between superstructure and substructure or end walls and between adjacent superstructure sections by a layer of ASTM D6380 Class S, Type III organic felt. When an organic felt bond breaker is specified for other structures, use either one layer of ASTM D6380 Class S, Type III or two layers of ASTM D226 Type II organic felt.

400-11.2 Finishing of Bearing Surfaces: Construct bearings surfaces (areas) to the tolerances as specified herein and in the other parts of the Contract Documents. When using neoprene bearing pads, finish the concrete surface to a uniform 'rough' texture using a burlap drag, fine bristle broom or float. For metal or high load rotational bearings, fill minor depressions, 1/8 inch maximum, caused by finishing, bush hammering, or grinding with a low-viscosity epoxy meeting the requirements of 926-1, Type F-2, applied by the use of a squeegee. Bearing surfaces may be ground to final position with carborundum. Check all bearing surfaces with a metallic straightedge prior to setting bearings or neoprene pads.

400-11.2.1 Deviation from Specified Elevations for Steel Beam Superstructures: Construct to the elevation shown on the Plans plus or minus 0.01 feet and do not exceed a 0.01 feet difference between specified elevations of bearing areas of adjacent bearings measured between the centerlines of bearing areas.

400-11.2.2 Deviation from Specified Elevations for Concrete Beam Superstructures: Construct to the elevation shown on the Plans plus or minus 0.02 feet.

400-11.2.3 Projecting Irregularities: Projecting irregularities will not exceed 1/16 inch.

400-11.2.4 Variations in Flatness for Neoprene Pads: In any direction, the pad is to be flat to within 1/16 inch. Pads designated to be sloped are not to deviate from the theoretical slope by the same amount.

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400-11.2.5 Variations in Flatness for Metal or High Load Rotational Bearings: Construct the bearing area to the tolerance indicated for the measured length along the orthogonal axes.

Bearing area length up to 30 inches long to plus or minus 1/16 inch.

Bearing area length over 30 inches up to 45 inches long to plus or minus 3/32 inch.

Bearing area length over 45 inches long to plus or minus 1/8 inch.

400-11.3 Bearing Pads: Use bearing pads for seating bridge shoes, ends of beams, and slabs of the types specified or required in the Plans.

Furnish and install neoprene pads as detailed in the Plans. Place neoprene pads, where specified or required, directly on concrete surfaces finished in accordance with the requirements of this Article. Ensure that pads, bearing areas of bridge seats, and metal bearing plates are thoroughly cleaned and free from oil, grease, and other foreign materials.

Exercise care in fabrication of related metal parts to avoid producing conditions detrimental to the performance of the pads, such as uneven bearing, excessive bulging, etc.

The Engineer will evaluate the degree of deformation and condition of bearing pads in the completed bridge on or before the final inspection required by 5-10 or when requested by the Contractor. As directed by the Engineer, correct horizontal bearing pad deformations that at the time of inspection exceed 50% of the bearing pad thickness or that the Engineer predicts will exceed 50% of the bearing pad thickness during future high or low temperature periods. Payment for this correction effort will be considered extra work in accordance with 4-3.

400-12 Anchor Bolts and Dowels.

Set anchor bolts and dowels as specified in Section 460.

Galvanize all anchor bolts as specified in Section 962.

400-13 Epoxy Bonding Compounds.

Where epoxy bonding compounds for bonding concrete are specified or required, apply the epoxy bonding materials only to clean, dry, structurally sound concrete surfaces. Provide surface preparation, application, and curing of epoxy bonding compound in strict accordance with the manufacturer's recommendations for each particular application.

400-14 Removal of Forms.

Use the table below as the criterion for minimum time or compressive strength required before removal of forms or supports.

When using the time period criterion, include in the time period all days except days in which the temperature falls below 40ºF.

Use the specified 28-day minimum compressive strength value as stated in 346-3.1 for each Class of Concrete utilized.

Table 400-2

Location of Concrete Placement	Minimum Time for Form Removal for any Strength Concrete*	Minimum (%) of 28-day Compressive Strength for Form Removal
(1) Deck slabs, top slabs of culverts and bottom of caps, forms under sidewalks, and safety curb overhangs extending more than 2 feet		

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Table 400-2		
Location of Concrete Placement	Minimum Time for Form Removal for any Strength Concrete*	Minimum (%) of 28-day Compressive Strength for Form Removal
(a) Class II Bridge Deck	7 days**	75**
(b) Class II (Other than Bridge Deck)	7 days	75
(c) Class III	7 days	70
(d) Class IV	7 days	60
(e) Class V	7 days	50
(2) Walls, piers, columns, sides of beams and other vertical surfaces	24 hours***	50***
(3) Front face form of curbs	6 hours	70
* For mass concrete, remove forms in accordance with Section346. ** Reference 400-16.4 ***Do not place additional load on the section until 70% of the specified 28-day concrete strength is attained. Also, refer to 400-7.4.		

When using the percent of required strength, cast test cylinders for each mix for compressive strength determination, develop a curing concrete strength versus time curve (S/T Curve) or a strength-maturity curve. Either curve may be used in lieu of multiple test cylinders to determine when the percent of required strength has been met.

Prior to use, obtain the Engineer's approval of the S/T Curve and its supporting data. An approved testing laboratory may be used to provide this information with approval of the Engineer. Plot S/T Curves using at least three different elapsed times that begin once test cylinders are cast; however, one of the elapsed times must be prior to the Contractor's intended form removal. Each elapsed time plotted must have a corresponding compressive strength computed by averaging the compressive strength of two test cylinders.

Cure such test cylinders as nearly as practical in the same manner as the concrete in the corresponding structural component, and test them in accordance with ASTM C39 and ASTM C31. Perform cylinder casting, curing, and testing at no expense to the Department and under the observation of the Engineer. When the S/T Curve indicates a compressive strength equal to or greater than the percentage of specified strength shown in the table above for form removal, the Contractor may remove the forms. When the ambient air temperature falls 15ºF or more below the ambient air temperature that existed during development of a S/T Curve, use a S/T Curve that corresponds to the lower temperature and that is developed in accordance with this section.

Prior to using the strength-maturity method, obtain the Engineer's approval of the strength-maturity curve and its supporting data. Estimate the strength development of concrete using the strength-maturity method in accordance with ASTM C1074. An approved testing laboratory may be used to provide this information with approval of the Engineer. Develop the strength-maturity curves at no expense to the Department.

Do not remove forms at any time without the consent of the Engineer. Even when the Engineer provides consent to remove the forms, the Contractor is responsible for the work.

400-15 Finishing Concrete.

400-15.1 General Surface Finish (Required for All Surfaces): After placing and consolidating the concrete, strike-off all exposed surfaces to the lines and grades indicated in the

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Plans in a manner that will leave a surface of uniform texture free of undesirable surface irregularities, cavities, and other defects. Cut back metal ties supporting reinforcement, conduit, and other appurtenances a minimum of 1 inch from finished surface. After removing excess mortar and concrete and while the concrete is still in a workable state, carefully tool all construction and expansion joints. Leave joint filler exposed for its full length with clean edges. Ensure that finished work in addition to that specified above is compatible and complementary to the class of surface finish required.

Remove all laitance, loose material, form oil and curing compound from exposed surfaces that do not require forming and from exposed surfaces requiring forming, after form removal. Remove fins and irregular projections flush with the surface. Clean, saturate with water, and fill all holes, tie cavities, honeycomb, chips and spalls. Prior to filling, prepare the surface to ensure that patching mortar will bond to the existing concrete. Exercise care during the roughening process to prevent excessive defacement and damage to the surface of the existing concrete. Use patching mortar blended from the mix ingredients of the existing concrete. Ensure the patching mortar closely matches the color of the existing concrete when fully cured. As an alternative, mortar consisting of the following materials may be used: 4 parts of ordinary gray portland cement, 1/2 part of white portland cement, 1 part of coal ash and 2 to 4 parts of sand. The blended mortar must closely match the color of the filled element once fully cured and the proportion of white portland cement may be adjusted to achieve as close a match as possible. Regardless of the type patching mortar used, provide a mortar surface closely resembling the existing surface.

Cure the newly placed mortar using a curing blanket or a Type I clear curing compound at a uniform coverage as recommended by the manufacturer, but not less than 0.06 gallon per square yard.

In the event unsatisfactory surfaces are obtained, repair these surfaces by methods approved by the Engineer or the affected concrete will be rejected. Repair any surface or remove rejected concrete at no expense to the Department.

400-15.2 Surface Finishes:

400-15.2.1 General: In addition to the general surface work specified for all exposed concrete surfaces, the Engineer may require one of the classes of surface finish listed below. For all such exposed surfaces, begin finish work for the applicable class specified, along with the general finish work, immediately after removal of the forms. In order to further ensure the required quality of the finish, remove forms no later than the minimum time specified for the forms to remain in place. Satisfactorily repair finished concrete surfaces which are subsequently disfigured or discolored at no expense to the Department.

Provide the required class of surface finish for the various items of structural concrete as shown in the Plans.

400-15.2.2 Class 1 Surface Finish: As soon as the pointing has sufficiently set, thoroughly saturate the exposed surfaces with water, and rub them with a medium coarse carborundum stone. Continue rubbing until the surface has been ground to a paste and remove all form marks, irregularities, and projections. In this process, do not introduce any additive material other than water. After the rubbing has produced a smooth surface of uniform color, allow the material which has been ground to a paste to reset under proper curing conditions. Subsequently, as a second operation, re-saturate the concrete surfaces with water, and thoroughly rub them with a fine carborundum stone. Continue this rubbing until the surface has a smooth, fine grain texture of uniform color.

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The Contractor may substitute a Class 5 applied finish coating in accordance with 400-15.2.6 as an alternate surface finish on all areas where Class 1 surface finish is specified.

400-15.2.3 Class 2 Surface Finish: As soon as pointing has sufficiently set, thoroughly saturate the exposed concrete surfaces with water and rub them with a medium coarse carborundum stone. Continue rubbing until the surface has been ground to a paste and remove all form marks, irregularities, and projections. In this process, do not introduce any additive material other than water.

After rubbing has produced a smooth surface finish, of uniform color, carefully brush the material which has been ground to a paste to a uniform texture, and allow it to reset under proper curing conditions. Carefully protect these surfaces from disfigurement and discoloration during subsequent construction operations.

400-15.2.4 Class 3 Surface Finish: Where this surface finish is specified, use forms with a form liner. Where specified or required on the Plans, use No. 89 coarse aggregate for concrete.

After concrete has been placed in the forms and compacted, finish all exposed surfaces which are not contained by the forms to produce a surface texture as nearly equal to that produced by the form as practicable. Generally, finish unformed surfaces to a smooth, dense surface with a steel trowel.

Perform all work, including general surface finish work, in a manner that will preserve the same surface texture and color produced by the form liner. Pointed areas may be rubbed with a dry carborundum stone.

400-15.2.5 Class 4 Deck Finish:

400-15.2.5.1 General: Apply a Class 4 finish on bridge decks and concrete approach slabs. On Short Bridges (bridges having a length less than or equal to 100 feet), and on Miscellaneous Bridges (Pedestrian, Trail and Movable Spans) regardless of length, meet the finish and smoothness requirements of 400-15.2.5.2 and 400-15.2.5.4. On Long Bridges (bridges having a length greater than 100 feet) meet the finish and smoothness requirements of 400-15.2.5.3 and 400-15.2.5.5. When an existing bridge deck is widened, see the Plans for the finish and smoothness requirements of the existing bridge deck and its new widened section. After meeting the screeding requirements of 400-7.13 and curing requirements of 400-16 and the smoothness requirements, herein, groove the bridge deck and approach slabs.

Regardless of bridge length, finish decks with less than 2 1/2 inches of top cover in accordance with the requirements for Short Bridges.

400-15.2.5.2 Plastic Surface Finish for Short and Miscellaneous Bridges: After screeding is completed, check the surface of the plastic concrete with a 10 foot straightedge, positioning and half-lapping the straightedge parallel to the centerline to cover the entire surface. Immediately correct deficiencies of more than 1/8 inch, measured as an ordinate between the surface and the straightedge.

Finish the concrete surface to a uniform texture using a burlap drag, fine bristle broom or float. Finish the deck to a smooth surface having a sandy texture without blemishes, marks or scratches deeper than 1/16 inch.

400-15.2.5.3 Plastic Surface Finish for Long Bridges: Do not moisten, manually float or apply texture to the concrete surface after the screed, with attached smoothing device, has passed unless correction of isolated surface irregularities is warranted and this should

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be done as soon as possible after screeding while the concrete is plastic. Correct all flaws such as cavities, blemishes, marks, or scratches that will not be removed by planing.

If the Engineer permits the addition of water when correcting flaws, apply moisture to the concrete surface only if required and only in the immediate vicinity of the isolated irregularity. Apply a quantity of moisture not greater than what is needed to facilitate correction of the irregularity and apply only a fog mist, above the concrete surface, by power driven spray equipment approved by the Engineer.

400-15.2.5.4 Smoothness Requirements for Short Bridges and Miscellaneous Bridges (including approach slabs): Perform a final straightedge check with a 10 foot straightedge, positioning and half-lapping the straightedge parallel to the centerline, approximately 5 feet apart to cover the entire surface. Correct all irregularities greater than 3/16 inch measured as an ordinate to the straightedge, by grinding. Perform grinding by the abrasive method using hand or power tools or by machine, to leave a smooth surface within a 1/8 inch tolerance.

400-15.2.5.5 Smoothness Evaluation and Concrete Surface Planing, Long Bridges (including approach slabs): Prior to planing, provide a smoothness evaluation of the completed bridge deck and exposed concrete surfaces of approach slabs by a computerized California-type profilograph in accordance with the criteria herein and FM 5-558. Furnish this evaluation through an independent provider approved by the Engineer, using equipment calibrated by the Engineer. All bridge deck and concrete approach slab surfaces within 2 feet of gutter lines are subject to this smoothness evaluation.

Prior to initial profilograph testing, complete work on the bridge deck and approach slabs. Thoroughly clean and clear the bridge deck and approach slab areas to be evaluated for smoothness of all obstructions and provide the smoothness evaluation. Ensure that no radio transmissions or other activities that might disrupt the automated profilograph equipment are allowed during the evaluation.

Average the Profile Index Value for the bridge deck, including the exposed concrete surfaces of the approach slabs, for the left and right wheel path of each lane. The maximum allowable Profile Index Value for acceptable smoothness is 10 inches per mile utilizing the 0.2 inch blanking band. Apply these criteria to a minimum of 100 feet of each lane. Additionally, correct individual bumps or depressions exceeding a cutoff height of 0.3 inch from a chord of 25 feet (see ASTM E1274) on the profilograph trace. Ensure that the surface meets a 1/4 inch in 10 feet straightedge check made transversely across the deck and approach slabs if determined necessary by the Engineer. Provide additional profilograph testing as necessary following longitudinal planing and any other actions taken to improve smoothness, until a profile meeting the acceptance criteria is obtained.

Regardless of whether expansion joints are installed before or after deck planing is complete, plane off the concrete deck surface to a minimum depth of 1/4 inch and also meet or exceed the profilograph smoothness criteria. Longitudinally plane the entire bridge deck and exposed concrete surfaces of the approach slabs using a self-propelled planing machine with gang mounted diamond saw cutting blades specifically designed for such work. Use the profilograph generated smoothness data, to establish the optimum planing machine settings. Plane the deck surface to within 2 feet of the gutter line so that there is a smooth transition, without vertical faces or sudden surface discontinuities, from the fully planed surface to the unplaned surface. Use a machine with a minimum wheel base length of 15 feet, constructed and operated in such manner that it does not cause strain or damage to deck or

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approach slab surfaces, excessive ravels, aggregate fractures or spalling. The equipment shall be approved by the Engineer. Perform longitudinal planing parallel to the roadway centerline, and provide a consistent, textured surface. Clean the surface of all slurry/debris generated during this work concurrently with operation of the machine.

After the deck has been planed the minimum 1/4 inch, reevaluate the surface smoothness using the profilograph testing described above. Perform cycles of planing and profilograph retesting as necessary until the deck and exposed concrete surfaces of approach slabs are in compliance with the smoothness criteria but do not exceed the maximum concrete removal depth of 1/2 inch.

400-15.2.5.6 Grooving: After the concrete surface profile, as required by 400-15.2.5, has been accepted by the Engineer, and prior to opening the bridge to traffic, groove the bridge deck and approach slabs perpendicular to the centerline of the structure. Do not groove the deck surface of pedestrian or trail bridges unless otherwise shown in the Contract Documents. Cut grooves into the hardened concrete using a mechanical saw device which will leave grooves nominally 1/8 inch wide and 3/16 inch deep. Space the grooves apart in random spacing center of grooves in the following sequence: 3/4 inch, 1-1/8 inch, 5/8 inch, 1 inch, 5/8 inch, 1-1/8 inch, 3/4 inch in 6 inch repetitions across the width to be grooved in one pass of the mechanical saw device. One 6 inch sequence may be adjusted by 1/4 sequence increments to accommodate various cutting head widths provided the general pattern is carried out. The tolerance for the width of the grooves is plus 1/16 inch to minus 0 inch and the tolerance for the depth of grooves is plus or minus1/16 inch. The tolerance for the spacing of the grooves is plus or minus1/16 inch.

Cut grooves continuously across the deck or approach slab to within 18 inches of gutter lines at traffic railing, curb line and median divider. At skewed metal expansion joints in bridge deck surfaces, adjust groove cutting by using narrow width cutting heads so that all grooves of the bridge deck surface or approach slab surface end within 6 inches, measured normal to centerline of the joint, leaving no ungrooved surface adjacent to each side of the joint greater than 6 inches in width. Ensure that the minimum distance to the first groove, measured normal from the edge of the concrete joint or from the junction between the concrete and the metal leg of the armored joint angle, is 1 inch. Produce grooves that are continuous across construction joints or other joints in the concrete surface less than 1/2 inch wide. Apply the same procedure described above where the gutter lines at traffic railing, curb lines and median dividers are not parallel to the centerline of the bridge to maintain the 18 inches maximum dimension from the grooves to the gutter line. Cut grooves continuously across formed concrete joints.

400-15.2.6 Class 5 Applied Finish Coating:

400-15.2.6.1 General: Place an applied finish coating upon all concrete surfaces where the Plans indicate Class 5 applied finish coating. Apply the finish coating after completion of the general surface work specified for all exposed concrete surfaces.

400-15.2.6.2 Material: For the coating material, use a commercial product designed specifically for this purpose. Use only coating material that is manufactured by one manufacturer and delivered to the job site in sealed containers bearing the manufacturer's original labels. Submit the manufacturer's written instructions to the Engineer.

400-15.2.6.3 Surface Preparation: Prepare the surface prior to the application of an applied finish coating by providing a surface finish in accordance with the requirements of 400-15.1. The Engineer will not require surface voids that are 1/4 inch or less in

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width and depth to be grouted prior to application of the finish coating. Fill surface void larger than 1/4 inch in width and depth an approved high strength, non metallic, non shrink grout meeting the requirements of Section 934, mixed and applied in accordance with the manufacturer's recommendations. Apply the grout by filling the surface voids using burlap pads, float sponges, or other acceptable methods. As soon as the grout has taken its initial set, brush the surface to remove all loose grout, leaving the surface smooth and free of any voids. Ensure that the surface to be coated is free from efflorescence, flaking coatings, curing compound, dirt, oil, and other substances deleterious to the applied finish coating. Prior to application of the finish coating onto precast or cast-in-place concrete surfaces, test the concrete surface at 30 foot intervals for the presence of curing compound using one or two drops of muriatic acid placed on the concrete surface. If curing compound is present, there will be no reaction between the acid and the concrete. If there is no reaction, remove the compound by pressure washing the concrete surfaces. Prepare the surfaces in accordance with the manufacturer's recommendations, and ensure that they are in a condition consistent with the manufacturer's requirements. Clean surfaces of existing structures in accordance with 400-19.

400-15.2.6.4 Application: Apply the finish coating utilizing a method recommended by the manufacturer. When applying the finish coating by spraying, supply heavy duty spray equipment capable of maintaining a constant pressure necessary for proper application. Mix and cure all coating materials in accordance with the manufacturer's written instructions. Apply the finished coating at a rate of 50, plus or minus 10 square feet per gallon.

400-15.2.6.5 Finished Product: Produce a texture of the completed finish coat that is generally similar to that of rubbed concrete. Ensure that the completed finished coating is tightly bonded to the structure and presents a uniform appearance and texture. If necessary, apply additional coats to produce the desired surface texture and uniformity.

Upon failure to adhere positively to the structure without chipping, flaking, or peeling, or to attain the desired surface appearance, remove coatings entirely from the structure, and reapply the finish coating after surface preparation until achieving the desired finished product. Do not allow the average thickness of the completed finish coating to exceed 1/8 inch.

400-15.2.6.6 Material Tests and Certification: Before any portion of any shipment of finish coating is applied on the project, submit to the Engineer a certificate from the manufacturer attesting that the commercial product furnished conforms to the same formula as that previously subjected to the tests specified in Section 975. In addition, submit the following product analysis, obtained from the manufacturer, for each batch of the material used:

1. Weight per gallon.
2. Consistency (Krebs Units).
3. Weight percent pigment.
4. Weight percent vehicle solids.
5. Infra-red spectra of vehicle solution.

400-15.2.7 Final Straightedging for Surfaces to Receive Asphalt Concrete Surface: Test the slab surfaces of poured-in-place decks which are to be surfaced with an asphalt concrete wearing course for trueness with a 10 foot straightedge, as specified above. As an exception, correct only irregularities of more than 1/4 inch measured as an ordinate (either above or below the general contour of the surface). The Engineer will not require belting or brooming of slabs that are to be surfaced with an asphalt concrete wearing course. For curing, meet the requirements specified for other deck slabs.

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400-15.2.8 Finishing Bridge Sidewalks: Finish bridge sidewalks in accordance with the applicable requirements of Section 522.

400-16 Curing Concrete.

400-16.1 Internal curing: At the Contractor's option use internal curing in combination with one or more of the external curing methods listed in this Section. Use lightweight fine aggregates from Department-approved sources meeting the requirements of ASTM C1761.

400-16.2 External curing: Cure cast-in-place and precast (non-prestressed) concrete as required herein for a minimum duration of 72 hours. If forms are loosened or removed before the 72 hour curing period is complete, expand the curing to cover these surfaces by either coating with curing compound or extending the continuous moist cure area.

Until curing has begun, retain concrete surface moisture at all times by maintaining a surface moisture evaporation rate less than 0.1 pound per square foot per hour. Periodically, at the site of concrete placement prior to and during the operation, measure the ambient air temperature, relative humidity and wind velocity with industrial grade weather monitoring instruments to determine the on-site evaporation rate. If the evaporation is, or is likely to become 0.1 pound per square foot per hour or greater, employ measures to prevent moisture loss such as application of evaporation retarder, application of supplemental moisture by fogging or reduction of the concrete temperature during batching. Compute the evaporation rate by using the nomograph in the ACI manual of Concrete Practice Part 2, Section 308R Guide to Curing Concrete, or by using an evaporation rate calculator approved by the Engineer.

400-16.2.1 Methods: Except where other curing methods are specified, select from the following options the chosen method(s) for curing all concrete components.

1. Continuous Moisture: Place burlap on the surface and keep it continuously saturated for the curing period by means of soaker hoses or automatic sprinklers. Water flow may be metered to cycle repetitively for five minutes on and five minutes off during the 72 hour curing period. Do not apply moisture manually. If side forms are loosened or removed during the curing period, extend the burlap so as to completely shield the sides of the members.

2. Membrane Curing Compound: Apply a white Type 2 curing compound to all surfaces at a uniform coverage as recommended by the manufacturer but not less than 0.06 gallon per square yard. Allow surfaces covered by the membrane curing compound to remain undisturbed for the curing period. Recoat any cracks, checks or other defects in the membrane seal which are detected during the curing period within one hour. If side forms are loosened during the curing period, maintain surface moisture and remove the forms within one hour and immediately coat the formed surfaces with a membrane curing compound. Bottom surfaces shall be similarly coated after removal of or from the forms.

If curing compound is to be applied by spraying, use a compressor driven sprayer of sufficient size to provide uniform mist. Standby equipment is required in case of mechanical failure and hand held pump-up sprayers may be used only as standby equipment.

3. Curing Blankets: Curing blankets may be used for curing the top surfaces of members while the member side forms remain in place. Do not use curing blankets which have been torn or punctured. Securely fasten all edges to provide as tight a seal as practical. Should the system fail to maintain a moist condition on the concrete surface, discontinue use of the blankets and continue curing using another method. Keep curing blankets in place for the duration of the curing period.

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4. Accelerated Cure:

a. General: Accelerated curing of the concrete can be achieved by use of either low pressure steam curing, radiant heat curing or continuous moisture and heat curing. If accelerated curing is completed before the 72 hour curing period has elapsed, continue curing for the remaining part of the 72 hour curing period in accordance with one of the curing methods listed above.

If accelerated curing is used, furnish temperature recording devices that will provide accurate, continuous and permanent records of the time and temperature relationship throughout the entire curing period. Provide one such recording thermometer for each 200 feet of placement length or part thereof. Initially calibrate recording thermometers and recalibrate at least annually.

The preheating period shall equal or exceed the time of initial set as determined by ASTM C403 and shall not be less than 4 hours. When the ambient air temperature is above 50ºF, allow the member to remain undisturbed in the ambient air for the preheating period. If the ambient air temperature is below 50ºF, apply heat during the preheating period to hold the air surrounding the member at a temperature of 50 to 90ºF.

To prevent moisture loss from exposed surfaces during the preheating period, enclose members as soon as possible after casting or keep the surfaces wet by fog mist or wet blankets. Use enclosures for heat curing that allow free circulation of heat about the member with a minimum moisture loss. The use of tarpaulins or similar flexible covers may be used provided they are kept in good repair and secured in such a manner to prevent the loss of heat and moisture. Use enclosures that cover the entire placement.

During the application or removal of the heat, do not allow the temperature rise or fall within the enclosure to exceed 40ºF per hour. Do not allow the curing temperature throughout the enclosure to exceed 160ºF. Maintain the curing temperature within a temperature range of 130 to 160ºF until the concrete has reached the required form removal strength for precast and cast-in-place components or the required release strength for prestressed concrete components.

b. Low-Pressure Steam: The steam used shall be in a saturated condition. Do not allow steam jets to impinge directly on the concrete, test cylinders, or forms. Cover control cylinders to prevent moisture loss and place them in a location where the temperature is representative of the average temperature of the enclosure.

c. Curing with Radiant Heat: Apply radiant heat by means of pipes circulating steam, hot oil or hot water, or by electric heating elements. Do not allow the heating elements to come in direct contact with the concrete or the forms. Distribute sources of heat in a manner that will prevent localized high temperatures above 160ºF. To prevent moisture loss during curing, keep the exposed surfaces wet by fog mist or wet blankets.

d. Continuous Moisture and Heat: This method consists of heating the enclosure in combination with the continuous moisture method described above.

In addition to the curing blankets, an auxiliary cover for retention of the heat will be required over the entire placement. Support this cover at a sufficient distance above the placement being cured to allow circulation of the heat.

400-16.3 Silica Fume Concrete: Cure silica fume concrete a minimum of 72 hours using continuous moisture cure. No substitution of alternative methods nor reduction in the time period is allowed. After completion of the 72 hour curing period, apply a membrane curing compound to all concrete surfaces. Apply curing compound according to 400-16.2.

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400-16.4 Bridge Decks and Approach Slabs: Cure bridge decks and approach slabs for a duration of seven days. Apply a membrane curing compound to the top surface in accordance with 400-16.2 using a compressor driven sprayer. In general, apply curing compound when the surface is damp and after all pooled water has evaporated. For Short bridges, begin applying curing compound immediately after the initially placed concrete has been floated, straightedged, textured and a damp surface condition exists and continue applying compound as concrete placement progresses with as little interruption as possible until the entire top surface has been coated with compound. For Long bridges, begin applying curing compound to the initially placed concrete as soon as a damp surface condition exists and continue applying compound as concrete placement progresses with as little interruption as possible until the entire top surface has been coated with compound. For all bridges, the elapsed time between the initial placement of deck or approach slab concrete and the completed application of curing compound must not exceed 120 minutes. The 120 minute limit may be extended by the Engineer if project specific factors (cool temperatures, high humidity, retarding admixtures, etc.) prolong wet surface conditions.

Prior to the first deck or approach slab placement, submit to the Engineer the method that will be used to periodically measure the rate of application of curing compound in, gallons per square foot as the concrete placement progresses. Prior to the placement of each deck or approach slab, submit to the Engineer the anticipated quantity of curing compound in gallons along with the corresponding square feet of concrete to be covered to meet the coverage rate in 400-16.2. Compute the actual quantity of curing compound applied at the conclusion of each concrete placement and submit the quantity to the Engineer. Apply the curing compound from a work platform.

Place curing blankets on all exposed surfaces which are not formed as soon as possible with minimal effect on the surface texture. Place the curing blankets with sufficient overlapping seams to form an effective moisture seal. Before using curing blankets, mend tears, splits, or other damage that would make them unsuitable. Discard curing blankets that are not repairable. Wet all curing blankets immediately after satisfactorily placing them and maintain them in a saturated condition throughout the seven-day curing period. Supply sufficient quantity of water meeting the requirements of Section 923 at the job site for wetting the blankets.

Where a bridge deck or approach slab is to be subjected to walking, wheeling or other approved construction traffic within the seven-day curing period, protect the curing blankets and the concrete surface from damage by placing wooden sheeting, plywood or other approved protective material in the travel areas.

When the ends of the curing blankets are rolled back to permit screeding of adjacent concrete, keep the exposed surfaces wet throughout the period of exposure.

Bridge deck bottom and side forms may be removed after 72 hours upon compliance with 400-14. Approach slab side forms may be removed after 72 hours. Apply membrane curing compound to all surfaces stripped of forms within one hour of loosening. Apply curing compound according to 400-16.2.

400-16.5 Construction Joints: Cure construction joint areas using either the continuous moisture or curing blankets method.

400-16.6 Concrete Barriers, Traffic Railings, Parapets and End Post: Ensure concrete is cured in accordance with 400-16.2(2), except that a clear Type 1-D curing compound that must contain a fugitive dye may be used in lieu of Type 2. If Type 1-D is used, its removal per 400-15.1 during finishing is not required. When construction is by the slip form method, coat

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all concrete surfaces with a curing compound that meets the requirements of 925-2, either within 30 minutes of extrusion or before the loss of water sheen, whichever occurs first. Ensure a curing compound coating period of not less than seven days after application. Prior to each concrete placement, submit to the Engineer the method that will be used to periodically measure the rate of application in gallons per square foot. Also, prior to each placement, submit to the Engineer the anticipated quantity of curing compound in gallons that will be used to meet the coverage rate specified in 400-16.2 along with the corresponding square footage of concrete barriers, traffic railings, parapets and end posts to be coated with that quantity. Measure the actual quantity of curing compound that is applied during each concrete placement and submit the quantity to the Engineer. Applied finish coatings that are flagged as permitted for use as a curing compound, may be used in lieu of a curing compound. If an applied finish coating is used in lieu of a curing compound, have a backup system that is in full compliance with 400-16.2(2) available at all times to ensure that an effective alternative system will be immediately available if the applied finish coating cannot be applied within 30 minutes of extrusion or before the loss of water sheen.

400-16.7 Removal of Membrane Curing Compounds: Provide the longest possible curing duration; however, remove curing compound on portions of members to be bonded to other concrete. Compounds may be removed by either sand or water blasting. Water blasting requires the use of water meeting the requirements of Section 923 and a minimum nozzle pressure of 2,900 psi.

400-17 Protection of Concrete.

400-17.1 Opening to Traffic: Do not open concrete bridge decks, approach slabs, or culverts to traffic for at least 14 days after concrete placement. During placement operations, concrete may be wheeled across previously placed slabs after they have set for 24 hours and plank runways are used to keep the loads over the beams.

400-17.2 Storing Materials on Bridge Slabs: Do not store heavy equipment or material, other than light forms or tools, on concrete bridge slabs or approach slabs until 14 days after they have been placed. Obtain approval from the Engineer prior to storing materials, tools or equipment on bridge decks at any time. Disperse any such loads to avoid overloading the structure.

400-17.3 Time of Placing Superstructure: Do not place the weight of the superstructure or beams on concrete substructure elements for at least 10 days after placement.

400-17.4 Alternate Procedure: As an alternative to the time delay periods set forth in 400-17.1 and 400-17.3, test cylinders may be prepared and tested by the Contractor in accordance with 346-5 and a determination made using one of the following methods:

1. When the cylinder test results indicate the minimum 28 day compressive strength shown in the Plans, concrete bridge decks, approach slabs, and culverts may be opened to traffic or the superstructure and beams may be placed on caps.
2. Submit signed and sealed calculations, prepared by a Specialty Engineer, demonstrating that the concrete caps can safely support the weight of the girders for the current concrete strength to the Engineer for approval.

In any event, comply with the curing provisions of 400-16.

400-18 Precast Planks, Slabs, and Girders.

400-18.1 General: Where so shown in the Contract Documents, the Contractor may construct concrete planks, slabs, girders, and other structural elements by precasting. In general,

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use a method that consists of casting structural elements in a casting yard, curing as specified in 400-16, transporting them to the site of the work, installing them on previously prepared supports and, where so shown in the Plans, joining them with poured-in-place slabs or keys. Handle and install precast prestressed members as specified in Section 450.

400-18.2 Casting: Cast precast elements on unyielding beds or pallets. Use special care in casting the bearing surfaces on both the elements and their foundations in order that these surfaces shall coincide when installing the elements. Check bearing surfaces on casting beds with a level and a straightedge prior to the casting. Similarly check corresponding surfaces on the foundations during finishing operations.

400-18.3 Poured-in-Place Keys: Where precast elements are to be joined with poured-in-place keys, carefully align the elements prior to pouring the keys.

400-18.4 Surface Finish: Finish the surface as specified in 400 15, except that where precast slabs and poured-in-place keys form the riding surface, give the entire surface a broomed finish.

400-18.5 Moving, Placing, and Opening to Traffic: Reinforced precast members may be moved from casting beds, placed in the structure, and opened to traffic at the ages shown in the following table:

Handling from casting beds to storage areas ..... 7 days
Placing in structure ..... 14 days

Opening to traffic:

Precast elements..... 14 days
Cast-in-place slabs over precast girders..... 14 days
Cast-in-place keys joining precast slabs ..... 7 days

As an alternate procedure, in lieu of the time delay periods set forth above, test beams may be cast from representative concrete, and cure them identically with the concrete in the corresponding structural component. Test the test beams in accordance with ASTM C31 and ASTM C78. When the test results indicate a flexural strength of 550 psi, or more, any of the operations listed above may proceed without completing the corresponding time delay period.

400-18.6 Setting Prestressed Slabs: Before permitting construction equipment on the bridge to erect slab units, submit sketches showing axle loads and spacing and a description of the intended method of setting slab units to the Engineer for approval. Do not use axle loads, spacing, and methods of setting which produce stresses in the slab units greater than the allowable stress.

400-18.7 Protection of Precast Elements: The Contractor is responsible for the safety of precast elements during all stages of construction. The Engineer will reject any precast elements that become cracked, broken, seriously spalled, or structurally impaired. Remove rejected precast elements from the work at no expense to the Department.

400-18.8 Form Material: Form material used to form hollow cores may be left in place. Ensure that the form material is neutral with respect to the generating of products harmful to the physical and structural properties of the concrete. The Contractor is responsible for any detrimental effects resulting from the presence of the form material within the precast element.

400-19 Cleaning and Coating Concrete Surfaces of Existing Structures.

For the purposes of this article, an existing structure is one that was in service prior to the start of the project to which this specification applies. For existing structures, clean concrete surfaces that are designated in the Contract Documents as receiving Class 5 applied finish coating by pressure washing prior to the application of coating. Use pressure washing equipment

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producing a minimum working pressure of 2,500 psi when measured at or near the nozzle. Do not damage or gouge uncoated concrete surfaces or previously coated concrete surfaces during cleaning operations. Remove all previously applied coating that is no longer adhering to the concrete or that is peeling, flaking or delaminating. Ensure that after the pressure wash cleaning and the removal of non-adherent coating, that the cleaned surfaces are free of efflorescence, grime, mold, mildew, oil or any other contaminants that might prevent proper adhesion of the new coating. After cleaning has been successfully completed, apply Class 5 Applied Finish Coating in accordance with 400-15.2.6 or as otherwise specified in the Plans.

400-20 Approach Slabs.

Construct approach slabs at the bridge ends in accordance with the applicable requirements of Section 350 using Class II (Bridge Deck) concrete. Place the reinforcement as specified in 350-7 and Section 415.

400-21 Disposition of Cracked Concrete.

400-21.1 General: The disposition of cracked concrete is described in this Article and applies to all cast-in-place concrete members, and once installed, to the precast and prestressed concrete members that are produced in accordance with 410, 450, 521, 534, 548 and 641.

400-21.2 Investigation, Documentation and Monitoring: The Engineer will inspect concrete surfaces as soon as surfaces are fully visible after casting, with the exception of surfaces of precast concrete products produced in offsite plants, between 7 and 31 days after the component has been burdened with full dead load, and a minimum of 7 days after the bridge has been opened to full unrestricted traffic. Additionally, for bridge decks that require planing, the Engineer will perform bridge deck crack measurements once the deck is free of all debris after planing is complete and before transverse grooves are cut. The Engineer will measure the width, length and depth of each crack and establish the precise location of the crack termination points relative to permanent reference points on the member. The Engineer will determine if coring of the concrete is necessary when an accurate measurement of crack depth cannot be determined by use of a mechanical probe. The Engineer will monitor and document the growth of individual cracks at an inspection interval determined by the Engineer to determine if cracks are active or dormant after initial inspection.

Provide the access, equipment and personnel needed for the Engineer to safely perform this work at no expense to the Department. Core cracks for use by the Engineer in locations and to depths specified by the Engineer. Additional compensation or time will not be granted for coring when the Engineer determines the cause of concrete cracking to be the responsibility of the Contractor.

400-21.3 Classification of Cracks: The Engineer will classify cracks as either nonstructural or structural. In general, nonstructural cracks are cracks 1/2 inch or less deep from the surface of the concrete; however, the Engineer may determine that a crack greater than 1/2 inch deep is nonstructural. In general, structural cracks are cracks that extend deeper than 1/2 inch. As an exception, all cracks in concrete bridge decks that are supported by beams or girders will be classified as nonstructural and repair will be in accordance with 400-21.5.1. However, if the Engineer determines that repair under 400-21.5.1 is unacceptable, repair in accordance with 400-21.5.2.

A crack that is fully or partially underwater at any time during its service life will be classified as a structural crack unless the Environment note on the General Notes sheet in the

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Plans categorizes the substructure as slightly aggressive, in which case, the nonstructural crack criteria may apply as determined by the Engineer.

Review and comment on the Engineer's crack classification; however, the Engineer will make the final determination.

400-21.4 Nonstructural Cracking Significance: The Engineer will determine the Cracking Significance. The Cracking Significance will be determined on the basis of total crack surface area as a percentage of total concrete surface area. Cracking significance will be categorized as Isolated, Occasional, Moderate or Severe according to the criteria in Tables 400-3 and 400-4. Cracking Significance will be determined on a LOT by LOT basis. A LOT will typically be made up of not more than 100 square feet and not less than 25 square feet of concrete surface area for structures other than bridge decks or typically not more than 400 square feet or not less than 100 square feet for bridge decks. A LOT will not extend beyond a single Elevation Range as shown in Table 400-3 or 400-4.

Review and comment on the Engineer's determination of Cracking Significance; however, the Engineer will make the final determination.

400-21.5 Repair Method: Repair or remove and replace cracked concrete as directed by the Engineer. Additional compensation or time will not be granted for repair or removal and replacement of cracked concrete when the Engineer determines the cause to be the responsibility of the Contractor.

400-21.5.1 Nonstructural Cracks: Repair each crack using the method as determined by the Engineer for each LOT in accordance with Table 400-3 or 400-4. When further investigation is required to determine repair or rejection, submit an Engineering Analysis Scope in accordance with 6-4, signed and sealed by a Specialty Engineer, to determine the strength and durability of the proposed repair. Upon approval of the Engineering Analysis Report (EAR) and final determination of the Engineer, repair or remove and replace the cracked concrete in accordance with the EAR.

400-21.5.2 Structural Cracks: Submit an Engineering Analysis Scope in accordance with 6-4, signed and sealed by the Contractor's Engineer of Record, to determine the strength and durability of the proposed repair. Upon approval of the EAR and final determination of the Engineer, repair or remove and replace the cracked concrete in accordance with the approved EAR.

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Table 400-3
DISPOSITION OF CRACKED CONCRETE OTHER THAN BRIDGE DECKS
[see separate Key of Abbreviations and Footnotes for Tables 400-3 and 400-4]

Elev. Range	Crack Width Range (inch) (2) x = crack width	Cracking Significance Range per LOT (1)											
		Isolated Less than 0.005%			Occasional 0.005% to<0.017%			Moderate 0.017% to<0.029%			Severe 0.029% or gtr.		
		Environment Category											
		SA	MA	EA	SA	MA	EA	SA	MA	EA	SA	MA	EA
Elevation: 0 to 6 ft AMHW	x ≤ 0.004	NT	NT	PS (6)	NT	PS (6)	PS (6)	PS (6)	PS (6)				
	0.004< x ≤ 0.008	NT	PS (6)	EI (3)	PS (6)	EI (3)	EI (3)	PS (6)					
	0.008< x ≤ 0.012	NT	PS (6)	EI									
	0.012< x ≤ 0.016	PS (6)	Investigate to Determine Appropriate Repair (4, 5) or Rejection										
	0.016< x ≤ 0.020												
	0.020< x ≤ 0.024									Reject and Replace			
	0.024< x ≤ 0.028												
	x > 0.028												
Elev.: More Than 6 ft to 12 ft AMHW	Crack Width	SA	MA	EA	SA	MA	EA	SA	MA	EA	SA	MA	EA
	x ≤ 0.004	NT	NT	PS (6)	NT	PS (6)	PS (6)	PS (6)	PS (6)	PS (6)	PS (6)		
	0.004< x ≤ 0.008	NT	PS (6)	EI (3)	PS (6)	PS (6)	EI (3)	PS (6)	EI (3)				
	0.008< x ≤ 0.012	NT	PS (6)	EI	EI	EI							
	0.012< x ≤ 0.016	PS (6)	EI	EI	EI								
	0.016< x ≤ 0.020	EI											
	0.020< x ≤ 0.024		Investigate to Determine Appropriate Repair (4, 5) or Rejection							Reject and Replace			
	0.024< x ≤ 0.028												
	x > 0.028												
Elev.: Over Land or More Than	Crack Width	SA	MA	EA	SA	MA	EA	SA	MA	EA	SA	MA	EA
	x ≤ 0.004	NT	NT	NT	NT	PS (6)	PS (6)	PS (6)	PS (6)	PS (6)	PS (6)		
	0.004< x ≤ 0.008	NT	PS (6)	PS (6)	PS (6)	PS (6)	EI (3)	PS (6)	EI (3)	EI (3)	PS (6)		

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<table>
<tr><td rowspan="6"></td><td>0.008< x ≤ 0.012</td><td>NT</td><td>PS (6)</td><td>EI</td><td>EI</td><td>EI</td><td>EI</td><td>EI</td><td>EI</td><td></td><td></td><td></td><td></td></tr>
<tr><td>0.012< x ≤ 0.016</td><td>PS (6)</td><td>EI</td><td>EI</td><td>EI</td><td>EI</td><td>EI</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>0.016< x ≤ 0.020</td><td>EI</td><td>EI</td><td>EI</td><td>EI</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>0.020< x ≤ 0.024</td><td>EI</td><td colspan="7" rowspan="2">Investigate to Determine Appropriate Repair (4, 5) or Rejection</td><td></td><td></td><td></td><td></td></tr>
<tr><td>0.024< x ≤ 0.028</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">Reject and Replace</td></tr>
<tr><td>x > 0.028</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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Table 400-4
DISPOSITION OF CRACKED CONCRETE BRIDGE DECKS
[see separate Key of Abbreviations and Footnotes for Tables 400-3 and 400-4]

Elev. Range	Crack Width Range (inch) [2] x = crack width	Cracking Significance Range per LOT [1]											
		Isolated less than 0.005%			Occasional 0.005% to<0.017%			Moderate 0.017% to<0.029%			Severe 0.029% or gtr.		
		Environment Category											
		SA	MA	EA	SA	MA	EA	SA	MA	EA	SA	MA	EA
Elevation: 12 feet or Less AMHW	x ≤ 0.004	NT	NT	NT	NT	NT	NT	NT	NT	NT			
	0.004< x ≤ 0.008	NT	NT	EI/M	NT	NT	EI/M	EI/M	EI/M	EI/M			
	0.008< x ≤ 0.012	NT	NT	EI/M	NT	EI/M	EI/M	EI/M	EI/M				
	0.012< x ≤ 0.016	NT	NT	EI/M	NT	EI/M							
	0.016< x ≤ 0.020	EI/M	EI/M	EI	EI								
	0.020< x ≤ 0.024	EI/M	EI	EI		Investigate to Determine Appropriate Repair [4, 5] or Rejection					Reject and Replace		
	0.024< x ≤ 0.028	EI/M	EI										
	x > 0.028												
Elevation: Over Land or More Than 12 feet AMHW	Crack Width	SA	MA	EA	SA	MA	EA	SA	MA	EA	SA	MA	EA
	x ≤ 0.004	NT	NT	NT	NT	NT	NT	NT	NT	NT			
	0.004< x ≤ 0.008	NT	NT	NT	NT	NT	EI/M	NT	EI/M	EI/M			
	0.008< x ≤ 0.012	NT	NT	EI/M	NT	NT	EI/M	EI/M	EI/M				
	0.012< x ≤ 0.016	NT	NT	EI/M	NT	EI/M							
	0.016< x ≤ 0.020	NT	EI/M	EI	EI/M								
	0.020< x ≤ 0.024	NT	EI/M	EI		Investigate to Determine Appropriate Repair [4, 5] or Rejection					Reject and Replace		
	0.024< x ≤ 0.028	NT	EI/M										
	x > 0.028												

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Key of Abbreviations and Footnotes for Tables 400-3 and 400-4		
Type Abbreviation	Abbreviation	Definition
Repair Method	EI	Epoxy Injection
	M	Methacrylate
	NT	No Treatment Required
	PS	Penetrant Sealer
Environment Category	EA	Extremely Aggressive
	MA	Moderately Aggressive
	SA	Slightly Aggressive
Reference Elevation	AMHW	Above Mean High Water

Footnotes

(1) Cracking Significance Range is determined by computing the ratio of Total Cracked Surface Area (TCSA) to Total Surface Area (TSA) per LOT in percent [(TCSA/TSA) x 100] then by identifying the Cracking Significance Range in which that value falls. TCSA is the sum of the surface areas of the individual cracks in the LOT. The surface area of an individual crack is determined by taking width measurements of the crack at 3 representative locations and then computing their average which is then multiplied by the crack length.

(2) Crack Width Range is determined by computing the width of an individual crack as computed in (1) above and then identifying the range in which that individual crack width falls.

(3) When the Engineer determines that a crack in the 0.004 inch to 0.008 inch width range cannot be injected then for Table 400-3 use penetrant sealer unless the surface is horizontal, in which case, use methacrylate if the manufacturer's recommendations allow it to be used and if it can be applied effectively as determined by the Engineer.

(4) (a) Perform epoxy injection of cracks in accordance with Section 411. Seal cracks with penetrant sealer or methacrylate as per Section 413. (b) Use only methacrylate or penetrant sealer that is compatible, according to manufacturer's recommendations, with previously applied materials such as curing compound or paint or remove such materials prior to application.

(5) When possible, prior to final acceptance of the project, seal cracks only after it has been determined that no additional growth will occur.

(6) Methacrylate shall be used on horizontal surfaces in lieu of penetrant sealer if the manufacturer's recommendations allow it to be used and if it can be applied effectively as determined by the Engineer.

(7) Unless directed otherwise by the Engineer, repair cracks in bridge decks only after the grinding and grooving required by 400-15.2.5 is fully complete.

400-22 Method of Measurement.

400-22.1 General: The quantities of concrete to be paid for will be the volume, in cubic yards, of each of the various classes shown in the Plans, in place, completed and accepted. The quantity of precast anchor beams to be paid for will be the number in place and accepted. The quantity of bridge deck grooving to be paid for will be the area, in square yards of bridge deck and approach slab, completed and accepted. The quantity of bridge deck grooving and planing to be paid for will be the area, in square yards of bridge deck and approach slab, completed and accepted.

Except for precast anchor beams, for any item of work constructed under this Section and for which measurement for payment is not to be made by the volume of concrete, measurement and payment for such work will be as specified in the Section under which the work is specified in detail.

No separate payment will be made for obtaining the required concrete finish.

400-22.2 Calculation of Volume of Concrete:

400-22.2.1 Dimensions: The quantity will be computed by the plan dimensions of the concrete, within the neat lines shown in the Plans, except that no deduction will be made for weep holes, deck drains, or encroachment of inlets and pipes in box culverts, and no chamfers, scorings, fillets, or radii 1 1/2 in^2 or less in cross-sectional area will be taken into account.

400-22.2.2 Pay Quantity: The quantity to be paid for will be the original plan quantity, measured as provided in 400-22.2.1.

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400-22.2.3 Items not Included in Measurement for Payment: No measurements or other allowances will be made for work or material for forms, falsework, cofferdams, pumping, bracing, expansion-joint material, etc. The volume of all materials embedded in the concrete, such as structural steel, pile heads, etc., except reinforcing bars or mesh, will be deducted when computing the volume of concrete to be paid for. For each foot of timber pile embedded, 0.8 cubic feet of concrete will be deducted. The cost of furnishing and placing dowel bars shall be included in the Contract unit price for the concrete.

400-22.2.4 Deck Girders and Beam Spans: In computing the volume of concrete in deck girders and beam spans, the thickness of the slab will be taken as the nominal thickness shown on the drawings and the width will be taken as the horizontal distance measured across the roadway. The volume of haunches over beams will be included in the volume to be paid for.

400-22.2.5 Stay-in-Place Metal Forms: When using stay-in-place metal forms to form the slab of deck girder and beam spans, the volume of concrete will be computed in accordance with the provisions of 400-22.2.4 except that the thickness of the slab over the projected plan area of the stay-in-place metal forms will be taken as the thickness shown on the drawings above the top surface of the forms. The concrete required to fill the form flutes will not be included in the volume of concrete thus computed.

400-22.3 Bridge Deck Grooving: The quantity to be paid for will be plan quantity in square yards, computed, using the area bound by the gutter lines (at traffic railings, curbs and median dividers) and the beginning and end of the bridge or the end of approach slabs, whichever is applicable, constructed, in place and accepted.

400-22.4 Bridge Deck Grooving and Planing: The quantity to be paid for will be plan quantity in square yards, computed, using the area bound by the gutter lines (at traffic railings, curbs and median dividers) and the beginning and end of the bridge or the end of approach slabs, whichever is applicable, constructed, in place and accepted.

400-22.5 Composite and Plain Neoprene Bearing Pads: The quantity to be paid for will be the original plan quantity, computed using the dimensions of the pads shown in the Plans.

400-22.6 Cleaning and Coating Concrete Surfaces: The quantity to be paid for will be the plan quantity in square feet for the areas shown in the Plans.

400-23 Basis of Payment.

400-23.1 Concrete:

400-23.1.1 General: Price and payment will be full compensation for each of the various classes of concrete shown in the Contract Documents.

400-23.1.2 Concrete Placed below Plan Depth: Authorized concrete placed in seal or footings 5 feet or less below the elevation of bottom of seal or footing as shown in the Plans will be paid for at the Contract price set forth in the Contract Documents under the pay items for substructure concrete.

Authorized concrete used in seal (or in the substructure where no seal is used) at a depth greater than 5 feet below the bottom of seal or footing as shown in the Plans will be paid for as Unforeseeable Work.

Such payment will be full compensation for the cofferdam construction, for excavation, and for all other expenses caused by the lowering of the footings.

400-23.1.3 Seal Concrete Required but Not Shown in Plans: When seal concrete is required as provided in 400-8 and there is no seal concrete shown in the Plans, it will be paid for as Unforeseeable Work.

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400-23.2 Precast Anchor Beams: Price and payment will be full compensation for the beams, including all reinforcing and materials necessary to complete the beams in place and accepted.

No separate prices will be allowed for the various types of anchor beams.

400-23.3 Reinforcing: Reinforcing bars, wires and mesh will be measured and paid for as provided in Section 415, except that no separate payment will be made for the welded wire reinforcement used in concrete jackets on steel piles or reinforcement contained in traffic railings, concrete barriers, traffic separators or parapets. Where so indicated in the Plans, the Department will not separately pay for reinforcing used in incidental concrete work, but the cost of such reinforcement shall be included in the Contract unit price for the concrete.

400-23.4 Bridge Deck Grooving: Price and payment will be full compensation for all grooving, equipment, labor, and material required to complete the work in an acceptable manner.

400-23.5 Bridge Deck Planing: Price and payment will be full compensation for all planing, equipment, labor, and material required to complete the work in an acceptable manner.

400-23.6 Composite and Plain Neoprene Bearing Pads: Price and payment will be full compensation for all work and materials required to complete installation of the pads, including sampling and testing.

400-23.7 Cleaning and Coating Concrete Surfaces: Price and payment will be full compensation for all work and materials required. The cost of coating new concrete will not be paid for separately, but will be included in the cost of the item to which it is applied.

400-23.8 General: The above prices and payments will be full compensation for all work specified in this Section, including all forms, falsework, joints, weep holes, drains, pipes, conduits, bearing pads, setting anchor bolts and dowels, surface finish, and cleaning up, as shown in the Plans or as directed. Where the Plans call for water stops, include the cost of the water stops in the Contract unit price for the concrete.

Unless payment is provided under a separate item in the Contract Documents, the above prices and payments will also include all clearing and grubbing; removal of existing structures; excavation, as provided in Section 125; and expansion joint angles and bolts.

The Department will not change the rate of payment for the various classes of concrete in which steel or FRP may be used due to the addition or reduction of reinforcing.

The Department will not make an allowance for cofferdams, pumping, bracing, or other materials or equipment not becoming a part of the finished structure. The Department will not pay for concrete placed outside the neat lines as shown in the Plans.

When using stay-in-place metal forms to form bridge decks, the forms, concrete required to fill the form flutes, attachments, supports, shoring, accessories, and all miscellaneous items or work required to install the forms shall be included in the Contract unit price of the superstructure concrete.

400-23.9 Payment Items:

Payment will be made under:

Item No. 400- 0-	Class NS Concrete – per cubic yard.
Item No. 400- 1-	Class I Concrete (Seal) - per cubic yard.
Item No. 400- 2-	Class II Concrete - per cubic yard.
Item No. 400- 3-	Class III Concrete - per cubic yard.
Item No. 400- 4-	Class IV Concrete - per cubic yard.
Item No. 400- 6-	Precast Anchor Beams - each.
Item No. 400- 7-	Bridge Deck Grooving - per square yard.

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Item No. 400- 8-	Class V Concrete - per cubic yard.
Item No. 400- 9-	Bridge Deck Planing - per square yard.
Item No. 400- 16-	Class VI Concrete - per cubic yard.
Item No. 400-143-	Cleaning and Coating Concrete Surfaces - per square foot.
Item No. 400-147-	Composite Neoprene Pads - per cubic foot.
Item No. 400-148-	Plain Neoprene Bearing Pads - per cubic foot.

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SECTION 407
THREE-SIDED PRECAST CONCRETE CULVERT

407-1 Description.

Design and construct a three-sided precast concrete culvert for the three-sided concrete culvert structure shown in the Contract Documents. Three-sided precast concrete culverts are defined as monolithic arched segments, frame segments with vertical walls and either horizontal or arched top slabs, or three-sided proprietary precast concrete bridge systems.

Meet the requirements of 449-1.

407-2 Materials.

Ensure that the materials used for the construction of precast culverts have certification statements from each source, showing that they meet the applicable requirements of the following:

Portland Cement Concrete	Section 346
Reinforcing for Concrete	Section 415
Precast Concrete Drainage Products	Section 449
Riprap	Section 530
Coarse Aggregate*	Section 901
Fine Aggregate*	Section 902
Curing Materials	Section 925
Materials for Concrete Repair	Section 930
Non-Shrink Grout	Section 934
Geotextile Fabrics	Section 985
Mechanical Connection Steel*	Section 460
External Sealing Band Wrap	ASTM C877

*Use products listed on the Department's Approved Product List (APL).

**The gradation requirements of aggregates are not applicable when using dry-cast concrete.

407-3 Limitations on Use.

Do not use three-sided precast culverts in lieu of four-sided culverts described in Section 410, however they may be considered as a Cost Savings Initiative Proposal (CSIP) in accordance with Section 4. Provide the required Section 346 concrete class and concrete cover in accordance with the Structures Design Guideline for the environmental classification shown in the Plans for the culvert location. Do not use a three-sided precast culvert to extend the inlets of existing multi-cell culverts due to the potential for clogging with debris.

407-4 Materials Acceptance and Testing.

407-4.1 General: Meet concrete materials, testing, inspection, and acceptance requirements of Section 346, as modified herein:

Precast culverts are produced using certification-acceptance criteria; therefore, assume responsibility for performance of all quality control testing and inspections in accordance with Section 346.

Prepare, cure, and test the test cylinders in accordance with ASTM C31 and ASTM C39 test methods. Follow the alternative method of concrete compaction, in accordance with ASTM C497, if the consistency of concrete is too stiff for compaction by rodding or

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internal vibrations. Expose shipping strength test cylinders to the same curing conditions as the precast concrete sections. The 28-day test cylinders shall be cured in accordance with Section 346.

Perform all concrete quality control testing and inspections in accordance with 346-9.2.

For training and other qualifications meet the requirements of Section 105. Test all QC samples for compressive strength in a laboratory meeting the requirements of Section 105.

407-4.2 Quality Assurance Inspection and Testing: The Engineer will perform periodic inspections, sampling, and testing to ensure of the quality and acceptability of the materials, methods, techniques, procedures and processes being utilized by the manufacturing facility in the fabrication of precast concrete culverts.

407-4.3 Special Requirements for Dry-Cast Concrete: Dry-cast concrete is defined as a very low slump concrete that requires continuous and intense vibration to compact the concrete, enabling immediate removal of the side forms without detrimental effects to the concrete when used in a dry-cast manufacturing process.

The target slump, air content ranges, and the plastic property tolerances in Section 346 are not applicable to dry-cast concrete.

Perform absorption tests on specimens from each LOT of dry-cast production in accordance with the test methods in ASTM C497. The absorption of each specimen must not exceed 9.0% of the dry mass for Test Method A procedure or 8.5% for Test Method B procedure. All specimens must be free of visible cracks and must represent the full thickness of the product. Test specimens after 28 days of standard curing or prior to the date of shipping if the precast concrete culvert sections are to be shipped before the completion of the 28-day curing period.

Core three specimens for Test Method B in accordance with ASTM C42 and meet the sampling location and size requirements of ASTM C497. Prepare or core a minimum of one specimen for Test Method A in accordance with the test cylinder requirements of ASTM C497. When the initial absorption specimen from a concrete culvert section fails to conform to the requirements of this Section, the absorption test may be made on another specimen from the same culvert section and the results of the retest may be substituted for the original test results for acceptance of the LOT. The manufacturer may test each concrete culvert section within a LOT and cull the culvert sections not meeting absorption requirements marking them as deficient with waterproof paint or other approved means. Deficient culvert sections must not be shipped to the project site. Reduce the frequency of absorption tests to one test every five LOTs when the results of five consecutive LOTs meet the specified limit.

407-5 Design Requirements.

Provide a design that complies with the requirements of the AASHTO LRFD Bridge Design Specifications and the Structures Design Guidelines. Perform a bridge load rating in accordance with the Structures Design Guidelines, for any design with a total span equal to or greater than 20 feet, when measured between the inside face of end supports, along the centerline of the roadway crossing. Submit design calculations, shop drawings and load rating for approval in accordance with Section 5. Ensure that the Contractor's Engineer of Record performs the design of the precast culvert and signs and seals the design plans, calculations and load rating. When the channel lining design is not provided in the Contract Documents or must be

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redesigned, submit a hydraulic analysis and scour evaluation, signed and sealed, by the Contractor's Engineer of Record.

Line the channel between footings with either a 6 inch minimum thick cast-in-place reinforced concrete slab with a 30 inch minimum depth toe wall at the inlet and outlet end of the structure, or a blanket of revetment designed in accordance with the Department Drainage Manual. Use lining designed to withstand the hydraulic forces and extend the lining a minimum of 10 feet beyond the ends of the structure. A riprap rubble ditch lining with a minimum thickness of 18 inches will be permitted if the flow velocity corresponding to the Design Flood Scour Event does not exceed five feet per second. Filter fabric must be used in conjunction with any revetment in accordance with Section 985. Design and construct the connection between the revetment or concrete slab and the culvert footing, to prevent the migration of soil through the connection.

Ensure that the bottoms of spread footings are a minimum of 30 inches below the bottom of the channel lining.

407-6 Other Elements of a Precast Culvert System.

Extend reinforcing from precast sections to provide adequate splice lengths or utilize a mechanical rebar splicing system (steel reinforcing only) listed on the Department's Approved Product List (APL) for securing reinforcing dowels for cast-in-place headwalls and wingwalls. Precast headwalls, wingwalls and culvert footings are permitted. Precast culvert footings must span a minimum of three culvert units and provide shear connections between adjacent units with keyed joints or cast-in-place closure sections. Precast footings under wingwalls are not permitted.

Submit all connection details for precast elements to the Engineer for approval. All mechanical connections must be galvanized in accordance with 962-7 or Type 316 (UNS S31600) stainless steel, except in extremely aggressive environments only Type 316L (UNS 31603) stainless steel is permitted for welded connections and Type 316 stainless steel for non-welded shapes and fasteners.

Unless otherwise addressed in the Plans, bedding material and compaction requirements for wingwalls and toe walls shall be the same as required for the footing in 407-12, except that the granular material may be placed to the inside edge of the toe wall.

All requirements of Section 400 and Section 415 apply to the fabrication of cast-in-place elements.

407-7 Fabrication.

407-7.1 Casting: Cast precast elements in unyielding beds and forms. Ensure bearing surfaces in casting forms are level and straight, and vertical surfaces are plumb prior to casting. Ensure surfaces within the forms, against which concrete will be cast, are clean and free from rust and hardened residual concrete. Provide full concrete cover clearance to all form wires and other miscellaneous pieces of metal, except as permitted by Section 415. Bend all tie wires away from the form surface to provide maximum concrete cover. Provide inserts and lifting devices in accordance with 450-9.2.1.

407-7.2 Surface Finish: Finish the precast elements in accordance with 400-15.1.

407-7.3 Curing: Perform the curing by any method prescribed in Sections 400 and 450, or by any other Department approved alternative curing method included in the manufacturer's QC Plan, or combinations thereof that have provided satisfactory results.

407-7.4 Fabrication Tolerances:

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407-7.4.1 Internal Dimensions: Ensure the internal dimensions do not vary more than one percent or two inches, whichever is less, from the design dimensions, with a maximum of 3/4 inches. The haunch dimensions shall not vary more than 3/4 inches from the design dimensions.

407-7.4.2 Slab and Wall Thickness: Ensure the slab and wall thicknesses are not less than that shown in the design Plans or approved shop drawings by more than five percent or 1/2 inches, whichever is greater. A thickness more than that required in the design will not be a cause for rejection.

407-7.4.3 Length of Opposite Surfaces: Ensure the variations in laying lengths of two opposite surfaces of the culvert segments are not more than 3/4 inch, except where beveled ends for laying curves, or skewed ends are specified by the Engineer.

407-7.4.4 Length of Section: Ensure the underrun in length of segments is not more than 1/8 inch per foot of length with a maximum of 1/2 inch in any culvert segment. The total underrun in length of the in-place precast culvert must not be less than 3 inches from the design length.

407-7.4.5 Tongue and Groove Joints or Ends: Ensure the planes formed by the ends of precast culvert sections do not vary perpendicular from the joint axis by more than 3/8 inches for internal spans or heights less than 15 feet, or more than 1/2 inches for internal spans or heights of 15 feet or greater.

407-7.4.6 Position of Reinforcement: Meet the requirements of 415-5.10.2 for the maximum variation in the position of slab steel. Meet the requirements of 415-5.8.2 for the maximum variation of the wall steel, except that the concrete cover must not be less than 1/4 inches nor more than 1/2 inches from the design dimensions.

407-7.4.7 Area of Reinforcement: Provide the area of reinforcement as indicated in the Plans or approved shop drawings as a minimum. If welded wire reinforcement is utilized in lieu of mild steel reinforcement, the provisions of 415-6 shall apply. Reinforcing steel areas greater than specified in the shop drawings will be acceptable when the reinforcing spacing is equal or less than specified in the shop drawings. Substitution of mild steel or welded wire reinforcement for fiber reinforced polymer (FRP) reinforcing, or vice versa, is not permitted.

407-7.5 Removal of Forms: Remove forms after the concrete has attained the minimum compressive strength requirements in the Producer QC Plan, but not less than 2500 psi. Products manufactured with dry-cast concrete, are exempt from this requirement.

407-7.6 Lifting and Removal from Casting Area: Handle all products, including those manufactured by the dry-cast process, upon the concrete attaining sufficient compressive strength as determined by the manufacturer and included as part of the Producer QC Plan, but not less than 2500 psi. Limit the flexural stresses from handling to three times the square root of the specified 28-day strength.

407-8 Joints.

Produce precast units with keyways at the adjoining surfaces or with butt joints between adjacent units. In the keyways, use a non-shrink grout listed on the APL. Design and construct the adjoining surfaces so that when placed together, they make a continuous line of units with a smooth interior free of appreciable irregularities within the permissible variations given in Section 11 of ASTM C1504. Seal all joints between precast units with a bituminous seal or low modulus silicone sealant listed on the APL, and provide an external sealing band in accordance with ASTM C877 along the outside of the joint. Determine the minimum width of sealing bands by substituting the larger of the clear rise or span of the precast concrete box section, for the

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equivalent pipe diameter in ASTM C877 Tables 1 and 2. Install external sealing band wrap in accordance with the manufacturer's instructions. Cover the external sealing band with a strip of filter fabric adhered to the precast unit. Ensure that the filter fabric strip is a minimum of 24 inches wide and meets the requirements of Section 985. Obtain the Engineer's approval of the adhesive used. Exercise care during backfilling to prevent damage to the filter fabric.

Construct headwalls, wingwalls, and other special features in place or as detailed on the shop drawings. Leave sufficient steel exposed or utilize a mechanical rebar splicing system listed on the APL, in end units for connection of headwalls, wingwalls and other cast-in-place sections.

407-9 Handling, Storage, and Shipping.

Handle, store, and ship precast culverts in a manner that prevents chipping, cracks, fractures, and excessive bending stress. Do not ship precast culverts to the project site prior to the completion of the 72-hour curing period and attainment of the required 28-day compressive strength.

The manufacturer is permitted to verify the shipping strength test, before 28 days, by testing compressive strength cylinders that are cured under conditions similar to the product or by testing temperature match cured cylinders. The manufacturer may use the maturity method, ASTM C1074, pulse velocity method in accordance with ASTM C597, or any other approved nondestructive test method to estimate the strength of concrete for determining form removal and handling strengths or before verification of shipping strength by test cylinders.

Curing temperature and cycle must be monitored on a minimum of one precast culvert curing cell from each day of production when nondestructive test methods or temperature match cured cylinders are used to determine concrete strengths.

The shipping strength test is the average compressive strength of two test cylinders. Do not ship any products until the QC Manager's stamp is affixed to the product.

407-10 Repairs and Rejection.

Evaluate cracks, spalls and other deficiencies in accordance with 450-12, except that cracks will be classified in accordance with 400-21. Classify fractures and cracks passing through the wall or slab, except for a single end crack that does not exceed the depth of the joint, as structural cracks. Repair nonstructural cracks in accordance with 400-21 (substructure requirements), and all other deficiencies in accordance with 450-13 or the plant's approved repair methods that are included as part of the Producer QC Plan. Ensure that the original performance and durability of the repaired precast culverts are maintained.

Use materials for concrete repair that will meet or exceed the strength requirement of the class of concrete used. Materials meeting the requirements of Section 930 may be substituted for non-shrink grout when required by 450-13. Precast culvert elements are subject to rejection if they fail to conform to any of the specification requirements after repair or when damaged ends would prevent making a satisfactory joint.

407-11 Marking.

Clearly mark indelibly the following information on the interior of each precast unit by indention, water proof paint, or other approved method as described in the producer QC Plan: three sided structure span, rise, maximum and minimum design earth cover, skew angle, date of manufacture, serial number, project number, and name or trademark of manufacturer.

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407-12 Construction Requirements.

Prior to constructing the footing, prepare the bearing soil in accordance with Section 455 for spread footings. If a precast concrete footing is used, prepare a 4-inch-thick layer of compacted granular bedding material to a minimum width of 12 inches outside the footing width and meet the density requirements of 125-9.2. Provide bedding material in accordance with Standard Plans, Index 120-001 select material, with not more than 15% fines passing the No. 200 U.S. Standard sieve, or other granular material approved by the Engineer.

Accomplish all footing construction in dry or dewatered excavations, as defined in 455-29. When coarse aggregate is approved for use as an alternate bedding or foundation backfill material, fully wrap the coarse aggregate with a layer of Type D-4 geotextile filter fabric, as specified in Section 985. At each end of any concrete slab channel lining, substitute the coarse aggregate with select material within four feet of toe walls.

Form a 3 inches deep key in the top surface of the footing 4 inches wider than the wall thickness. Ensure that footings reach a compressive strength of 3,000 psi before placing precast units.

Place the units as shown in the shop drawings. Carefully set the structure to the true line and grade. Set the units in a bed of mortar placed in the keyway in the top of the footing. Fill the keyway with mortar, and float the mortar flush with the top of the footing or use shims between the footer and culvert during setting, then inject non-shrink grout under the culvert walls. Seal blockouts and holes provided for lifting or joint restraint by using an epoxy mortar or non-shrink grout in accordance with Sections 926 or 934.

Carefully place backfill against the filter fabric and joint seal to avoid damage to the material. Use mechanical tampers or approved compacting equipment to compact all backfill and embankment immediately adjacent to each side of the structure. Place the backfill within 4 feet of each side of the structure in lifts of 8 inches or less (loose depth). Do not operate heavy compaction equipment within 4 feet of the structure. Ensure that the backfill elevation differential between both sides of the structure does not exceed 24 inches. Backfill behind wingwalls in accordance with Section 125. Carry backfill in front of wingwalls to the finished grade surface shown in the Plans.

407-13 Shop Drawings.

Submit details of all precast culvert elements and modifications to cast-in-place elements for approval to the Engineer prior to manufacturing in accordance with 5-1.4. These shop drawings must include the proposed layout, full reinforcing details, lifting devices, a note describing the casting method for the precast culverts and full details of any modifications to cast-in-place elements and any connections. All details must be submitted as a complete package including modifications to cast-in-place elements.

407-14 Method of Measurement.

The quantity to be paid for will be the plan quantity at the price bid for the sum of the items shown in the Contract Documents. The length of precast culvert is measured along the centerline of the structure, from the outside face of the headwalls at each end. No increase in length will be permitted for multiple barrel precast culvert installations or extension of precast culverts ends to avoid skewed end conditions.

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407-15 Basis of Payment.

Price and payment will be full compensation for all work and materials specified in this Section necessary to complete the structure, including dewatering, excavation, channel excavation, channel lining, backfilling, footings, headwalls, wingwalls, toe walls and other miscellaneous items.

Payment will be made under:

Item No. 407- 1- Precast Three-Sided Culvert - per foot.

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SECTION 410
PRECAST CONCRETE BOX CULVERT

410-1 Description.

Provide precast four-sided concrete box culverts as an alternative to the structure shown in the Contract Documents. Only monolithic segments, or two-piece segments with three-sided bottom sections and a simple support top slab section, are permitted. Two-piece segments are limited to installations with a minimum of two feet fill height above the top slab.

Construct headwalls, wingwalls and other special features using cast-in-place concrete. Precast wingwalls, cut-off walls or headwalls are not permitted unless otherwise noted in the Contract Documents.

Meet the requirements in 449-1.

410-2 Materials.

Ensure that the materials used for the construction of precast box culverts have certification statements from each source, showing that they meet the applicable requirements of the following:

Portland Cement Concrete	Section 346
Reinforcing for Concrete	Section 415
Precast Concrete Drainage Products	Section 449
Wire for Site Cage Machines	Section 931
Coarse Aggregate*	Section 901
Fine Aggregate*	Section 902
Curing Materials for Concrete	Section 925
Materials For Concrete Repair**	Section 930
Non-Shrink Grout**	Section 934
Liner Repair Systems	Section 948
Joint Materials	ASTM C443, ASTM C877 or ASTM C990
Geotextile Fabrics	Section 985

* The gradation requirements of aggregates are not applicable when using dry-cast concrete.

** Use products listed on the Department's Approved Product List (APL).

410-3 Materials Acceptance and Testing of Precast Box Culverts.

410-3.1 General: Meet the requirements of Section 346, except as modified herein:

Prepare, cure, and test the test cylinders in accordance with ASTM C31 and ASTM C39 test methods. Follow the alternative method of compaction, in accordance with ASTM C497, if the consistency of concrete is too stiff for compaction by rodding or internal vibrations. Expose shipping strength test cylinders to the same curing conditions as the precast concrete box sections.

Perform all concrete quality control testing and inspections in accordance with 346-9.2.

For training and other qualifications meet the requirements of Section 105. Test all QC samples for compressive strength in a laboratory meeting the requirements of Section 105.

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410-3.2 Quality Assurance Inspection and Testing: The Engineer will perform periodic inspections, sampling, and testing to ensure of the quality and acceptability of the materials, methods, techniques, procedures and processes being utilized by the manufacturing facility in the fabrication of precast concrete box culverts.

410-3.3 Special Requirements for Dry-Cast Concrete: Dry-cast concrete is defined as a very low slump concrete that requires continuous and intense vibration to compact the concrete, enabling immediate removal of the side forms without detrimental effects to the concrete when used in a dry-cast manufacturing process.

The target slump, air content ranges, and the plastic property tolerances of Section 346 are not applicable to dry-cast concrete.

Perform absorption tests on specimens from each LOT of dry-cast production in accordance with the test methods in ASTM C497. The absorption of each specimen must not exceed 9.0 percent of the dry mass for Test Method A procedure or 8.5 percent for Test Method B procedure. All specimens must be free of visible cracks and must represent the full thickness of the product. Test specimens after 28 days of standard curing, or prior to the date of shipping if the precast box sections are to be shipped before the completion of the 28 day curing period.

Core three specimens for Test Method B in accordance with ASTM C42 and meet the sampling location and size requirements of ASTM C497. Prepare or core a minimum of one specimen for Test Method A in accordance with the test cylinder requirements of ASTM C497. When the initial absorption specimen from a concrete box section fails to conform to this Specification, the absorption test may be made on another specimen from the same box section and the results of the retest may be substituted for the original test results for acceptance of the LOT. The manufacturer may test each box section within a LOT and cull the box sections not meeting absorption requirements marking them as deficient with waterproof paint or other approved means. Deficient box sections must not be shipped to the project site. Reduce the frequency of absorption tests to one test every five LOTs when the results of five consecutive LOTs meet the specified limit.

410-4 Design of Precast Concrete Box Sections.

410-4.1 General: In lieu of a cast-in-place concrete box section or if specified in the Contract Documents, provide precast box culverts in accordance with Standard Plans, Index 400-291 and the following:

Segment lengths must be between 4 feet and 16 feet. Short-side wall lengths for end segments of skewed culverts, may be less than 4 feet when approved by the Engineer.

Provide tongue and groove joints at the ends of segments. For two-piece box culvert segments, provide keyed joints for the top slab-to-wall connection to prevent lateral displacement at the top of the walls, and double-sided tongue and groove joints in the bottom slab to minimize differential settlement between segments. Alternate methods to prevent differential settlement may be used when included in the Contract Documents or approved by the Engineer. Concrete cover at the joints may be reduced from the nominal cover shown in the Contract Documents, in accordance with the Standard Plans, but not less than 1 inch clear to the ends or inside mating surfaces of the joints or 1-1/2 inches clear to the outside surface of the joint for slightly and moderately aggressive environments, or 2 inches clear to the outside surface for extremely aggressive environments.

Meet one of the following design options:

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410-4.1.1 Equivalent to Cast-In-Place Designs: Provide precast box segments identical to the plan details, including reinforcing steel grade or FRP reinforcing type, sizes and spacings, concrete cover, concrete class, and slab and wall dimensions. Reinforcing bar sizes and spacings may be reduced provided the equivalent area of reinforcing is provided in each layer. Haunch dimensions may be increased with the approval of the Engineer, but not greater than 8 inches for box culverts with internal spans less than 6 feet, or 12 inches for box culverts with larger internal spans.

410-4.1.2 Standard Precast Designs: Provide precast box segments in accordance with Standard Plans, Index 400-292 with the same hydraulic opening, fill height and reinforcing bar cover as shown in the Plans, for the most critical design loading combination. Perform a bridge load rating in accordance with the Structures Design Guidelines, for any multiple barrel culverts with a total span equal to or greater than 20 feet, when measured between the inside face of end supports, along the centerline of the roadway crossing.

410-4.1.3 Modified or Special Designs: Submit Modified Designs which differ from the standard precast designs in 410-4.1.2 with modifications to the wall and slab thickness haunch dimensions, or the use of FRP reinforcing. Submit Special Designs for sizes, elements and loads other than those referenced in 410-4.1.2. Redesign box culverts using the same AASHTO design specification, live load, hydraulic opening, fill height, minimum concrete class and concrete cover as shown in the Contract Documents. Special Designs will be required for all two-piece concrete box culvert segments. Provide a minimum member thickness not less than 75% of the thickness of the corresponding member of an equivalent Standard Plans, Index 400-292 box culvert, but not less than 7 inches for culverts with 2 inch concrete cover or 8 inches for 3 inch concrete cover. Perform a bridge load rating in accordance with the Structures Design Guidelines, for any redesign with a total span equal to or greater than 20 feet, when measure between the inside face of end supports, along the centerline of the roadway crossing.

410-4.2 Design Submittals: Submit shop drawings for all design options in accordance with 410-12. Submit design calculations, revised plans and load rating when required for approval in accordance with Section 5 for Modified or Special Designs. Ensure that a Specialty Engineer performs the design for Modified Designs of the box culvert and signs and seals the calculations.

Ensure that the Contractor’s Engineer of Record performs any bridge load rating and the design for any Special Designs and signs and seals the revised plans, calculations and load rating.

410-5 Other Elements of a Precast Box Culvert System.

Extend reinforcing from precast sections to provide adequate splice lengths or utilize a mechanical rebar splicing system (steel reinforcing only) listed on the Department’s Approved Product List (APL) for securing reinforcing dowels for headwalls, toe walls and wingwalls.

Cast all elements of the headwalls and wingwalls (footing and stem) in-place, unless otherwise noted in the Contract Documents. Cast all cut-off or toe walls for precast box end segments in-place only. Extend the depth of cut-off or toe walls an additional 6 inches with the limits of the bedding material. Bedding material and compaction requirements for wingwalls are the same as required for precast box sections, except that the granular material may be placed to the inside edge of the toe wall, unless otherwise specified in the Contract Documents. Bedding material is not required for cast-in-place wingwall footings.

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All requirements of Section 400 and Section 415 apply to the fabrication of these elements. Backfill the locations behind the walls in accordance with the requirements of Section 125.

410-6 Fabrication.

410-6.1 Casting: Cast precast elements in unyielding beds and forms. Ensure bearing surfaces in casting forms are level and straight, and vertical surfaces are plumb prior to casting. Ensure surfaces within the forms against which concrete will be cast, are clean and free from rust and hardened residual concrete. Provide full concrete cover clearance to all form wires and other miscellaneous pieces of metal, except as permitted by Section 415. Bend all tie wires away from the form surface to provide maximum concrete cover. Provide inserts and lifting devices in accordance with 450-9.2.1.

410-6.2 Surface Finish: Finish the precast elements in accordance with 400-15.1.

410-6.3 Curing: Perform the curing by any method prescribed in Sections 400 and 450, or by any other Department approved alternate curing method included in the approved Producer QC Plan, or combinations thereof that have provided satisfactory results.

410-6.4 Fabrication Tolerances:

410-6.4.1 Internal Dimensions: Ensure the internal dimensions do not vary more than 1% from the design dimensions, with a maximum of 3/4 inch. Ensure the haunch dimensions do not vary more than 1/4 inch from the design dimensions.

410-6.4.2 Slab and Wall Thickness: Ensure the slab and wall thickness are not less than that shown in the Plans or approved shop drawings by more than 5 percent or 3/16 inch, whichever is greater. A thickness more than that required in the design will not be a cause for rejection although payment will be for plan quantity only.

410-6.4.3 Length of Opposite Surfaces: Ensure the variations in laying lengths of two opposite surfaces of the box section are not more than 1/8 inch per foot of clear span, with a maximum of 5/8 inches for precast boxes with a clear span of up to 7 feet and a maximum of 3/4 inches for boxes with a clear span greater than 7 feet. The exception to this is when beveled ends, for the purpose of laying curves, or skewed ends are specified by the Engineer.

410-6.4.4 Length of Section: Ensure the under run in length of sections is not more than 1/8 inch per foot of length with a maximum of 1/2 inches in any box section.

410-6.4.5 Tongue and Groove Joints or Ends: Ensure the planes formed by the ends of box sections do not vary perpendicular from the joint axis by more than the following:

1. Profiled Rubber Gasket Joints (ASTM C1677): 1/8 inch per foot of internal span with a maximum 5/8 inches for internal spans or heights less than or equal to 7 feet, and a maximum of 3/4 inches for internal spans greater than 7 feet.
2. Preformed Flexible Joints (ASTM C990): 1/4 inches for internal spans or heights less than 5 feet, or more than 3/8 inches for internal spans or heights of 5 feet or greater.

410-6.4.6 Position of Reinforcement: Meet the requirements of 415-5.10.2 for the maximum variation in the position of slab reinforcing. Meet the requirements of 415-5.8.2 for the maximum variation of wall reinforcing, except that the concrete cover must not be less than 1/4 inches nor more than 1/2 inches from the design dimensions.

410-6.4.7 Area of Reinforcement: Provide the area of reinforcement as indicated in the Plans or approved shop drawings as a minimum. If welded wire reinforcement is utilized in lieu of mild steel reinforcement, the provisions of 415-6 apply.

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410-6.5 Removal of Forms: Remove forms after the concrete has attained the minimum compressive strength requirements included as part of the Producer QC Plan, but not less than the following:

Table 410-1	
Vertically cast walls and slabs for four-sided sections	1,000 psi
Three-sided box culvert bottom section	2,500 psi
Horizontally cast self-supporting slabs or walls	2,500 psi

Products manufactured with dry-cast concrete, are exempt from these requirements.

410-6.6 Lifting and Removal From Casting Area: Handle all products, including those manufactured with dry-cast concrete, after the concrete attains sufficient compressive strength as determined by the manufacturer but not less than the following, unless otherwise approved in the Producer QC Plan:

Table 410-2	
Vertically cast and stored elements (walls and slabs)	1,000 psi
Form/pallet supported elements (walls or slabs)	1,000 psi
Self-supporting four-sided sections	1,000 psi
Self-supporting horizontal slabs or three-sided sections	2,500 psi

Limit the flexural tension stresses from handling to a maximum allowable stress of three times the square root of the concrete compressive strength in psi, prior to the concrete attaining the required 28-day strength.

410-7 Handling, Storage, and Shipping.

Handle, store, and ship precast box culverts in a manner that prevents chipping, cracks, fractures, and excessive bending stress. Do not ship precast box culverts before the concrete attains the required 28-day strength.

The manufacturer is permitted to verify the shipping strength test, before 28 days, by testing compressive strength cylinders that are cured under the conditions similar to the product or by testing temperature match cured cylinders. The manufacturer may use the maturity method, ASTM C 1074, pulse velocity method in accordance with ASTM C 597, or any other approved nondestructive test method to estimate the strength of concrete for determining form removal and handling strengths or before verification of shipping strength by test cylinders.

Curing temperature and cycle must be monitored on a minimum of one box culvert curing cell from each day of production when nondestructive test methods or temperature match cured cylinders are used to determine concrete strengths.

The shipping strength test is the average compressive strength of two test cylinders. Do not ship any products until the QC Manager’s stamp is affixed to the product.

410-8 Repairs and Rejection.

Evaluate cracks, spalls and other deficiencies in accordance with 450-12. Classify fractures and cracks passing through the wall or slab, except for a single end crack with a length that does not exceed the depth of the joint, as major cracks. Walls and slab areas outside the

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middle half of the internal span will be considered non-critical locations for the purpose of evaluating cracks. Repair cracks and all other deficiencies in accordance with 450-13 or the plant's approved repair methods that are included as part of the Producer QC Plan. Ensure that the original performance and durability of the repaired box culverts are maintained.

Use materials for concrete repair that will meet or exceed the strength requirement of the class of concrete used. Materials meeting the requirements of Section 930 may be substituted for non-shrink grout when required by 450-13. Precast box culvert elements are subject to rejection if they fail to conform to any of the Specification requirements after repair or when damaged ends would prevent making a satisfactory joint.

410-9 Marking.

Ensure each section of Precast Box Culvert has permanently and clear marking on an inside face by indentation, waterproof paint, or as specified in the Producer QC Plan, showing the manufacture date, serial number, project number, and manufacturer's name or symbol. The top of the box culvert must also be clearly indicated with waterproof paint or as specified in the Producer QC Plan.

410-10 Trench, Foundation, Laying, and Backfill.

410-10.1 General: Meet the requirements of Section 125 and/or Section 121, for trench excavation, foundation construction, laying and backfilling and the following:

Lay all precast box culvert sections on a dry, slightly yielding foundation, to ensure uniform bearing across the full width of the bottom slab. Provide dewatering devices, if applicable, in accordance with 455-29, capable of maintaining a stable and surface-dry trench bottom. Construct any temporary sheet piling used in cofferdams, retaining walls and to incorporate the Contractor's specific means and methods, in accordance with 125-3.

410-10.2 Bedding: Provide bedding that consists of a minimum 6 inch depth of select material, with not more than 15% fines passing the No. 200 U.S. Standard sieve, in accordance with Standard Plans, Index 120-001 or other granular material approved by the Engineer. Place bedding in maximum 6 inch compacted layers below the culvert to a minimum width of 12 inches outside the exterior walls of the culvert and meet the density requirements of 125-9.2. When coarse aggregate is approved for use as an alternate bedding material, wrap the bottom and sides of the coarse aggregate with a layer of Type D-4 geotextile filter fabric as specified in Section 985, and substituted the coarse aggregate with select material within 4 feet of the cut-off or toe walls at each end of the precast box culvert. Obtain the Engineer's approval before using flowable fill for bedding material. Provide other special bedding material, when required by the Contract Documents.

Set grade forms 12 inches outside each exterior wall of the box culvert. Uniformly compact this material and then grade off using the forms. Set the grade forms approximately 1/8 inches to 1/4 inches above the theoretical grade line to allow for soil compression. Adjust this distance to yield the proper grade, but do not use in lieu of the proper compaction of the granular bedding material. Remove the forms after placing the precast box culvert section.

410-10.3 Placement of Precast Box Culvert Sections: Obtain the Engineer's approval of the method of controlling line and grade during culvert installation. Use a method that allows rapid checking of the previously laid sections. Maintain line and grade on sections previously set. The Engineer will consider sections which do not retain the plan line within 0.10 foot or grade within 0.10 foot during laying of subsequent sections, as not having been laid to line and grade. Take up and relay sections not to line and grade without additional compensation.

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410-10.4 Placement of Multiple Barrel Culverts: For multiple barrel installations using single-cell precast box sections, provide positive lateral support between the precast box culverts consisting of non-shrink grout, concrete meeting the requirements of Section 347 or non-excavatable flowable fill prior to backfilling. Provide partial height backfill or bracing to maintain alignment, when approved by the Engineer.

410-10.5 Backfilling: Begin backfilling only after the Engineers approval. Seal blockouts and holes provided for lifting or joint restraint by plugging using an epoxy mortar or non-shrink grout in accordance with Sections 926 or 934 and properly cure to ensure a sound and watertight plug, prior to backfilling.

410-10.6 Underdrain and Weep Holes: Provide a continuous underdrain in accordance with Standard Plans, Index 400-289.

410-11 Joints.

410-11.1 General: Make field joints for precast concrete box culvert sections with either profile rubber gaskets or preformed joint sealants, unless otherwise detailed in the Plans or approved shop drawings. Joint openings at the outside face must not exceed 1-1/2 inches in the assembled position at any location along the joint perimeter. Ensure a minimum 50% overlap of the joint tongue and groove around the entire perimeter of the box in the assembled position.

Completely wrap the outside of each joint with Type D-3 geotextile filter fabric as specified in Section 985. Provide fabric with a minimum width of 2 feet and a length sufficient to ensure a minimum overlap of 24 inches. The filter fabric must extend a minimum of 12 inches beyond each side of the joint. Secure the fabric tightly against the box culvert sections with metal or plastic strapping. Other methods which will hold the fabric securely against the wall of the culvert until the backfill is placed and compacted, may be used when approved by the Engineer. When specified in the Plans, secure the joint by a suitable device capable of holding the sections to line and grade as well as fully home. Remove these devices and repair locations as necessary if intrusive into the concrete after placing and compacting sufficient backfill to secure the sections.

410-11.2 Profile Rubber Gaskets: Install field joints in accordance with the joint manufacturer's instructions and meet the following:

1. Meet the requirements of ASTM C1677,
2. Store all gaskets in a cool place prior to use,
3. Submit to the Engineer written details regarding configuration of the joint and gasket required to create a soil-tight seal. Do not apply mortar, joint compound or other filler which would restrict the flexibility of the joint.

410-11.3 Preformed Flexible Joint Sealants: Install field joints in accordance with the joint manufacturer's instructions and meet the following:

1. Meet the requirements of ASTM C990,
2. Submit to the Engineer a written recommendation of the size (cross-sectional area) of joint sealant which will create a soil-tight seal. Ensure that this amount is the minimum quantity of bitumen sealant used. Do not brush or wipe joint surfaces which are to be in contact with the joint sealant with cement slurry. Fill minor voids with non-shrink grout,
3. Thoroughly clean and dry all joint surfaces which are to be in contact with the sealant material. When recommended by the sealant manufacturer, apply a primer of the type recommended to all joint surfaces which are to be in contact with the sealant material.

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4. Apply sealant to form a continuous seal around each joint. The sealant must be protected by a removable wrapper. Do not remove the paper wrapper on the exterior surface of the preformed flexible joint sealant until immediately prior to joining the precast sections. Apply the joint sealant only to dry surfaces. When the atmospheric temperature is below 60°F, either store the joint sealant in an area above 70°F, or artificially warm the joint sealant to 70°F in a manner satisfactory to the Engineer. After assembly, ensure that there is full contact and compression of the sealant for the entire perimeter of the joint, as evidenced by the presence of minor bulging along any visible edges of the sealant. Neatly trim any extruded sealant flush with the concrete surface.

410-11.4 Water-tight Joint Treatment: Provide water-tight joints when shown in the Contract Documents. Utilize an external sealing band in accordance with ASTM C877 in addition to the requirements of 410-11.2 or 410-11.3. Determine the minimum width of sealing bands by substituting the larger of the clear rise or span of the precast concrete box section, for the equivalent pipe diameter in ASTM C877 Tables 1 and 2. Install external sealing band wrap in accordance with the manufacturer's instructions prior to wrapping the joint with geotextile filter fabric.

410-12 Shop Drawings.

Submit details of all precast box culvert elements for approval to the Engineer prior to manufacturing in accordance with 5-1.4. These shop drawings must include the proposed layout, lifting devices, and a note describing the casting method for the precast box culverts and details of any modifications to cast-in-place sections or connections thereto. All details must be submitted as a complete package including modifications to cast-in-place sections.

410-13 Method of Measurement.

The quantity to be paid for will be plan quantity for the structure shown in the Contract Documents in accordance with 400-22 and 415-7.

410-14 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including the cost of special bedding material and its placement, additional cut-off or toe wall depth, temporary sheet piling, graded forms, joint materials, filter fabric material, attachment of the filter fabric, dewatering, excavation, channel excavation and lining, backfilling, restraining devices and any other materials or equipment necessary to make a complete and accepted installation.

Payment will be made under pay items for concrete (culverts), reinforcing steel (roadway), and FRP reinforcing.

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SECTION 411
EPOXY INJECTION OF CRACKS IN CONCRETE STRUCTURES

411-1 Description.

Inject epoxy into cracks in portland cement concrete.

411-2 Materials.

Meet the requirements of Section 926 and as follows:

Use Type E compound epoxy for injection.

Use Type F-1 compound epoxy for sealing crack surfaces in preparation for injection.

Use epoxy materials listed on the Department's Approved Product List (APL).

411-3 Equipment.

For the equipment used to inject the epoxy, meet the recommendations of the epoxy injection material manufacturer and the following requirements:

1. Use equipment that has the capacity to automatically proportion the material components within the mix ratio tolerances set by the epoxy materials manufacturer.

2. Use equipment that has the capacity to automatically mix the epoxy component materials within the pump and injection apparatus. The Engineer will not allow batch mixing.

3. Use equipment that has the capacity to inject the epoxy resin under controlled variable pressures up to 200 psi, with a pressure gauge mounted at or near the nozzle to indicate the actual working pressure.

411-4 Injection Personnel Qualifications.

Employ personnel trained in performing injection work similar to that required for the project to carry out the epoxy injection of cracks in concrete. Provide an on-site supervisor for the epoxy injection work who is qualified by one of the following methods:

1. Certified by the manufacturer of the epoxy injection material as having the necessary competence to accomplish the epoxy injection work in a satisfactory and safe manner in compliance with these Specifications.

2. They can furnish documented evidence that they have a minimum of three years experience of on-site supervision of similar epoxy injection work and a list of five contracts in which similar epoxy injection was acceptably completed. Ensure that the listed experience in on-site supervision and completed contracts contains the project name and location, names of contracting parties, the owner's name, brief description of the work, and dates of completion of the epoxy injection work.

Submit written evidence showing personnel training and the on-site supervisor's qualification to the Department prior to beginning any epoxy injection work.

411-5 Crack Surface Preparation and Cleaning Requirements.

Clean the area surrounding the cracks of all deteriorated concrete, efflorescence and other contaminants detrimental to the adhesion of the surface sealing epoxy compound. Clean the interiors of the cracks with air under sufficient pressure to remove loose materials entrapped within the crack including efflorescence.

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411-6 Sealing Cracks for Epoxy Injection.

After cleaning, drill injection port holes using a swivel drill chuck and hollow drill bits, including a vacuum attachment which will remove dust and debris generated during drilling. Determine the spacing of the injection port holes by the size of the crack and the depth of the crack in the concrete substrate. Generally, space the injection ports from 4 to 8 inches apart. Determine the actual spacing of injection ports by field trials. Drill the holes to a minimum depth of 5/8 inch, exercising care in aligning the hole along the plane of the crack so that the hole follows the crack for the full 5/8 inch depth.

Insert the injection ports in the drilled holes approximately 1/2 inch, allowing for a small reservoir below the injection port.

After cleaning the cracks and drilling the injection port holes, seal the crack surface and the injection ports with suitable epoxy.

411-7 Epoxy Injection.

Inject the epoxy in accordance with the epoxy manufacturer's instructions. Determine the actual injection procedures and pressures in field trials, based on crack widths and depth into the substrate and sufficiency of the results.

411-8 Cleaning After Epoxy Injection.

Clean concrete surface areas of excess epoxy materials and injection ports after completing the epoxy injection work. Clean in a manner which will not damage the concrete by scraping, light sand blasting, grinding, use of solvents, or any other appropriate method approved by the Engineer. Clean excess materials so that no epoxy material or injection ports extend beyond the plane surface of the concrete.

411-9 Acceptance.

Drill three cores located in each day's work as directed by the Engineer. Take drilled core samples containing representative crack sizes. The Engineer will accept the epoxy injection work represented by the core samples when the core samples indicate that 90% of the crack void greater than 0.006 inch wide is filled with epoxy resin and the concrete of the core sample is bonded through the crack into a unit.

Reinject epoxy injection work which does not satisfy the acceptance criteria, and correct it as necessary at no expense to the Department. Install additional injection ports as required to achieve satisfactory reinjection of epoxy resin.

After the epoxy injection work is completed and accepted, fill the core holes with an epoxy mortar consisting of one part by volume epoxy injection resin and four parts by volume clean, dry sand. Supply the sand in moisture proof bags. Do not use previously opened bags of sand for making epoxy mortar. The Contractor may use one part by volume epoxy material for sealing with one part by volume clean, dry sand in lieu of the above.

411-10 Method of Measurement.

411-10.1 Epoxy Material: The quantity to be paid will be the volume, in gallons, authorized, injected, and accepted.

411-10.2 Inject and Seal Crack: The quantity to be paid will be the length, in feet, authorized and accepted, measured along the approximate centerline of the sealed crack.

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411-11 Basis of Payment.

411-11.1 Epoxy Material: Price and payment will be full compensation for all work specified in this Section, including furnishing the epoxy material, and miscellaneous related costs, storage, handling, etc.

411-11.2 Inject and Seal Crack: Price and payment will constitute full compensation for furnishing all labor, equipment, incidentals and materials (except epoxy), for cleaning and sealing the crack, and all labor and equipment for injecting the crack.

411-11.3 Payment Items: Payment will be made under:

Item No. 411-	1-	Epoxy Material - per gallon.
Item No. 411-	2-	Inject and Seal Crack - per foot.

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SECTION 413
SEALING CRACKS AND CONCRETE STRUCTURE SURFACES

413-1 Description.

Seal concrete surfaces and cracks in concrete using materials, surface preparation, and application of penetrant sealers and high molecular weight methacrylates (HMWM) as specified in this Section and in accordance with the manufacturer recommendations. Consult with the FDOT State Materials Office (SMO) in the event of conflict between the manufacturer's recommendations and this Specification. Perform surface preparation and application to all areas as shown in the Plans or as directed by the Engineer.

413-2 Penetrant Sealers.

413-2.1 Materials: Use alkylalkoxysilane penetrant sealers, with 40 percent solids and active materials dispersed in water that meet the following:

Table 413-1
Physical Properties of Penetrant Sealers

Appearance	White, or light gray color or fugitive dye
VOC content (EPA method 24)	Less than 350 g/l
Flash Point (ASTM 3278)	Greater than 200°F SETA
Resistance to Chloride ion penetration AASHTO T 259 and T 260	Less than 0.52 pounds/yd3(criteria of 1.5) at 1/2 inch level; 0.00 pounds/yd3 (criteria of 0.75) at 1 inch level
Water absorption test (ASTM C642)	0.50% maximum/48 hours; 1.5% maximum/50 days
NCHRP 244	
Series II - cube test	
Water weight gain	85% reduction minimum
Absorbed chloride	87% reduction minimum
Series IV - Southern climate	
Absorbed chloride	95% reduction minimum
Scaling resistance (ASTM C672)	(non - air - entrained concrete) 0 rating "No Scaling" (100 cycles)

413-2.2 Surface Preparation for Penetrant Sealer:

413-2.2.1 General: Prepare concrete surfaces to receive a penetrant sealer in accordance with these Specifications dependent on whether the surfaces are of recently cast concrete (new construction) or of existing concrete.

413-2.2.2 Surface Preparation for New Construction: Remove substances such as dust, grime, dirt, curing compounds, form oil, debris, etc. by water blasting, light sandblasting, wire brushing, or other methods acceptable to the Engineer, all in accordance with the penetrant sealer manufacturer's recommendations. When using cleaning methods other than water blasting, wash the cleaned surfaces with water meeting the requirements of Section 923, as a final cleaning operation.

413-2.2.3 Surface Preparation for Existing Concrete: Remove substances such as dust, grime, dirt, stains, mineral deposits, oil, bituminous materials, debris, and all other

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deleterious material by using water blasting equipment of sufficient operating capacity and pressure, all in accordance with the penetrant sealer manufacturer's recommendations.

413-2.2.4 Cleaning Equipment: Use approved water blasting equipment to clean existing concrete surfaces. Use water blasting equipment which is specifically manufactured to clean concrete surfaces. Use equipment that has a minimum rated nozzle capacity of 6,000 psi using the spray head proposed for use in the work.

413-2.2.5 Water for Blasting: Use water meeting the requirements of Section 923.

413-2.2.6 Concrete Surface Cleaning Operation: Exercise sufficient care during the cleaning operation to minimize the removal of the concrete matrix. Furnish hand tools, power grinders, and other similar equipment to remove materials which cannot be removed by water blasting without abrading the concrete matrix beyond acceptable limits. Wash concrete surfaces cleaned by methods other than water blasting with water blasting equipment as the final cleaning operation.

Limit the duration of water blasting to provide a light abraded surface. Do not allow surface abrasion to exceed 0.016 inch. The Engineer will not require further cleaning of stains still apparent after abrading to a depth of 0.016 inch. Avoid exposure of coarse aggregate by water blasting.

Reclean concrete surfaces which become contaminated before applying the penetrant sealer at no expense to the Department prior to applying the penetrant sealer.

413-2.3 Application of Penetrant Sealer Materials: Apply the penetrant sealer only to surfaces which have been prepared in accordance with these Specifications and approved by the Engineer. For application of the penetrant sealer, meet these Specifications and the penetrant sealer manufacturer's recommendations.

Prior to application of any penetrant sealer, cure concrete for a minimum of 21 days.

Apply penetrant sealer no later than ten days after completion of the surface preparation and prior to any contamination of the prepared surfaces as determined by the Engineer.

413-2.3.1 Application Equipment: Apply the penetrant sealer using any suitable air or airless sprayer with an operating pressure of approximately 20 psi.

413-2.3.2 Application Limitations: Apply the penetrant sealer material only when the ambient air temperature is between 50 and 90ºF. Apply the penetrant sealer only to concrete surfaces which have dried a minimum of 48 hours after water from any source last contacted the concrete surfaces. Do not apply the penetrant sealer when winds are blowing 25 mph or more, during rainfall, or when water spray or mist is present.

413-2.3.3 Application: Apply the penetrant sealer only to concrete surfaces that have been prepared in accordance with the requirements and limitations set forth in these Specifications. Determine the actual coverage rate in square feet per gallon on the basis of field trials. Conduct a field trial to determine coverage rate at the beginning of any penetrant sealer application operation. Conduct additional confirmation field trials at a frequency of once for every 5,000 ft^2 applied, each production day of application, or when the character of the work changes, whichever is sooner. For each field trial, determine the optimum coverage rate for 500 ft^2 of surface area. Maintain the penetrant sealer application rate between 155 and 225 ft^2 covered per gallon of penetrant sealer used. Apply the penetrant sealer in a uniform manner

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without puddling and skips. Redistribute any penetrant sealer which is applied and subsequently puddles in low areas over the concrete surfaces by use of a squeegee.

Begin the application of the penetrant at the lowest elevation and proceed upward toward higher elevations unless otherwise approved by the Engineer.

Maintain operating pressures in the sprayers used for application of the penetrant sealer material sufficiently low so that atomization or misting of the material does not occur. Saturate cracks to refusal when used as crack sealer per 400-21.

413-2.4 Control of Materials:

413-2.4.1 Packaging and Identification: Deliver the penetrant sealer to the project in unopened, sealed containers with the manufacturer's label identifying the product and with numbered seals intact. Ensure that each container is clearly marked by the manufacturer with the following information:

1. Manufacturer's name and address.
2. Product name.
3. Date of manufacture.
4. Expiration date.
5. LOT identification number.
6. Container serial number.

413-2.4.2 Manufacturer's Certification: Submit to the Engineer a certification conforming to the requirements of Section 6 from the manufacturer, confirming that the penetrant sealer meets the requirements of this Section. Do not incorporate these materials into the project until the Engineer has accepted and approved the certification for the material. Submit such certification for each LOT of material delivered to the project. In each certification, identify the serial or LOT numbers of the containers certified.

413-2.4.3 Materials Sampling for Tests: The Engineer may require samples from each LOT or container of materials delivered to the project or from containers at the point of use. When samples are required, furnish samples in accordance with the Engineer's instructions.

413-2.4.4 Storage of Materials: Store materials delivered to the job site in original unopened containers within an appropriate storage facility. Use a storage facility that provides protection from the elements, and safe and secure storage of the materials.

413-2.4.5 Unused Material in Opened Containers: Do not return unused material in opened containers to storage for later use. Either apply such material to appropriate areas on concrete surfaces or remove and dispose of it at offsite locations provided by the Contractor.

413-2.5 Acceptance: The Engineer will accept penetrant sealer application when it is determined that the Contractor has properly cleaned all surface areas to be sealed and has applied the penetrant sealer within the required rates of application.

413-3 High Molecular Weight Methacrylate (HMWM).

413-3.1 General: Perform the surface preparation and application of a high molecular weight methacrylate to seal cracks on horizontal and slightly sloped concrete surfaces as approved by the Engineer. Applications on bridge decks and other riding surfaces will require the addition of sand over the treated areas to increase the surface friction number (FN) measured as described by AASHTO T242.

The rate of application (ft^2 of concrete per gallon) and the application method and equipment to achieve a minimum average penetration of 1 inch must be approved by the SMO

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prior to commencement of work based on the size, depth and the internal condition of cracks. Submit a written sealer application plan based on the above described crack characteristics for approval by the SMO. In addition, provide a minimum of 14 days advanced notice so that personnel from the SMO may be present at the beginning of work to evaluate the cracks and submit final approval of the application rate if such is requested by the Engineer. Make arrangements with the material manufacturer to provide an on-site technical representative with a minimum of ten previous projects with experience in the application and formulation of the methacrylates for the initial application and certify that the mixing ratio, application methods, and sand broadcasting are correct and in accordance with their recommendations. The representative shall then visit the site to provide quality assurance observations every two weeks for applications lasting longer than two weeks.

Maintain a daily log of used resin material to be verified by the Engineer. Include the drum or container identification number in the log as well as the date and location of use. Retain the containers at the jobsite until the Engineer verifies its use and authorizes removal from the site.

413-3.2 Materials: Use a methacrylate system that has a three component formulation consisting of methacrylate monomer, cumene hydroperoxide (CHP) initiator, and cobalt promoter. The methacrylate system cannot contain wax. Use a HMWM system that is approved by the Department and included on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their products must submit an application conforming to the requirements of Section 6 along with the following documentation:

1. Manufacturer's material installation instructions showing the product can be installed in accordance with this Section.

2. Independent laboratory test data and results showing the product has been tested in accordance with the requirements of this Section and meets the requirements.

3. Qualification of their on-site representatives.

413-3.2.1 Properties: Use a methacrylate system that meets the following physical and performance requirements:

Table 413-2 Physical Properties of Methacrylate System	
Density (ASTM D1481)	8.5 - 9.0 lb/gl at 77° F
Flash Point (ASTM D93)	> 200°F (Pensky Martens CC)
Odor	Low
Bulk Cure Speed	3 Hours @ 73°F (max.)
Surface Cure	8 Hours @ 73°F (max.)
Gel Time[(1)]	60 minutes (max.) @ 73.4 ± 1.8°F
Tack Free Time	4-6 Hours (max.) (at 72°F and 50% Relative Humidity
Compressive Strength (ASTM D695)	6,500 psi (min)
Tensile Strength (ASTM D638)	1,300 psi (min)
Shear Bond Adhesion (ASTM C882)	600 psi (min)
Elongation[(2)] (ASTM D638)	Report
Physical Properties of Methacrylate monomer (Part A)	
Viscosity (ASTM D2196, Method A)	14-20 cps using Ultra Low Adapter

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1. Use a test method capable of measuring the gel time to the nearest 0.5 minute. 2. Do not use methacrylate with elongation less than 20% for concrete decks supported by steel girders.

The monomer shall have a shelf life of no less than 12 months and shall be no more than 8 months old at the time of application. Provide each container shipped to the job site with the following information on a manufacturer's label: manufacturer's name, product name, LOT or batch number, date of production, and drum serial number. Identify the catalysts by their generic classification and provide the date of manufacture.

413-3.2.2 Sand: Use uniformly graded 6-20 (or similar), clean, bagged, blast sand for spreading over the applied polymer on bridge decks and other riding surfaces. Certify that the sand has a maximum moisture content that does not exceed 0.25% and that the maximum amount of dust or other material that may pass through a No. 200 sieve -200 content) is not greater than 0.75%.

Store the sand at a location that will preserve the above described conditions and characteristics of the sand until applied.

413-3.2.3 Identifier: Use methacrylates with a fluorescent dye when applying methacrylate over previously sealed cracks. The fluorescent dye shall be part of the manufacturer formulation and be clearly fluorescent under a UV light source provided by the Contractor.

413-3.3 Surface Preparation:

413-3.3.1 Cleaning: On the day of application, thoroughly power sweep the area to be treated to remove all dust, dirt or debris present. On bridge decks and other riding surfaces, use a tractor mounted (or similar) power broom with non-metallic bristles suitable for the intended purpose.

Use a power vacuum after sweeping when sealing cracks on grooved bridge decks. Re-clean the deck as necessary immediately prior to the application as debris may be blown back onto the work area by adjacent traffic or other means.

If present, remove oils and oil based substances from the concrete surface using an approved solvent.

413-3.3.2 Containment: Provide adequate containment to prevent the sealer material from flowing beyond the designated area of application. Plug any drain holes or openings within the work area. Prevent airborne material from dispersing onto open traffic lanes or outside the work area.

413-3.3.3 Raised Pavement Markers (RPMs): Protect by masking or clean after application, all existing RPMs affected by the application of the methacrylate. Alternatively, remove and replace such RPMs as indicated in the Contract Documents.

413-3.4 Application:

413-3.4.1 Equipment: Apply the methacrylate material according to the manufacturer's specifications using mobile equipment capable of distributing material on large areas of decks and riding surfaces. Apply the material by hand using adequate containers for isolated or localized applications.

413-3.4.2 Mixing: Mix the methylmethacrylate material following the manufacturer's specified mixing proportions for the catalysts. Perform the initial mixing by equally dividing the resin to be used into two separate containers. In all instances, mix the initiator (CHP) at the HMWM manufacturer's specified volume with 50% of the monomer resin in one container and the cobalt promoter at the HMWM manufacturer's specified volume with the other 50% in the second container. After properly blending, combine the two resins and mix as per manufacturer's instructions. For spray bar application, mix the activator/resin blend and

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the promoter/resin blend through a static mixer in the feed line located ahead of the material distribution bars where polymerization would start. Calibrate the valves to the static mixer to ensure a one to one mixing ratio of the two blends.

413-3.4.3 Polymer Application (Mobile Distribution): Distribute the monomer uniformly over the work area using a pressure nozzle or spray head distribution bar system. Provide feed to the distribution bar(s) using positive displacement pumps moving equal amounts of the two monomer blends from two calibrated drums.

Calibrate the equipment to mix the two monomer blends to the recommended ratio (by volume) within plus or minus 5%. The discharge volume shall be calibrated to the moving speed to provide a discharge rate capability ranging from 50 to 200 square feet per gallon at a pressure ranging from 15 to 60 psi.

The typical application rate of the material is approximately 100 square feet per gallon. Prior to application of the monomer, the SMO will approve the final production application rate based on the internal characteristics of the cracks as determined from Contractor supplied cores that the Engineer approves as being representative of the overall cracking conditions.

413-3.4.4 Polymer Application (Localized Distribution): Distribute the material by hand over the work area using pails or other suitable containers adequate for the size of the area. This only applies to localized small areas or areas where the use of mobile distribution equipment would be considered impractical as approved by the Engineer.

Do not re-use containers or mixing paddles fully or partially contaminated with polymerized methacrylate.

413-3.4.5 Sealing of Cracks: Regardless of the method used to apply the material over the concrete surface, work the material back and forth over the cracks to maximize the amount of material to be absorbed by the cracks. Move the material over the cracks using brooms, squeegees or paint brushes as appropriate, based on the size of the area. Commence this operation immediately after distributing the material on the concrete surface. Continue this operation until no additional material is flowing inside the cracks or the material begins to exhibit signs of polymerization.

Do not distribute material over areas larger than what the available personnel can effectively work over the cracks within the limits of the pot life.

413-3.4.6 Sand Distribution: Apply sand over the monomer treated area within a timely period following the application of the polymer based on the manufacturer's recommendations for the existing conditions. Use equipment that will produce a uniform distribution of the sand over the treated area. If wheel mounted, use a sand spreader that has pneumatic tires compatible with the treatment material such that no tire footprints are left on the deck surface.

Use an initial application rate of 1.0 (plus or minus 0.05) pounds of sand per square yard of treated area and adjust the rate as necessary to produce a friction number (FN) of no less than FN40R greater than or equal to 35 at 7 days. If friction numbers below those specified are obtained, completely remove all loose sand from the surface and re-apply the polymer at a rate of 150 square feet per gallon and spread additional sand as necessary to achieve the specified friction numbers. Remove the surface material by grinding, shot blasting, or other approved method if satisfactory friction values are not achieved. Friction tests must be conducted in accordance with AASHTO T242, using the ribbed tire option. Secure the services of an

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independent enterprise with prior experience on roadway friction testing with the equipment described to perform the friction tests.

413-3.5 Opening Riding Surfaces to Traffic: Protect the sand covered area from vehicular traffic until the polymer has fully cured. After curing, power vacuum to remove excess sand from the riding surface, before opening to traffic.

413-3.6 Acceptance Tests: Verify penetration of the methacrylate into the cracks by extracting a 2 inch diameter core (1-1/2 inch deep) for every 1,000 square feet or less (if application is less than 1,000 square feet) of sealed concrete. Use caution to prevent cutting the reinforcing steel. Frequency of verification may be reduced by the SMO with the concurrence of the Engineer.

Test curing on the treated area using a cotton strand or cotton ball. Consider the material fully cured and ready for traffic when polymer does not adhere to the cotton ball when pressed against the treated surface and then pulled away. Obtain approval from the Engineer prior to reopening area to traffic.

413-3.7 Limitations: Apply the material only under weather conditions recommended by the manufacturer and when no rainfall has occurred during the previous 48 hours and no rain is expected for the next 6 hours following completion of the application.

413-4 Method of Measurement.

Prestressed, precast items designated in the Plans to be sealed with penetrant sealer, will not be measured for separate payment. The Contractor shall include the cost of cleaning, sealing, and applying penetrant sealer with the cost of the prestressed, precast items. For cast-in-place surfaces to be sealed with penetrant sealer, the quantities to be paid for will be the volume, in gallons, of penetrant sealer as determined by use of the field measured area satisfactorily sealed divided by the approved application rate based on field trials, and the area, in square feet, of cleaning and sealing concrete surfaces as determined by field measurement, completed and accepted.

Quantities of high molecular weight methacrylate to be paid will be based on the volume in gallons of monomer resin material (not including the promoter, initiator, and fluorescent dye) actually used to seal the cracked surfaces at the approved application rate, and the dimensions of the treated areas in square feet.

The area of application will be computed based on the plan dimensions of concrete surface sealed with methacrylate. For localized application, the Engineer will determine the method of measurement that most accurately reflects the area of application in square feet.

413-5 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section, including cleaning, furnishing and applying the material required to satisfactorily clean and seal cracks and designated surface areas, testing, and miscellaneous related costs including storage, handling, etc.

No additional compensation will be made for material, reapplication or removal due to Contractor error, or to correct deficient friction values.

Payment will be made under:

Item No. 413-149-	Penetrant Sealer - per gallon
Item No. 413-151-	Methacrylate Monomer - per gallon
Item No. 413-154-	Cleaning and Sealing Concrete Surfaces - per square foot

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SECTION 415
REINFORCING FOR CONCRETE

415-1 Description.

Furnish and place steel and fiber reinforced polymer (FRP) reinforcing of the quality, type, size, and quantity designated. Obtain all FRP reinforcing bars from a producer on the Department's Production Facility Listing.

415-2 Materials.

Meet the following requirements:

Steel Bar Reinforcement	931-1.1
Steel Welded Wire Reinforcement	931-1.2
FRP Bar Reinforcement	932-3

415-3 Protection of Material.

415-3.1 Steel Reinforcing: Store steel reinforcement above the surface of the ground, upon platforms, skids, or other supports, and protect it from mechanical injury and surface deterioration. Ensure that the steel reinforcement is free from loose rust, scale, dirt, paint, oil, and other foreign material prior to incorporation into the work.

415-3.2 Fiber Reinforcing Polymer (FRP) Reinforcing: Store FRP reinforcement above the surface of the ground, in boxes or upon platforms, skids, or other supports, and protect it from mechanical injury and direct exposure to UV light. Ensure that the FRP reinforcement is free from dirt, paint, oil, and other foreign material prior to incorporation into the work.

415-4 Bending, Splicing, and Cutting.

415-4.1 Steel Reinforcing: Fabricate reinforcing bars as prescribed in the CRSI Manual of Standard Practice. Shop bend the reinforcement cold to the shapes indicated in the Plans. Do not bend the reinforcement to shape in the field. Minor bending adjustments may be performed in the field with the approval of the Engineer.

Do not hot bend or straighten, weld, or thermal cut reinforcing steel.

415-4.2 Fiber Reinforcing Polymer (FRP) Reinforcing: No field fabrication of FRP reinforcing bars is permitted except tying and field cutting per ACI 440.5. Do not bend or straighten, couple, thermal cut, or shear cut FRP reinforcing bars.

415-5 Placing and Fastening.

415-5.1 General: Unless otherwise specified in the Contract Documents, the tolerance for bar spacing is plus or minus 1 inch from the plan position and the tolerance for concrete cover is minus 1/4 inch or plus 1/2 inch from the plan dimensions. Construct all tie patterns referenced by this Section in accordance with the CRSI Manual of Standard Practice.

415-5.2 Concrete Blocks for Spacing: Use precast concrete blocks to space and support the reinforcing bars. Use concrete blocks with a strength equal to or greater than the concrete in which they are to be placed and have wires cast into them for fastening to the reinforcing bars. Moist-cure the blocks for at least three days.

Submit a certification verifying the class of concrete used to fabricate the concrete blocks, and identifying the batch and load of concrete from which the concrete blocks were cast.

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415-5.3 Tying:

415-5.3.1 Steel Reinforcing: Tie steel reinforcing using pliable steel wire that readily bends and twists without breaking and that provides a tie of sufficient strength to hold the steel reinforcing in its proper position. Tie stainless reinforcing steel using plastic coated pliable steel wire; or stainless steel wire meeting the requirements of ASTM A276, UNS S31600.

Non-metallic fasteners for steel reinforcing may be used in precast concrete products upon approval by the appropriate District Materials Office (DMO).

415-5.3.2 Fiber Reinforcing Polymer (FRP) Reinforcing: Tie FRP reinforcing using self-locking plastic straps; or plastic coated pliable steel wire that readily bends and twists without breaking and that provides a tie of sufficient strength to hold the FRP reinforcing in its proper position.

415-5.4 Splices: Where splices are authorized, rigidly clamp the bars or tie them in a manner meeting the Engineer's approval. Use the lap splice length as shown on the Plans.

415-5.4.1 Steel Reinforcing: Do not use welded splices for steel reinforcing except as specifically authorized by the Engineer and meeting the requirements of AWS D 1.4 Structural Welding Code - Reinforcing Steel.

Use mechanical couplers or splice devices for steel reinforcing that are listed on the Department's Approved Product List (APL).

415-5.4.2 Fiber Reinforcing Polymer (FRP) Reinforcing: Do not use mechanical couplers for FRP reinforcing. Use lap splices only.

415-5.5 Footings:

415-5.5.1 Supports: Support footing mat reinforcing with concrete blocks having dimensions not greater than 4 by 4 inches by plan clearance. Fasten concrete blocks to the steel using the cast-in wires.

415-5.5.2 Tolerances: Place footing mat reinforcing within 1/2 inch vertically from the plan bottom clearance and within 1 inch from the plan side clearance.

415-5.5.3 Tying: Tie footing mat reinforcing with a double-strand single tie at all intersections on the periphery and at alternate intersections within the mat.

415-5.6 Dowel Bars for Columns and Walls:

415-5.6.1 Supports and Positioning: Position dowel bars projecting into columns and walls so as to allow splicing of the vertical bars to the dowels and to tie the dowel bars in their plan position. Support the dowel bars by a rigid template such that concrete placement does not disturb their position. Support the reinforcing prior to placement of the footing concrete and do not insert dowel bars into the plastic concrete.

415-5.6.2 Tolerances: Place the dowels within 1/2 inch of their plan position and with a side clearance tolerance not exceeding 1/4 inch.

415-5.7 Verticals and Hoops for Columns:

415-5.7.1 Spacing-off from Side Forms: Space column reinforcing bars from the side forms by concrete blocks of dimensions not exceeding 2 inches by 2 inches by clearance dimension. Securely fasten each block to the reinforcing.

415-5.7.2 Tolerances and Clearance:

1. Column Verticals: Place column verticals within 1/2 inch of their plan position. Ensure that the side form clearance is within 1/4 inch of the specified clearance.

2. Column Hoops: Place every hoop within 1 inch of the plan position for the specific hoop, with no accumulation of such tolerance caused by the spacing between any

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two hoops. Ensure that side form clearance for any hoop is within 1/2 inch of its specified clearance.

415-5.7.3 Tying: Tie the column hoops to the column verticals at each intersection, by a cross tie or figure 8 tie.

415-5.8 Wall Reinforcing (Not Including Dowel Bars):

415-5.8.1 Supports: Space wall reinforcing bars from the side forms by concrete blocks of dimensions not greater than 2 inches by 2 inches by clearance dimensions. Fix the spacing between wall mats by means satisfactory to the Engineer.

415-5.8.2 Tolerance: Except when necessary to clear a fixture, place reinforcing bars within 1 inch of plan position. Ensure that the number of bars in any affected unit is as specified, and place the remainder of the bars (not thus affected) within 1 inch of plan location.

415-5.8.3 Tying: Tie retaining wall reinforcing bars with a cross tie or figure 8 tie at each intersection on the periphery and at every third intersection within the mat. If workmen use the reinforcing as a ladder, provide additional ties as directed by the Engineer.

Tie noise and perimeter wall reinforcing bars with a single tie at each intersection on the periphery and at every third intersection within the mat.

415-5.9 Beams and Caps:

415-5.9.1 Supports: Maintain bottom clearances by approved heavy beam bolsters. Support additional layers of main longitudinal reinforcing bars from the lower layers by heavy upper-beam bolsters, placed directly over low supports.

Begin the spacing of beam bolsters at not more than 2 feet from the end of the beams or caps and space the additionally required bolsters at not more than 4 feet.

Use concrete blocks, having dimensions not greater than 2 inches by 2 inches by specified clearance, fastened to the reinforcing bars by the cast-in wires, for spacing the upper main longitudinal bars below the top bars. Maintain the side clearance by concrete blocks, having dimensions not greater than 2 inches by 2 inches by required clearance, fastened to the reinforcing bars by the cast-in wires.

415-5.9.2 Tolerances: Place the main longitudinal reinforcing bars so as to provide a bottom and top clearance within 1/4 inch of the plan vertical dimensions for all layers. Space the bars from side forms within 1/2 inch of the specified spacing.

Place stirrups within 1 inch of the plan position for each individual stirrup and do not allow the tolerance to accumulate.

415-5.9.3 Tying: Tie all intersecting bars with a double-strand single tie.

415-5.10 Deck Slabs:

415-5.10.1 Supports:

1. Bottom Mats: Support the bottom mat of reinforcing bars using slab bolsters or concrete blocks. Use one row of slab bolsters placed 6 inches from the edge of the slab and two rows down each deck section between beams. Do not allow the spacing between rows to exceed 4 feet, measured center to center.

Use concrete blocks 2 inches by 2 inches by clearance dimensions. Space concrete blocks 4 feet on center as a maximum.

2. Top Mats: Support the top mats of reinforcing bars by either continuous or individual high chairs. Provide high chairs along both sides of each beam and approximately 6 inches back from the edge of the beam. Place the outside row of high chairs 6 inches from the edge of the slab. If using individual high chairs, do not allow the longitudinal spacing to be greater than 4 feet.

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As an alternate to the above, on prestressed beam construction, the Contractor may support the top mat of reinforcing bars on the shear connectors bent to the proper elevation with one line of high chairs centered between the beams.

3. Truss Bars: Support truss bars at each end of the top bends by continuous high chairs or by individual high chairs spaced longitudinally at not more than 4 feet.

415-5.10.2 Tolerances: Ensure that top and bottom clearances are within 1/4 inch from those shown in the Plans.

Ensure that end and bottom clearances are within 1/4 inch from those shown in the Plans.

Ensure that end and edge clearances are within 1/4 inch of the clearance specified.

Place curb bars within 1/4 inch in any direction of the plan position.

415-5.10.3 Tying: Tie all reinforcing bars in each layer with a double-strand single tie at every intersection on the periphery and at every third intersection in the interior area. Alternatively, at the Contractor's option, tie all reinforcing bars in each layer with a single-strand single tie at every intersection on the periphery and at every other intersection within the interior area. Alternatively, at the Contractor's option, if annealed soft-iron wire with uncoated diameter equivalent or greater than 16 gauge (0.062 in.) is used, tie all reinforcing bars in each layer with a single-strand single tie at every intersection on the periphery and at every third intersection in the interior area. If encountering difficulty in maintaining the reinforcing bars in position during the placing of concrete, tie additional intersections as necessary to hold the reinforcing bars secure.

415-5.11 Box Culverts:

415-5.11.1 Supports:

1. Bottom Slabs: In the bottom slabs of box culverts, provide supports for single-mat reinforcing bars and for bottom-mat reinforcing bars, including placement and spacing, as specified for footing mat steel in 415-5.5. In addition, where the Plans call for more than one mat of reinforcing bars in the bottom slab of the culvert, support the top mat away from the bottom mat, either by upper beam bolsters or by other means satisfactory to the Engineer.

2. Walls: Place, space and support the reinforcing bars in walls of box culverts in accordance with the requirements of 415-5.8.

3. Top Slabs: In the top slabs of box culverts, support the bottom mats of reinforcing bars by a row of slab bolsters 12 inches from the inside face of the walls and with additional rows of bolsters at spacings not exceeding 4 feet, center to center. As an exception, unless the Engineer deems the use of the slab bolsters as necessary to obtain proper support, the Contractor may use concrete blocks as the supporting device. Use blocks of dimensions not greater than 2 inches by 2 inches by the required clearance, with spacings not exceeding 4 feet in any direction. Fasten blocks to the reinforcing steel by the cast-in wires.

4. Truss Bars: Support truss bars as specified in 415-5.10.

415-5.11.2 Tolerances: Use tolerances in placing the reinforcing bars in box culvert slabs as specified for deck slabs in 415-5.10. Use tolerances for placing bars in walls as specified in 415-5.8.

415-5.11.3 Tying: Tie reinforcing bars in box culverts as specified for deck slabs in 415-5.10.

415-5.12 Cleaning: Before placing any concrete, clean all mortar from the reinforcement.

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415-5.13 Bar Supports:

415-5.13.1 General: Provide reinforcing bar supports manufactured in accordance with all requirements of the CRSI Manual of Standard Practice. Use bar supports of adequate strength to withstand a 300 pound concentrated load without permanent deformation or breakage, with deflection less than 5% of the support height.

Ensure that no more than 5% of the reinforcing bar supports exhibit unsatisfactory performance, breakage, or permanent deformation during bar tying and/or concrete placement operations. If a bar support does not achieve this level of performance, reduce the average spacing between bar supports by 15%, or remove that product from use on the job.

Ensure that bar supports do not move during concrete placing operations. To prevent movement, tie supports to the reinforcing bars.

When using bar supports on corrugated metal stay-in-place forms, use supports specifically designed for the form being used.

For structural elements located in extremely aggressive environments, do not use metal bar supports in contact with removable forms or floor surfaces to support reinforcing bars.

415-5.13.2 Metal Bar Supports: For metal bar supports in contact with removable forms, provide supports constructed with molded plastic legs or plastic protected metal legs or bolster rails. Do not allow any portion of the bar support other than the molded plastic leg or plastic protected portion of the metal leg or bolster rail to be closer than 1/2 inch from the removable form surface for concrete to be cast.

Submit certification verifying that all metal bar supports meet the following requirements:

1. That they are manufactured from cold drawn steel wire in accordance with the wire sizes and geometrical dimensions shown in the CRSI Manual of Standard Practice, Chapter 3.

2. That the plastic used for protection of the steel legs or bolster rails has a thickness of 3/32 inch or greater at points of contact with the form work.

Provide plastic protection by a dipping operation, by adding premolded plastic tips to the legs of the support or by molding plastic to the top wire of the support. Ensure that the plastic material used for protection of steel legs does not chip, crack, deform, or peel during use.

Do not use metal bar supports to support FRP reinforcing bars.

415-5.13.3 Plastic Bar Supports and Spacers: Use non-stackable plastic bar supports and spacers. Bar supports shall be able to meet the concentrated load requirements of 415-5.13 within a working temperature range of 20 to 150°F. Spacers shall be able to provide sufficient strength to support reinforcing steel in the required position without deformation and relaxation under job conditions. For drilled shafts, use wheel spacers with a smooth perimeter surface.

Submit protection from sunlight until placed in the form and mold in a configuration which does not restrict concrete flow and consolidation.

All plastic bar supports and spacers shall have a maximum water absorption of 0.5% at 7 days as per ASTM D570. Plastic bar supports and spacers made of recycled plastic products must meet the additional requirements of Section 972.

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Submit to the Engineer independent lab test data and certification verifying that the plastic spacers meet the requirements specified herein.

Use plastic bar supports listed on the Department's APL. Provide each individual bar support with an identification number unique to the particular model permanently marked on the surface as included in the APL. Manufacturers seeking evaluation of products for inclusion on the APL must submit an application in accordance with Section 6 and include certified test reports from an independent laboratory showing that the plastic bar supports meet all the requirements specified herein.

415-6 Welded Deformed Steel Wire Reinforcement.

415-6.1 General: Provide welded deformed steel wire reinforcement as shown in the Plans or as a substitute for deformed bar reinforcement when approved on the shop drawings. Propose substitutions of welded deformed steel wire reinforcement in a manner that provides a cross-sectional area per foot of welded deformed steel wire equal to that provided in the Plans for deformed bar reinforcement. Orient the deformed wires of welded deformed steel wire reinforcement in the same position as bar reinforcement detailed in the Plans. Cross wires of welded deformed steel wire reinforcement may be deformed or smooth and must have a cross-sectional area at least 35% greater than the area of the deformed wire.

415-6.2 Design: When welded deformed steel wire reinforcement is substituted for deformed bar reinforcement, ensure that the development length, splices, shear reinforcement, and distribution meet the requirements of the AASHTO LRFD Bridge Design Specifications.

415-7 Method of Measurement.

415-7.1 Reinforcing Steel: The quantity to be paid for will be the plan quantity, in pounds, of reinforcing steel, stainless reinforcing steel, or low carbon chromium reinforcing steel incorporated into the completed work and accepted, subject to any changes approved by the Engineer. The quantity will not include the reinforcing steel (all types) in any item of work for which the basis of payment already includes the steel reinforcement. No additional payment will be made for substitutions of welded deformed wire reinforcement proposed by the Contractor. No separate payment will be made for reinforcing steel (all types) in pipe endwalls. No deduction will be made from reinforcing steel (all types) quantities for encroachment of inlets and pipes in box culverts. The lengths to be used in the calculation will be the detailed lengths of bars as shown in the Plans.

415-7.2 Unit Weights of Steel Bars: The unit weights used will be CRSI Standard Reinforcing Steel Bar Weights.

415-7.3 Welded Wire Reinforcement: Where welded wire reinforcement is to be paid for by weight, the quantity to be paid for will be the product of the area, in square feet, of the welded wire reinforcement incorporated into the completed work and accepted, multiplied by the manufacturer's standard weight per square foot.

When welded deformed steel wire reinforcement is substituted for deformed bar reinforcement, the quantity to be paid for will be the quantity which would be paid for if bar reinforcement as detailed in the Plans were utilized, based on plan quantity.

415-7.4 Fiber Reinforcing Polymer (FRP) Reinforcing: The quantity to be paid for will be the plan quantity, in linear feet, of bar incorporated into the completed work and accepted, subject to any changes approved by the Engineer. The quantity will not include the FRP bar in any item of work for which the basis of payment already includes the FRP bars. The lengths to be used in the calculation will be the detailed lengths of bars as shown in the Plans.

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415-8 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including all welding, all clips, spacers, ties, mechanical couplers, etc., and wire or other material used for fastening the reinforcement in place.

If spliced bars are used when full length bars might reasonably be required, the quantity paid for will be only that which would be obtained if full length bars were used, with no allowance for lap.

Payment will be made under:

Item No. 415- 1-	Reinforcing Steel - per pound.
Item No. 415- 2-	Stainless Reinforcing Steel - per pound.
Item No. 415- 3-	Low Carbon Chromium Reinforcing Steel - per pound.
Item No. 415- 10-	Fiber Reinforced Polymer Reinforcing Bar - per linear foot.

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SECTION 416
INSTALLATION OF POST-INSTALLED ANCHOR SYSTEMS AND DOWELS FOR STRUCTURAL APPLICATIONS IN CONCRETE ELEMENTS

416-1 Description.

Prepare and install post-installed anchor systems and dowels in hardened concrete as indicated in the Plans, as directed by the Engineer, and in accordance with the manufacturer's instructions and this Section.

Post-installed anchors and dowels in this Section are intended for use in structural applications where designated in the Plans.

416-2 Materials.

416-2.1 Adhesive Bonded Anchors and Dowels: Use adhesive bonding material systems which meet the requirements of Section 937 and are included on the Approved Product List (APL). Use anchors and dowels installed in positions ranging from vertically downward to horizontal.

416-2.1.1 Type HV Adhesives: Use Type HV adhesive bonding materials for all installations other than constructing doweled pile splices. Do not use Type HV adhesives as a substitute for Type HSHV adhesives.

416-2.1.2 Type HSHV Adhesives: Use higher strength Type HSHV adhesive bonding materials for installation of traffic railing reinforcement and anchor bolts into existing concrete bridge decks and approach slabs. Type HSHV adhesives may be used as a substitute for Type HV adhesives provided the length and diameter of the anchor bolt and drilled hole remain as designed for the Type HV adhesive.

416-2.1.3 Storage of Materials: Store materials delivered to the job site in the original unopened containers within an appropriate facility capable of maintaining storage conditions consistent with the manufacturer's recommendations.

416-3 Equipment.

Install adhesive-bonded anchor systems with equipment conforming to the manufacturer's recommendation for the type of system installed.

416-4 Preparing of Concrete Members.

416-4.1 Adhesive-Bonded Anchors and Dowels: Ensure that concrete members receiving adhesive-bonded anchors or dowels are structurally sound and free of cracks in the vicinity of the anchor or dowel to be installed. Unless other equipment is recommended by the adhesive manufacturer, drill holes to the diameter required by the manufacturer, but as a minimum, not less than 105% of the diameter including deformations, nor more than 150% of the nominal diameter of the steel bar anchor or dowel, using a rotary hammer drill and bit.

Use a metal detector specifically designed for locating steel in concrete to avoid conflicts with existing steel reinforcement whenever placement tolerances and edge clearances permit. Perform core drilling through existing steel reinforcement only when approved by the Engineer. Dry the drilled holes completely prior to cleaning and installing the anchors or dowels.

Clean and prepare drilled holes in accordance with the manufacturer's recommendations, but as a minimum, use oil free compressed air to remove loose particles from drilling, brush inside surface to free loose particles trapped in pores, then use compressed air

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again to remove the remaining loose particles. Use a non-metallic bristle brush and avoid over-brushing to prevent polishing the inside surface of the drilled hole.

416-5 Installation Methods.

416-5.1 Adhesive-Bonded Anchors and Dowels: Remove all debris, oils, and any other deleterious material from the anchors and dowels to avoid contamination of the adhesive bonding material. Install anchors or dowels in accordance with the details shown in the Plans and the manufacturer's instructions, with particular attention to requirements and limitations due to anchor position, dampness, ambient temperature, and curing.

Use adequate quantities of the adhesive bonding material to fill the drilled hole to within 1/4 inch of the concrete surface measured after placement of the steel bar or anchor. For horizontal and downwardly inclined installations, provide temporary supports to maintain the anchors or dowels in the center of the drilled holes until the adhesive bonding material has cured.

416-6 Field Testing of Post-Installed Anchor Systems and Dowels.

416-6.1 General: Provide an independent testing agency to perform field testing of post-installed anchors or dowels under the direction of a Professional Engineer registered in the State of Florida. Submit test reports for each LOT signed and sealed by the Professional Engineer. Perform restrained static tension tests to prevent damage to the surrounding concrete. A restrained test is defined as a test conducted in accordance with ASTM E488 except that the test equipment support clearance requirements of ASTM E488 do not apply. The opening in the reaction base shall be approximately equal to the drilled hole diameter for the anchor to preclude concrete or masonry failure, but allow bond failure for the adhesive-bonded anchors and dowels. Displacement measurement for field testing is not required.

Divide the post-installed anchors or dowels into LOTs for testing and acceptance. Each LOT must contain a maximum of 100 anchors or dowels, of the same type, manufacturer, diameter, embedment length and adhesive bonding material system (if applicable) installed on the same day. Randomly select four of the anchors or dowels in each LOT for testing, except if there are three or less in the LOT, in which case, test all anchors or dowels, unless otherwise directed by the Engineer. If three consecutive LOTs have no failing tests, sample the next three LOTs at a 2% rate, rounded up to the nearest whole number, and if these LOTs have no failing tests, sample at a rate of 1%, rounded up to the nearest whole number, for the remaining LOTs unless there is a failure; however, regardless of LOT size, sample at least one anchor or dowel per LOT. For every failed field test, perform two additional field tests on adjacent untested anchors or dowels within the LOT. Continue additional field tests until no more test failures occur, or all anchors or dowels within the LOT are tested. For the next LOT after a failed LOT, randomly select four of the anchors or dowels in each LOT for testing, except if there are three or less in the LOT, test all anchors or dowels unless otherwise directed by the Engineer then conform to the sampling rate procedure above including rate reductions as appropriate for subsequent LOTs.

416-6.1.1 Adhesive-Bonded Anchors: Field test installed anchors and dowels for applications connecting traffic railings to bridge decks, approach slabs and concrete pavement using Type HSHV adhesives. The Engineer may also require field testing of installed anchors and dowels for other applications. Any field testing of installed anchors which is required by the Engineer and not quantified in the Contract Documents shall be paid for by the Department unless a failure occurs during the field testing.

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Test individual anchors and dowels by proof loading in tension to 85% of the specified bond strength in accordance with Section 937 based on the nominal anchor or dowel diameter and embedment depth, but not more than 90% of the yield strength of the anchor or dowel, unless otherwise shown in the Contract Documents.

416-6.2 Removal & Replacement of Failed Test Specimens: Remove all anchors and dowels that fail the field test, in accordance with the manufacturer's recommendation and without damage to the surrounding concrete. For adhesive-bonded anchors, redrill holes to remove adhesive bonding material residue and clean in accordance with 416-4. Reinstall new anchors and dowels in accordance with 416-5. Do not reuse the failed anchors and dowels unless approved by the Engineer. Assign reinstalled anchors into new LOTs only containing reinstalled anchors or dowels of the same diameter, embedment length and adhesive bonding material system, and field test in accordance with 416-6.

416-7 Acceptance.

The Engineer will base acceptance of post-installed anchor systems on determining that the material requirements of Section 937, the installation and testing requirements of this Section and the placement requirements of the Plans have been met.

416-8 Basis of Payment.

The work specified in this Section will not be paid for directly, but will be considered as incidental work.

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SECTION 425
INLETS, MANHOLES, AND JUNCTION BOXES

425-1 Description.

Construct inlets, manholes, and junction boxes from reinforced concrete as shown in the Standard Plans and the Plans. Furnish and install the necessary metal frames and gratings. Construct yard drains from concrete meeting the requirements of Section 347. Adjust structures shown in the Plans to be adjusted or requiring adjustment for the satisfactory completion of the work.

For precast structures, meet the requirements in 449-1.

425-2 Composition and Proportioning.

425-2.1 Concrete: For inlets, manholes, and junction boxes, use Class II or IV concrete, as designated in the Plans and Standard Plans and as specified in Section 346. For concrete aprons and yard drains, use concrete as specified in Section 347.

425-2.2 Mortar: For brick masonry, make the mortar by mixing one-part cement to three parts sand. Miami Oolitic rock screenings may be substituted for the sand, provided the screenings meet the requirements of 902 except for gradation requirements. Use materials passing the No. 8 sieve that are well graded from coarse to fine. Submit documentation, from a Department approved mine or a Department approved concrete plant, confirming the sand or sand substitute meets the requirements of 902-3.2.

Preblended masonry cement mortar may be used in lieu of the above-specified mortar. Deliver the product in original and unopened packages properly identified by brand name of manufacturer, net weight of package, and type. Store the material in full compliance with the manufacturer's recommendations. Material must be used within manufacturer's recommended shelf life.

425-3 Materials.

425-3.1 General: Meet the following requirements:

Sand (for mortar).....Section 902
Portland Cement.....Section 921
Water.....Section 923
Reinforcing Steel ..... Sections 931 and 415
Liner Repair Systems.....Section 948
Brick and Concrete Masonry Units.....Section 949
Castings for Frames and Gratings.....Section 962
Masonry Cement, Type M or S.....ASTM C91
Preblended Dry Masonry Cement Mortar, Type M or S .....
.....ASTM C1714

425-3.2 Gratings, Covers, and Frames: Use gratings and frames fabricated from structural steel or cast iron as designated in the appropriate Standard Plans Index. When "Alt. G" grates are specified in the Plans, provide structural steel grates that are galvanized in accordance with the requirements of ASTM A123 and hardware galvanized in accordance with the requirements of ASTM A153.

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Use rigid frames and covers either 24 inches or 36 inches or optional three-piece adjustable frames and covers as indicated in Standard Plans, Index 425-001.

For three-piece adjustable frames, the inner frame may include replaceable resilient seats to support the cover. In addition, the inner frame shall indicate it is adjustable, by clearly having the word “adjustable” imprinted into the exposed portion of the inner frame so “adjustable” is visible from the roadway after installation.

425-3.3 Skimmer: Include 1.5% by weight of carbon black with plastic skimmers on french drain systems.

425-4 Forms.

Design and construct wood or metal forms so that they may be removed without damaging the concrete. Build forms true to line and grade and brace them in a substantial and unyielding manner. Obtain the Engineer’s approval before filling them with concrete.

425-5 Precast Inlets, Manholes, and Junction Boxes.

Precast inlets, manholes, and junction boxes, designed and fabricated in accordance with the Plans, the Standard Plans and Section 449 may be substituted for cast-in-place units.

425-6 Skimmers.

Furnish and install skimmers in accordance with the Plans and Standard Plans.

425-7 Construction Methods.

425-7.1 Excavation: Excavate as specified in Section 125.

Where unsuitable material for foundations is encountered, excavate the unsuitable material and backfill with suitable material prior to constructing or setting inlets, manholes and junction boxes.

As an option to the above and with the Engineer’s approval, the Contractor may carry the walls down to a depth required for a satisfactory foundation, backfill to 8 inches below the flowline with clean sand and cast a non-reinforced 8 inch floor.

425-7.2 Placing and Curing Concrete: Place the concrete in the forms, to the depth shown in the Plans, and thoroughly vibrate it. After the concrete has hardened sufficiently, cover it with suitable material and keep it moist for a period of three days. Finish the traffic surface in accordance with 522-7.2, or with a simulated broom finish approved by the Engineer.

425-7.3 Setting Manhole Castings: After curing the concrete as specified above, set the frame of the casting in a full mortar bed composed of one-part portland cement to two parts of fine aggregate.

425-7.3.1 Standard Castings: Set manhole frames in a mortar bed and adjust to grade using brick or concrete grade rings, with a maximum 12 inch adjustment.

425-7.3.2 Optional Adjustable Castings: When using a three-piece adjustable frame and cover, install the frame and cover with brick or concrete grade rings to the base course height. Make adjustments using the inner frame in accordance with the manufacturer’s installation recommendations so the inner frame and cover meet the grade and slope of the pavement surface opened to traffic.

425-7.4 Reinforcing Steel: Follow the construction methods for the steel reinforcement as specified in Section 415.

425-7.5 Laying Brick: Brick masonry may be used if the structure is circular and constructed in place, or for adjustments of rectangular risers up to a maximum 12 inches in

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height. Saturate all brick with water before laying. Bond the brick thoroughly into the mortar using the shove-joint method to lay the brick. Arrange headers and stretchers so as to bond the mass thoroughly. Finish the joints properly as the work progresses and ensure that they are not less than 1/4 inch or more than 3/4 inch in thickness. Do not use spalls or bats except for shaping around irregular openings or when unavoidable at corners.

425-7.6 Backfilling: Backfill as specified in Section 125, meeting the specific requirements for backfilling and compaction around inlets, manholes, and junction boxes detailed in 125-8.1 and 125-8.2. However; for outfall lines beyond the sidewalk or future sidewalk area, where no vehicular traffic will pass over the pipe, inlets, manholes, and junction boxes, compact backfill as required in 125-9.2.2.

425-7.7 Adjusting Structures: Adjust existing manholes, catch basins, inlets, valve boxes, etc., within the limits of the proposed work, to meet the finished grade of the proposed pavement, or if outside of the proposed pavement area, to the finished grade designated in the Plans for such structures. Adjust structures prior to placement of final asphalt pavement surface layer. Adjust structures to match final pavement surface cross-slope. Use materials and construction methods which meet the requirements specified above to adjust the existing structures.

The Contractor may extend manholes needing to be raised using adjustable extension rings of the type which do not require the removal of the existing manhole frame. Use an extension device that provides positive locking action and permits adjustment in height as well as diameter and meets the approval of the Engineer. When adjusting structures in flexible pavement, restore final road surface in accordance with Standard Plans, Index 125-001.

425-8 Method of Measurement.

The quantities to be paid for will be the number of inlets, manholes, junction boxes, and yard drains, completed and accepted; and the number of structures of these types (including also valve boxes) satisfactorily adjusted. Performance Turf will be paid in accordance with Section 570.

425-9 Basis of Payment.

425-9.1 New Structures: Price and payment will be full compensation for furnishing all materials and completing all work described herein or shown in the Plans, including all clearing and grubbing outside the limits of clearing and grubbing as shown in the Plans, all excavation except the volume included in the measurement designated to be paid for under the items for the grading work on the project, all backfilling around the structures, the disposal of surplus material, and the furnishing and placing of all aprons, gratings, frames, covers, and any other necessary fittings.

425-9.2 Adjusted Structures: When an item of payment for adjusting manholes, valve boxes, or inlets is provided in the proposal, price and payment will be full compensation for the number of such structures designated to be paid for under such separate items, and which are satisfactorily adjusted, at the Contract unit prices each for adjusting inlets, adjusting manholes, and adjusting valve boxes.

For any of such types of these structures required to be adjusted but for which no separate item of payment is shown in the proposal for the specific type, payment will be made under the item of adjusting miscellaneous structures.

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425-9.3 Payment Items: Payment will be made under:

Item No.425- 1-	Inlets - each.
Item No.425- 2-	Manholes - each.
Item No.425- 3-	Junction Boxes - each.
Item No.425- 4-	Adjusting Inlets - each.
Item No.425- 5-	Adjusting Manholes - each.
Item No.425- 6-	Adjusting Valve Boxes - each.
Item No.425- 8-	Adjusting Miscellaneous Structures - each.
Item No.425- 10-	Yard Drains - each.
Item No. 425- 17-	Back of Sidewalk Endwall - each.

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SECTION 430
PIPE CULVERTS

430-1 Description.

Furnish and install drainage pipe and end sections at the locations called for in the Plans. Furnish and construct joints and connections to existing pipes, catch basins, inlets, manholes, walls, etc., as may be required to complete the work.

Obtain pipe culverts and drainage products from a plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.

At the beginning of each project, submit a notarized certification statement to the Engineer in accordance with Section 6. The Quality Control Manager's stamp or label on each product indicates certification that the product was fabricated in conformance with the Producer QC Plan, the Contract, and this Section. Ensure that each shipment of drainage products to the project site is accompanied with a QC signed or stamped delivery ticket providing the description and the list of the products.

When the Producer Quality Control Program is suspended by the Department, accept responsibility of either obtaining products from a plant with an approved Quality Control Program, or await re-approval of the plant. The Engineer will not allow changes in Contract Time or completion dates as a result of the plant's loss of qualification. Accept responsibility for all delay costs or other costs associated with the loss of the plant's qualification.

Construct structural plate pipe culverts or underdrains in accordance with Sections 435 and 440.

For pipe culverts installed by jack & bore, install in accordance with Section 556.

430-2 Materials.

430-2.1 Pipe: Meet the following requirements:

Concrete Pipe	Section 449
Steel Pipe	556-2.1
Round Rubber Gaskets	Section 942
Resilient Connectors*	Section 942
Corrugated Steel Pipe and Pipe Arch	Section 943
Corrugated Aluminum Pipe and Pipe Arch	Section 945
Corrugated Polyethylene Pipe	Section 948
Steel Reinforced Polyethylene Ribbed Pipe	Section 948
Steel Reinforced Polyethylene Corrugated Pipe	Section 948
Corrugated Polypropylene Pipe	Section 948
Corrugated Polyvinyl Chloride (PVC) Pipe	Section 948
Fiberglass Reinforced Polymer Pipe	Section 948
Metal Grates	Section 962
Pipe Sleeve Adapters	Section 948

*Use resilient connector products listed on the Department's Approved Product List (APL).

430-2.2 Joint Materials: Use joint materials specified in 430-7 through 430-9 according to type of pipe and conditions of usage.

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430-2.3 Mortar: Use mortar composed of one part Portland cement and two parts of clean, sharp sand, to which mixture the Contractor may add hydrated lime in an amount not to exceed 15% of the cement content. Use mortar within 30 minutes after its preparation.

430-2.4 End Treatments: Meet the requirements of Section 425-3.1. For precast end treatments, meet the requirements in 449-1. Use the concrete Class designated in the Plans and Standard Plans, and as specified in Section 346 and 347.

430-2.5 Grates: Use metal gratings that meet the requirements of 962-8.

430-2.6 Filter Fabric: Use a Type D-3 filter fabric meeting the requirements specified in Section 985, and listed on the Department's Approved Product List (APL).

430-3 Type of Pipe to be Used.

430-3.1 General: Prior to the preconstruction conference, submit to the Engineer which optional pipe material from the optional materials tabulation sheet will be used. Once a pipe material is selected, do not change pipe materials without approval of the Engineer.

When the Plans designate a type (or types) of pipe, use only the type (or choose from the types) designated. As an exception, when the Plans designate reinforced concrete pipe as Class S, Class I, Class II, Class III and Class IV, the Contractor may use non-reinforced concrete pipe up to and including 36 inch in diameter.

430-3.2 Side Drain: If the Plans do not designate a type (or types) of pipe, the Contractor may use either a minimum Class I concrete pipe, corrugated steel pipe, corrugated aluminum pipe, corrugated high-density polyethylene pipe, steel reinforced polyethylene ribbed pipe, polypropylene pipe, or PVC pipe. If one of the metal types is chosen, use the minimum gage specified in Section 943 for steel pipe or Section 945 for aluminum pipe. Alternatively, when metal pipe is allowed and no future maintenance concerns exist, the Contractor may propose the pipe gage based on the Department's Drainage Manual and Culvert Service Life Estimator for approval by the Engineer. When extending existing pipes, construct the pipe extensions of the same size and kind as the existing pipe. Extensions of existing pipes, whose materials are no longer produced, shall be extended with the most similar pipe material available.

Non-reinforced concrete pipe may also be substituted for concrete pipe in side drains, subject to the provisions of 430-3.1.

430-4 Laying Pipe.

430-4.1 General: Lay all pipe, true to the lines and grades given, with bells upgrade and spigot end fully entered into the bell. When pipe with quadrant reinforcement or circular pipe with elliptical reinforcement is used, install the pipe in a position such that the manufacturer's marks designating "top" and "bottom" of the pipe are not more than five degrees from the vertical plane through the longitudinal axis of the pipe. Do not allow departure from and return to plan alignment and grade to exceed 1/16 inch per foot of nominal pipe length, with a total of not more than 1 inch departure from theoretical line and grade. Take up and relay any pipe that is not in true alignment or which shows any settlement after laying at no additional expense to the Department.

Do not use concrete pipe with lift holes except round pipe which has an inside diameter in excess of 54 inches or any elliptical pipe.

Repair lift holes, if present, with hand-placed, stiff, non-shrink, 1-to-1 mortar of cement and fine sand, after first washing out the hole with water. Completely fill the void created by the lift hole with mortar. Cover the repaired area with a 24 inch by 24 inch piece of filter fabric secured to the pipe.

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Follow the manufacturer's instructions, to secure the filter fabric to the pipe, until the backfill is placed and compacted.

Do not cut or drill into or through the corrugations or ribs of plastic pipe except when necessary to meet the dimensional requirements shown in the Plans.

When installing pipes in structures, construct inlet and outlet pipes of the same size and kind as the connecting pipe shown in the Plans. Use the same pipe material within each continuous run of pipe. Extend the pipes through the walls for a distance beyond the outside surface sufficient for the intended connections, and construct the concrete around them neatly to prevent leakage along their outer surface as shown on Standard Plans, Index 425-001. Keep the inlet and outlet pipes flush with the inside of the wall. Resilient connectors as specified in 942-3 may be used in lieu of a masonry seal.

Furnish and install a filter fabric jacket around all pipe joints and the joint between the pipe and the structure in accordance with Standard Plans, Indexes 425-001 and 430-001. Use fabric meeting the physical requirements of Type D-3 specified in Section 985. Extend the fabric a minimum of 12 inches beyond each side of the joint or both edges of the coupling band, if a coupling band is used. The fabric must have a minimum width of 24 inches, and a length sufficient to provide a minimum overlap of 24 inches. Secure the filter fabric jacket against the outside of the pipe by metal or plastic strapping or by other methods approved by the Engineer.

Meet the following minimum joint standards:

Table 430-1	
Pipe Application	Minimum Standard
Storm and Cross Drains	Water-tight
Gutter Drain	Water-tight
Side Drains	Soil-tight

When rubber gaskets are to be installed in the pipe joint, the gasket must be the sole element relied on to maintain a tight joint. Soil tight joints must be watertight to 2 psi. Water-tight joints must be water-tight to 5 psi unless a higher pressure rating is required in the Plans.

When laying pipes that pass through mechanically stabilized earth (MSE) reinforced fill, connect the portion of the pipe within the wall to the external portion of the pipe run only after the full height of the wall supported embankment is in place.

When Wall Zone Pipes are shown in the Plans, meet the following requirements:

1. Use resilient connectors on pipes entering and leaving drainage structures.

2. Provide a 2 to 4 inch pipe overhang beyond the drainage structure internal walls.

3. For pipes without welded joints, meet the following additional requirements:

a. Pipe joints must be watertight to 10.8 psi when pulled out 2 inches from the fully homed position in both straight alignment and 5% deflection.

b. Do not allow the gap between sections of pipe to exceed 5/8 inch for all pipe diameters.

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430-4.2 Trench Excavation: Excavate the trench for storm and cross drains, and side drains as specified in Section 125.

430-4.3 Foundation: Provide a suitable foundation, where the foundation material is of inadequate supporting value, as determined by the Engineer. Remove the unsuitable material and replace it with suitable material, as specified in 125-8. Where in the Engineer's opinion, the removal and replacement of unsuitable material is not practicable, he may direct alternates in the design of the pipeline, as required to provide adequate support. Minor changes in the grade or alignment will not be considered as an adequate basis for extra compensation.

Do not lay pipe on blocks or timbers, or on other unyielding material, except where the use of such devices is called for in the Plans.

430-4.4 Backfilling: Backfill around the pipe as specified in 125-8 unless specific backfilling procedures are described in the Contract Documents.

430-4.5 Plugging Pipe: When existing pipe culverts are to be permanently placed out of service, fill them with flowable fill that is non-excavatable, contains a minimum 350 pounds per cubic yard of cementitious material and meets the requirements of Section 121 and/or plug them with masonry plugs as shown in the Plans. Install masonry plugs that are a minimum of 8 inches in thickness, in accordance with Standard Plans, Index 430-001.

When proposed or existing pipe culverts are to be temporarily placed out of service, plug them with prefabricated plugs as shown in the Plans. Install prefabricated plugs in accordance with the manufacturer's recommendations. Do not fill or construct masonry plugs in any pipe culvert intended for current or future service.

430-4.6 End Treatment: Place an end treatment at each storm and cross drain, and side drain as shown in the Plans. Sod around end treatments in accordance with Standard Plans, Index 570-001.

430-4.6.1 U-Type Concrete Endwalls: Construct in accordance with the Plans and Standards Plans, Indexes 430-010 through 430-012 and Index 430-090.

430-4.6.2 Flared End Sections: Construct in accordance with the Plans and Standard Plans, Index 430-020. Use precast flared end sections only.

430-4.6.3 Mitered End Sections: Construct in accordance with the Plans and Standard Plans, Indexes 430-021 and 430-022. Construct mitered end sections for corrugated high-density polyethylene (HDPE) pipe, polypropylene (PP) pipe, steel reinforced polyethylene ribbed (SRPE) pipe and polyvinyl-chloride (PVC) pipe as specified in Section 948 and as detailed in the Standard Plans.

430-4.6.4 Straight and Winged Concrete Endwalls: Construct in accordance with the Plans and Standard Plans, Indexes 430-030 through 430-040.

Provide end treatments for corrugated polyethylene pipe, polypropylene pipe, and PVC pipe as specified in Section 948, or as detailed in the Plans.

430-4.7 Metal Pipe Protection: Apply a bituminous coating to the surface area of the pipe within and 12 inches beyond the concrete or mortar seal prior to sealing, to protect corrugated steel or aluminum pipe embedded in a concrete structure, such as an inlet, manhole, junction box, endwall, or concrete jacket.

Ensure that the surface preparation, application methods (dry film thickness and conditions during application), and equipment used are in accordance with the coating manufacturers' published specifications.

Obtain the Engineer's approval of the coating products used.

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430-4.8 Pipe Inspection: For pipes installed under the roadway, inspection is to be conducted when backfill reaches 3 feet above the pipe crown or upon completion of the stabilized subgrade. For pipe installed within fills, including embankments confined by walls, inspection is to be conducted when compacted embankment reaches 3 feet above the pipe crown or the finished earthwork grade as specified in the Plans. Prior to conducting the inspection, submit to the Engineer an inspection schedule for dewatering the installed pipe, and the removal of all silt, debris, and obstructions. Submit pipe inspection videos and reports to the Department for review prior to the continuation of paving.

For pipe 48 inches or less in diameter, submit to the Engineer the video files and reports using low barrel distortion video equipment with laser profile technology, non-contact video micrometer and associated software. For all pipe types, provide a Pipe Observation Summary Report for each pipe run that shall include:

1. Actual recorded length and width measurements of all cracks within the pipe.
2. Actual recorded separation measurement of all rigid pipe joints.
3. Detailed written observations of leaks, debris, or other damage or defects.

For flexible pipe types, submit a Pipe Ovality Report for each pipe run that includes:

1. Representative diameter of the pipe.
2. Pipe deformation/deflections measurements with the 5% deflection limit clearly delineated.

Laser profiling and measurement technology must be certified by the company performing the work to be in compliance with the calibration criteria posted at: https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/construction/engineers/environmental/laser-profiling-calibration-criteria.pdf. Reports submitted in electronic media are preferred.

For pipe larger than 48 inches, submit to the Engineer a detailed visual inspection summary report for each pipe run, including photos, locations and details of deficient cracks, joint separations, infiltration, and damage.

The Engineer may waive this requirement for side drains and cross drains which are short enough to inspect from each end of the pipe.

430-4.8.1 Video Report: Provide video files via digital media (DVD, flash drive, or other) or by online digital distribution with a minimum standard resolution of 720 x 480. Use a camera with lighting suitable to allow a clear picture of the entire periphery of the pipe. Center the camera in the pipe both vertically and horizontally and be able to pan and tilt to a 90-degree angle with the axis of the pipe and rotating 360 degrees. Use equipment to move the camera through the pipe that will not obstruct the camera's view or interfere with proper documentation of the pipe's condition.

The video image shall be clear, focused, and relatively free from roll, static, or other image distortion qualities that would prevent the reviewer from evaluating the condition of the pipe. The video will include identification before each section of pipe filmed. The identification will include the project number, the structure number corresponding to the structure number in the Plans for the project, size of pipe, the date and time, and indicate which pipe is being filmed if multiple pipes are connected to the structure. Notes should be taken during the video recording process. Submit these notes along with the video.

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Move the camera through the pipe at a speed not greater than 30 feet per minute. Mark the video with the distance down the pipe. The distance shall have an accuracy of one foot per 100 feet. Film the entire circumference at each joint. Stop the camera and pan when necessary to document and measure defects. Position the camera head perpendicular to all defects requiring measurement by the video micrometer.

430-4.8.2 Reinspection: At any time after reviewing the submitted pipe inspection reports, the Engineer may direct additional inspections. If no defects are observed during the reinspection, the Department will pay for the cost of the reinspections in accordance with 4-3. If defects are observed, the reinspection and all work performed to correct the defects will be done at no cost to the Department. Acceptance of all replacements or repairs will be based on video documentation of the completed work prior to Final Acceptance.

430-5 Removing Existing Pipe.

If the Plans indicate that existing pipe is to remain the property of the Department, collect and stack along the right-of-way all existing pipe or pipe arch so indicated in the Plans to be removed, or that does not conform to the lines and grades of the proposed work and that is not to be re-laid, as directed by the Engineer. Take care to prevent damage to salvageable pipe during removal and stacking operations.

430-6 Placing Pipe Under Railroad.

430-6.1 General: Construct pipe culverts under railroad tracks in accordance with the requirements of the railroad company.

Perform all the shoring under the tracks, and sheeting and bracing of the trench, required by the railroad company or deemed necessary by the Engineer in order to ensure safe and uninterrupted movement of the railroad equipment, at no expense to the Department.

430-6.2 Requirements of the Railroad Company: Install pipe using methods required by the railroad company and shown in the Contract Documents.

When the general method of installation required by the railroad company is indicated in the Plans, do not alter such method, or any other specific details of the installation which might be indicated in the Plans, without receiving approval or direction from the railroad, followed by written approval from the Engineer.

430-6.3 Notification to Railroad Company: Notify the railroad company and the Engineer at least ten days prior to the date on which pipe is to be placed under the railroad tracks.

430-6.4 Placing Pipe by Jacking: Obtain the Engineer's and the railroad company's approval of the details of the jacking method to be used, when placing pipe through the railroad embankment, before the work is started.

430-6.5 Use of Tunnel Liner: When the railroad company requires that a tunnel liner be used for placing the pipe in lieu of the jacking method, the Department will pay for the tunnel liner material separately in cases where the Contract Documents do not require the use of a tunnel liner. For these cases the Department will reimburse the Contractor for the actual cost of the liner, delivered at the site. The Department will base such cost on a liner having the minimum gage acceptable to the railroad.

430-7 Specific Requirements for Concrete Pipe.

430-7.1 Sealing Joints: Seal the pipe joints with round rubber or profile gaskets meeting the requirements of Section 449. Ensure that the gasket and the surface of the pipe joint, including the gasket recess, are clean and free from grit, dirt, and other foreign matter, at the time

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the joints are made. In order to facilitate closure of the joint, application of a vegetable soap lubricant immediately before closing of the joint will be permitted. Prelubricated gaskets may be used in lieu of a vegetable soap lubricant when the lubricating material is certified to be inert with respect to the rubber material.

430-7.2 Laying Requirements for Concrete Pipe with Rubber Gasket Joints: Do not allow the gap between sections of pipe to exceed 5/8 inch for pipe diameters of 12 inches through 18 inches, 7/8 inch for pipe diameters of 24 through 66 inches, and 1 inch for pipe diameters 72 inches and larger. Where minor imperfections in the manufacture of the pipe create an apparent gap in excess of the tabulated gap, the Engineer will accept the joint provided that the imperfection does not exceed 1/3 the circumference of the pipe, and the rubber gasket is 1/4 inch or more past the pipe joint entrance taper. Where concrete pipes are outside of these tolerances, replace them at no expense to the Department. Do not apply mortar, joint compound, or other filler to the gap which would restrict the flexibility of the joint.

430-7.3 Field Joints for Elliptical Concrete Pipe: Use either a preformed plastic gasket material or an approved rubber gasket to make a field joint.

430-7.3.1 Plastic Gasket: Meet the following requirements when field joints are made from preformed plastic gasket material:

430-7.3.1.1 General: Install field joints in accordance with the manufacturer's instructions and the following:

430-7.3.1.2 Material: Meet the requirements of 942-2.

430-7.3.1.3 Joint Design: Ensure that the pipe manufacturer submits details to the Engineer regarding configuration of the joint and the amount of gasket material required to affect a satisfactory seal. Do not brush or wipe joint surfaces which are to be in contact with the gasket material with a cement slurry. Fill minor voids with cement slurry.

430-7.3.1.4 Primer: Apply a primer of the type recommended by the manufacturer of the gasket material to all joint surfaces which are to be in contact with the gasket material, prior to application of the gasket material. Thoroughly clean and dry the surface to be primed.

430-7.3.1.5 Application of Gasket: Apply gasket material to form a continuous gasket around the entire circumference of the leading edge of the tongue and the groove joint, in accordance with the detail shown on Standard Plans, Index 430-001. Do not remove the paper wrapper on the exterior surface of the gasket material until immediately prior to joining of sections. Apply plastic gasket material only to surfaces which are dry. When the atmospheric temperature is below 60ºF, either store plastic joint seal gaskets in an area above 70ºF, or artificially warm the gaskets to 70ºF in a manner satisfactory to the Engineer.

430-7.3.1.6 Installation of Pipe: Remove and reposition or replace any displaced or contaminated gasket as directed by the Engineer. Install the pipe in a dry trench. Carefully shape the bottom of the trench to minimize the need for realignment of sections of pipe after they are placed in the trench. Hold to a minimum any realignment of a joint after the gaskets come into contact. Prior to joining the pipes, fill the entire joint with gasket material and ensure that when the pipes are joined there is evidence of squeeze-out of gasket material for the entire internal and external circumference of the joint. Trim excess material on the interior of the pipe to provide a smooth interior surface. If a joint is defective, remove the leading section of pipe and reseal the joint.

430-7.3.2 Rubber Gasket: Meet the following requirements when field joints are made with profile rubber gaskets:

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430-7.3.2.1 General: Install field joints in accordance with the manufacturer's instructions and the following:

430-7.3.2.2 Material: Meet the requirements of 942-4.

430-7.3.2.3 Joint Design: Ensure that the pipe manufacturer submits details to the Engineer regarding configuration of the joint and gasket required to effect a satisfactory seal. Do not apply mortar, joint compound, or other filler which would restrict the flexibility of the gasket joint.

430-7.4 Requirements for Concrete Radius Pipe:

430-7.4.1 Design: Construct concrete radius pipe in segments not longer than 4 feet (along the pipe centerline), except where another length is called for in the Contract Documents. Join each segment using round rubber gaskets. Ensure that the pipe manufacturer submits details of the proposed joint, segment length and shape for approval by the Engineer, prior to manufacture.

430-7.4.2 Pre-Assembly: Ensure that the manufacturer pre-assembles the entire radius section in his yard, in the presence of the Engineer, to ensure a proper fit for all parts. At the option of the manufacturer, the Contractor may assemble the pipe without gaskets. Consecutively number the joints on both the interior and exterior surfaces of each joint, and make match marks showing proper position of joints. Install the pipe at the project site in the same order as pre-assembly.

430-8 Specific Requirements for Corrugated Metal Pipe.

430-8.1 Field Joints:

430-8.1.1 General: Make a field joint with locking bands, as specified in Article 9 of AASHTO M36 and AASHTO M196M for aluminum pipe. For aluminum pipe, fabricate bands from the same alloy as the culvert sheeting.

When existing pipe to be extended is helically fabricated, make a field joint between the existing pipe and the new pipe using one of the following methods:

1. Cut the new pipe to remove one of the re-rolled annular end sections required in Sections 943 or 945, or fabricate the pipe so that the re-rolled annular section is fabricated only on one end. Use either a spiral (helical) band with a gasket or a flat band with gaskets as required by 430-8.1.2 (2) to join the pipe sections.

2. The Contractor may construct a concrete jacket as shown on Standard Plans, Index 430-001.

430-8.1.2 Side Drain, Storm and Cross Drain, and Gutter Drains: Where corrugated metal pipe is used as side drain, storm and cross drain, or gutter drain, use a rubber or neoprene gasket of a design shown to provide a joint as specified in 430-4.

Use a gasket of one of the following dimensions:

1. For annular joints with 1/2 inch depth corrugation: either a single gasket a minimum of 7 inches by 3/8 inch or two gaskets a minimum of 3-1/2 inches by 3/8 inch; and for annular joints with 1 inch depth corrugations: either a single gasket a minimum of 7 inches by 7/8 inch or two gaskets a minimum of 3-1/2 inches by 7/8 inch.

2. For helical joints with 1/2 inch depth corrugation: either a single gasket a minimum of 5 inches by 1 inch or two gaskets a minimum of 3-1/2 inches by 1 inch; and for helical joints with 1 inch depth corrugations: either a single gasket a minimum of 5 inches by 1-1/2 inches or two gaskets a minimum of 3-1/2 inches by 1-1/2 inches.

3. Such other gasket designs as may be approved by the Engineer.

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If, in lieu of a single gasket spanning the joint, two gaskets are used, place these individual gaskets approximately 2 inches from each pipe end at the joint. When two gaskets are used, seal the overlapping area on the coupling band between the gaskets consistent with the joint performance specified. The Contractor may tuck a strip of preformed gasket material over the bottom lip of the band for this purpose. Use coupling bands that provide a minimum circumferential overlap of 3 inches. As the end connections on the coupling band are tightened, ensure that there is no local bending of the band or the connection. Use precurved coupling bands on pipe diameters of 24 inches or less.

Use flat gaskets meeting the requirements of ASTM D1056, designation 2C2 or 2B3. In placing flat gaskets on pipe prior to placing the coupling band, do not stretch the gasket more than 15% of its original circumference. Use circular gaskets meeting the requirements of ASTM C361. Do not stretch the circular gasket more than 20% of its original circumference in placing the gasket on pipe. Use preformed plastic gasket material meeting the composition requirements of 942-2.2.

Apply an approved vegetable soap lubricant, as specified for concrete pipe in 430-7.1.1.

430-8.1.3 Alternate Joint: In lieu of the above-specified combination of locking bands and flat gaskets, the Contractor may make field joints for these pipe installations by the following combinations:

1. Use the metal bands as specified in Article 9 of AASHTO M36M that are at least 10-1/2 inches wide and consist of a flat central section with a corrugated section near each end, designed to match the annular corrugation in the pipe with which they are to be used. Connect the bands in a manner approved by the Engineer, with a suitable fastening device such as the use of two galvanized 1/2 inch diameter bolts through a galvanized bar and galvanized strap, suitably welded to the band. Use a strap that is the same gage as the band.

Where helically corrugated pipe is to be jointed by this alternate combination, ensure that at least the last two corrugations of each pipe section are annular, and designed such that the band will engage each pipe end with the next-to-outside annular corrugation.

2. For these bands, use a rubber gasket with a circular cross-section of the "O-ring" type conforming to ASTM C361. Use gaskets having the following cross-sectional diameter for the given size of pipe:

Table 430-2
Non-SI Units

Pipe Size	Gasket Diameter
12 inches through 36 inches (with 1/2 inch depth corrugations)	13/16 inch
42 inches through 96 inches (with 1/2 inch depth corrugations)	7/8 inch
36 inches through 120 inches (with 1 inch depth corrugations)	1-3/8 inches

Use preformed gasket material to seal the overlapping area on the coupling band between gaskets.

3. Use channel band couplers in helical pipe with ends which have been reformed and flanged specifically to receive these bands. Use channel band couplers that are of a two piece design, are fabricated from galvanized steel stock conforming to AASHTO M36, have

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2 inch by 2 inch by 3/16 inch angles fastened to the band ends to allow for proper tightening, and meet the following:

Table 430-3 Non SI Units	
Band Thickness	Pipe Wall Thickness
0.079 inch	0.109 inch or lighter
0.109 inch	0.138 inch or heavier
3/4 inch wide	0.109 inch or lighter
1 inch wide	0.138 inch or heavier

Furnish two 1/2 inch diameter connection bolts with each band, that conform to ASTM A307, Grade A and are electroplated in accordance with ASTM B633.

Use a gasket with the joint that is a hydrocarbon blend of butyl rubber meeting the chemical composition and physical properties of 942-2.2. Use a 3/8 by 3/4 inch gasket for pipe fabricated from 0.109 inch or lighter material and a 3/8 by 1 inch gasket for pipe fabricated from 0.138 inch and heavier material.

The Contractor may use a flange band coupler without the gasket for all applications other than side drain, storm and cross drain, and gutter drain.

Do not use the flange band coupler to join dissimilar types of pipe.

The Contractor may join reformed flanged helical pipe to existing annular or reformed pipe having annular ends. On non-gasketed installations, use either an annular band or an alternate joint described in 430-8.1.3. On gasketed installations, use an annular band, minimum of five corrugations in width, in conjunction with two O-ring gaskets as specified in 430-8.1.3. Use mastic material to seal the area of band overlap.

The minimum joint performance standards specified in 430-4.1 apply.

430-8.2 Laying and Shape Requirements for Corrugated Metal Pipe: Install pipe using either a trench or open ditch procedure.

Check pipe shape regularly during backfilling to verify acceptability of the construction method used. Pipe deflected 5% or more of the certified actual mean diameter of the pipe at final inspection shall be replaced at no cost to the Department. Deflection measurements are taken at the point of smallest diameter on the corrugations.

430-9 Specific Requirements for Steel Reinforced Polyethylene Ribbed Pipe, Corrugated High-Density Polyethylene Pipe, Polypropylene Pipe, and Polyvinyl Chloride (PVC) Pipe.

430-9.1 Sampling Requirements: Submit a sample of each pipe material and diameter used on each project to the Engineer a minimum of two weeks prior to the installation, provided that the pipe meets all of the following:

1. Pipe material is PVC, HDPE, steel reinforced polyethylene
2. Pipe is corrugated or ribbed
3. Pipe diameter is 12” or larger
4. Project quantity for a pipe diameter is more than 100 linear feet, unless intended for use as cross drain
5. Pipe is not perforated, unless the material is PVC
6. Pipe is intended for applications requiring 100 year design service life as defined in the Florida Department of Transportation Drainage Manual.

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The length of each sample pipe section must comprise at least seven regular corrugations (not including the first three corrugations of the pipe on the bell or spigot ends).

430-9.2 Field Joints: Use gasketed joints to seal side drain, and storm and cross drain. Use gaskets meeting the requirements of Section 449. Ensure that the pipe manufacturer provides a joint design approved by the Engineer before use.

430-9.2.1 Requirements For Use In Structures With Resilient Connectors: Use pipe sleeve adapters in accordance with Section 948-2 and 948-7.

430-9.3 Installation Requirements Including Trenching, Foundation and Backfilling Operations: Check structure shape regularly during backfilling to verify acceptability of the construction method used.

Replace pipe deflected 5% or more of the certified actual mean diameter of the pipe at final inspection at no cost to the Department.

430-10 Desilting Pipe or Concrete Box Culvert.

Desilt pipe culvert and concrete box culvert as designated in the Plans.

430-11 Method of Measurement.

430-11.1 New Pipe Installed by Excavation or Trenching: The quantity of storm and cross drain pipe, storm drain trench, side drain and gutter drain pipe, installed by pipe culvert optional material - excavation or trenching, to be paid for will be plan quantity, in place and accepted. The plan quantity will be determined from the inside wall of the structure and from station/offset location for end treatments as shown in the Plans, along the centerline of the pipe.

Adjustment to bid quantities, prices and payment will not be allowed for increases, decreases, or changes in material or installation requirements due to the use of any optional pipe materials.

If adjustments are required due to Plan errors or omissions or authorized field changes, the plotted material and not the material elected would be used to establish new pay quantities.

Pipe sizes other than round (elliptical/arch) are summarized and paid for using equivalent round pipe diameter.

430-11.2 New Pipe Installed by Jack & Bore: The quantity of storm and cross drain pipe, storm drain trench, side drain and gutter drain pipe, installed by pipe culvert optional material - jack & bore, to be paid for will be the plan quantity, in place and accepted. The measurement and payment will be the plan quantity length of the casing or carrier pipe installed by jack & bore.

Carrier pipe installed through/inside the casing is paid for as pipe culvert optional material – excavation or trenching.

430-11.3 End Treatment: The quantity of all end treatments to be paid for will be the number completed and accepted. For mitered end sections, the measurement will be per each end of pipe. Sod will be paid for in accordance with Section 570.

430-12 Basis of Payment.

430-12.1 General: Prices and payments will be full compensation for all work specified in this Section, including all excavation except the volume included in the items for the grading work on the project, and except for other items specified for separate payment in Section 125; all backfilling material and compaction; disposal of surplus material; and all clearing and grubbing outside of the required limits of clearing and grubbing as shown in the Plans.

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No separate payment will be made for bituminous coating, concrete collars, or concrete jackets.

No payment will be made for failed bore paths, injection of excavatable flowable fill, products taken out of service, or incomplete installations. Payment will include all work and materials necessary for jack & bore, including boring, backfilling, flowable fill, and restoration materials necessary for a complete and accepted installation.

No payment will be made for jack & bore until a Bore Path Report has been submitted to the Engineer.

430-12.2 Removing Existing Pipe: When existing pipe is removed and replaced with new pipe approximately at the same location, the cost of excavating and removing the old pipe and of its disposal will be included in the Contract unit price for clearing and grubbing.

430-12.3 Site Restoration: The cost of restoring the site, as specified in 125-11, that is disturbed, solely for the purpose of constructing pipe culvert, will be included in the Contract unit price for the pipe culvert, unless designated specifically to be paid for under other items.

430-12.4 Plugging Pipes: The cost of temporarily plugging a pipe culvert, either proposed or existing, will be incidental to the contract unit price for new pipe culvert.

The cost of filling and/or plugging an existing pipe culvert that is to be permanently placed out of service will be paid for at the contract unit price for filling and plugging pipe, per cubic yard. Price and payment will be full compensation for flowable fill, masonry, concrete, mortar, and all labor and materials necessary to complete the work.

When the project includes no quantities for new pipe culverts, and temporary plugs are required for existing pipe culverts, the cost will be considered as extra work, in accordance with 4-3.5.

430-12.5 Desilting Pipe: Desilting pipe will be paid for at the contract unit price per foot for each pipe desilted. Price and payment will be full compensation for furnishing all equipment, tools and labor, disposal of silt and debris, and all incidentals necessary for satisfactorily performing the work.

430-12.6 Desilting Concrete Box Culverts: Price and payment will be full compensation for all work required.

430-12.7 Flared End Sections: Price and payment will be full compensation for all concrete, reinforcement, toe walls, and all work and materials required.

430-12.8 Mitered End Sections: Price and payment will be full compensation for all materials, pipe, grates when required, fasteners, reinforcing, connectors, anchors, concrete, sealants, jackets and coupling bands, and all work required.

430-12.9 U-Type Endwalls: Price and payment will be full compensation for all materials concrete, reinforcement, grate, baffles, accessories, and all work required. Fencing, when called for in the Plans, will be paid for under Fencing, Type B, per foot. Rip rap will be paid for in accordance with Section 530.

430-12.10 Straight and Winged Endwalls: Price and payment will be full compensation for all concrete, reinforcement, grate, accessories, and all work and materials required.

430-12.11 Railroad Requirements: Where pipe culvert is constructed under railroad tracks, the Contract unit price for the pipe culvert will include the costs of any jacking operations and the operation of placing the pipe by use of a tunnel liner, (except as specified for unanticipated tunnel liner, in 430-6.5, where reimbursement is to be made for such unanticipated liner), and all other work necessary to meet the requirements of the railroad company, excluding

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the costs of watchman or flagman services provided by the railroad company, except as provided below.

The Department will reimburse the Contractor for the actual costs of any trestle bridge work which is performed by the railroad's forces, as billed to him by the railroad, less the value of any salvage materials derived there from, whether such salvage materials are retained by the railroad company or by the Contractor. When the work of shoring and bracing is to be performed by the railroad, such fact will be stipulated in the Contract Documents and the Contractor will be required to pay to the railroad the amount of such costs, which amount will be reimbursed to him by the Department. The Contract unit price for the pipe culvert shall include the costs of all other work of shoring and bracing.

430-12.12 Payment Items: Payment will be made under:

Item No.	430- 17-	Pipe Culvert Optional Material - Excavation or Trenching - per foot.
Item No.	430- 18-	Pipe Culvert Optional Material - Jack & Bore - per foot.
Item No.	430- 94-	Desilting Pipe - per foot.
Item No.	430- 96-	Polyvinyl Chloride Pipe - per foot.
Item No.	430- 98-	Mitered End Section - each.
Item No.	430-200-	Flared End Sections - each.
Item No.	430-400-	Winged Concrete Endwalls - each.
Item No.	430- 5-	Straight Concrete Endwalls - each.
Item No.	430- 6-	U-Type Concrete Endwalls - each.
Item No.	430-830-	Filling and Plugging Pipe - cubic yard.
Item No.	430-950-	Desilting Concrete Box Culvert - per cubic yard.

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SECTION 431
PIPE LINER

431-1 Description.

Rehabilitate drainage pipe by installing a pipe liner in accordance with the requirements of this Section. The Plans will indicate the location of the pipe to be rehabilitated, the material composition and the alternate liner types that may be used to rehabilitate the pipe, and the method of liner installation.

431-2 Materials.

Meet the requirements of Section 948.

431-3 Pre-installation Requirements.

Prior to installing the pipe liner, inspect the host pipe and ensure that it is clean, dry and stable. Inspect the host pipe by means of closed circuit television. The closed circuit television inspection may be augmented by a visual inspection in which persons enter a host pipe to inspect it, at no additional cost to the Department. Obtain written approval from the Engineer prior to allowing persons to enter a host pipe. Furnish all equipment necessary to inspect, remove silt and other debris, and dewater the host pipe to the satisfaction of the Engineer. Seal cracks and joints using an approved chemical grout of either acrylamide base gel, acrylic base gel, urethane base gel, or urethane base foam. Place flowable fill as directed by the Engineer to maintain the stability of the host pipe.

431-4 Installation Methods.

431-4.1 General: Install the liner using one of, or a combination of, the following methods: sliplining, inverting, pulling/pushing, spiral winding, paneling, coating, or bursting. Seal or grout the annular space between the interior of the host pipe and the exterior of the liner according to the liner manufacturer's written instructions.

431-4.2 Sliplining: Use either polyethylene, high density polyethylene, polyvinyl chloride, fiberglass, steel or aluminum pipe liner. Install the liner by joining discrete lengths, panels or segments of the pipe liner in a manhole or other access point and inserting the liner into the host pipe.

431-4.2.1 Polyethylene: Install polyethylene pipe liner in accordance with ASTM F585. The manufacturer's written instructions may be substituted for ASTM F585 with written permission from the Engineer.

431-4.2.2 High Density Polyethylene: Install high density polyethylene pipe liner in accordance with ASTM F585. The manufacturer's written instructions may be substituted for ASTM F585 with written permission from the Engineer.

431-4.2.3 Polyvinyl Chloride: Install polyvinyl chloride pipe liner in accordance with ASTM F1698.

431-4.2.4 Fiberglass, Steel or Aluminum: Install fiberglass, steel or aluminum pipe liner in accordance with the manufacturer's written instructions.

431-4.2.5 Steel Reinforced Polyethylene Ribbed Pipe: Install reinforced pipe liner in accordance with ASTM F585. The manufacturer's written instructions may be substituted for ASTM F585 with written permission from the Engineer.

431-4.3 Inverting: Install a resin impregnated felt tube pipe liner into the host pipe, and cure in place, in accordance with ASTM F1216.

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431-4.4 Pulling/Pushing: Install the liner in accordance with the manufacturer's written instructions. Protect the pipe liner end using a device that uniformly distributes the applied load around the perimeter of the liner. Continuously monitor the applied load, and do not stretch the liner by more than 1% of its original length. For liner lengths of 100 feet or less, the end protection device may be omitted, with written permission from the Engineer. Do not seal the liner ends or begin grouting prior to 24 hours after liner installation.

431-4.5 Spiral Winding: Install the pipe liner in accordance with ASTM F1698 or ASTM F1741.

431-4.6 Paneling: Install the pipe liner in accordance with the manufacturer's written instructions. Limit paneling to host pipes having 90 inch or greater internal diameters. Do not place panels where a liner joint will lie along or near the crown of the host pipe.

431-4.7 Coating: Use materials and install the pipe liner in accordance with the manufacturer's written instructions.

431-4.8 Bursting: Install the pipe liner in accordance with the manufacturer's written instructions. Limit bursting to vitrified clay or concrete crossdrain or sidedrain pipe having no lateral connections or risers. Further limit bursting to locations where no part of the host pipe passes within 5 feet of any buried utility or pavement base material.

431-5 Acceptance.

Inspect the complete rehabilitation by means of closed circuit television. Obtain written approval from the Engineer prior to allowing persons to enter a host pipe. Provide the Engineer videos of all preliminary and final inspections.

431-6 Method of Measurement.

The quantity of pipe liner to be paid for will be the length, per foot, of pipe liner installed and accepted, measured along the centerline of the pipe, from end to end.

431-7 Basis of Payment.

Price and payment for pipe liner will be full compensation for furnishing and installing the pipe liner in accordance with the requirements of this Section, including all materials, labor and incidentals required to dewater and clean host pipe, dispose of all silt and debris, seal cracks and joints in the host pipe, and seal and grout the annular space between the liner and interior of the host pipe.

Price and payment for pipe liner will also be full compensation for all equipment, materials and labor required for inspections, and for furnishing videos of the inspections to the Engineer.

Payment will be made under:

Item No. 431- 1- Pipe Liner - per foot.

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SECTION 435
STRUCTURAL PLATE PIPE AND PIPE ARCH CULVERTS

435-1 Description.

Construct structural plate pipe and pipe arch culverts as shown in the Plans.

Obtain pipe culverts from a plant currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.

At the beginning of each project, submit a notarized certification statement to the Engineer from a company designated representative certifying that the structural steel plant will manufacture the products in accordance with the requirements set forth in the Contract Documents and plant's approved Quality Control (QC) Plan. The QC Manager's stamp on each product indicates certification that the product was fabricated in conformance with the Contractor's QC Plan, the Contract, and this Section. Ensure that each shipment of structural plate products to the project site is accompanied with a QC signed or stamped delivery ticket providing the description and the list of the products.

When the producer's Quality Control Program is suspended by the Department, accept responsibility of either obtaining products from a plant with an approved Quality Control Program, or await re-approval of the plant.

The Engineer will not allow changes in Contract Time or completion dates as a result of the plant's loss of qualification. Accept responsibility for all delay costs or other costs associated with the loss of the plant's qualification.

435-2 Materials.

Meet the following requirements:

Steel Pipe .....Section 944
Aluminum Pipe .....Section 945
Liner Repair Systems .....Section 948

When the Plans call for bituminous coated pipe or pipe arch, meet the coating requirements of 944-4.

When other types of coating material are shown in the Plans, use a coating that consists of at least two coats of the specified material, applied at the job site. Apply the coating by brush or by spray.

435-3 Trench, Foundation, Laying, and Backfill.

Perform this work as specified in Section 430, and as follows.

Provide a foundation for the bottom plates that is of uniform density and carefully shaped to fit the lower plate of the pipe or pipe arch. Thoroughly tamp the backfill material against the remaining plates.

435-4 Assembly.

Assemble the plates to form the pipe or pipe arch structure in accordance with the diagram furnished by the manufacturer. Connect the plates by bolting tightly in all bolt holes provided.

435-5 Method of Measurement.

The quantities to be paid for will be the plan quantity, in feet, of pipe or pipe arch, installed in place, completed and accepted. The quantity will be measured along the centerline of

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the structure from end to end of metal for full section structures, from average end to end at top and bottom for beveled-end structures.

435-6 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section, including all materials, backfilling, and disposal of surplus material and all excavation except the volume included in the items for grading work and for other items specified for payment in Section 125.

Payment will be made under:

Item No. 435- Structural Plate Pipe Culvert - per foot.

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SECTION 436
TRENCH DRAIN

436-1 Description.

Construct trench drain, with one of the materials listed below, for the purpose of collecting and removing surface run-off from paved areas. Furnish and install trench drain in accordance with the Standard Plans, at the locations shown in the Plans or as directed by the Engineer.

436-2 Materials.

Provide preformed channels or pipe with sufficient strength to withstand construction handling and placement of concrete backfill without deforming or deviating from line and grade. Submit certification to the Engineer from the manufacturer that the trench drain system meets the requirements of this Section.

436-2.1 Channels/Pipe: Meet the following requirements:

Steel Pipe	Section 943
Aluminum Pipe	Section 945
Polyethylene	Section 948 and ASTM D3350
Polymer Concrete	ASTM D6783
Fiberglass	ASTM D3517

436-2.2 Concrete Backfill: Use concrete that meets the requirements of Section 347.

436-2.3 Grates: Provide steel grates and supporting frames that meet the requirements of Section 962. Ductile iron frames and grates must meet the requirements of ASTM A536. Ensure that ductile iron grates and frames are compatible and from the same manufacturer. Frames must be anchored into the concrete backfill with studs bolts or lugs. Grates must have at least 30% open area and fasten securely to frames to avoid rattling, Grates must be removable for the entire channel length and have vandal resistant locking devices. Ensure that frames have a minimum of 4 inch long studs, bolts or lugs at all four corners.

436-2.4 Clean-Out covers for Type 1 Drains: Install steel or ductile iron covers that meet the requirements of Section 962.

436-2.5 Outlet Pipe: Connect outlet pipe to the trench drain with standard manufactured connectors. Unless a particular type is called for in the Plans, use any of the following types of pipe:

Concrete	Section 449
Steel	Section 943
Aluminum	Section 945
Polyvinyl Chloride	948-1.7
Polyethylene	948.2.3

436-3 Installation.

Submit to the Engineer the proposed method of installation, noting any deviation from the manufacturer’s recommendations. Place concrete backfill in the trench against undisturbed material at the sides and bottom of the trench in a manner that will prevent floating or shifting of the trench drain, and will prevent voids in, or segregation of the concrete. Tamp and spade to prevent honeycombing. Form the top surface to the lines shown in the Plans. Remove any foreign material that falls into the trench prior to or during placement of concrete.

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436-4 Method of Measurement.

The quantity to be paid for will be plan quantity, in place and accepted. The plan quantity will be measured from the inside wall of the structure as shown in the Plans, along the centerline of the pipe/channel. Curb placed with trench drain will be paid in accordance with Section 520.

436-5 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including all materials, tools, equipment, concrete backfilling, outlet pipe, connections to new or existing structures and all incidentals necessary to complete the work.

Payment will be made under:

Item No. 436- 1- Trench Drain - per foot.

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SECTION 440
UNDERDRAINS

440-1 Description.

Construct underdrains, underdrain cleanout structures, underdrain inspection boxes and underdrain outlet pipes in accordance with the Plans and Standard Plans, Indexes 440-001 and 440-002. Use any one of the types of pipe listed in 440-2, unless a particular type is specifically required. Use only perforated pipe, and do not use open joints.

440-2 Materials.

Meet the following requirements:

Concrete Pipe	Section 449
Filter Aggregate	Section 902
Corrugated Steel Pipe	Section 943
Corrugated Aluminum Pipe	Section 945
Polyvinyl-Chloride Pipe	Section 948
Corrugated High Density Polyethylene Pipe	Section 948
Corrugated Polypropylene Pipe	Section 948
Steel Reinforced Polyethylene Ribbed Pipe	Section 948
Filter Fabric Sock	Section 948
Geotextile Fabrics*	Section 985

*Use products listed on the Department's Approved Product List (APL).

440-3 Excavating Trench.

Excavate the trench carefully, to the depth required to permit the pipe to be laid to the grade required, and to the dimensions shown in the Plans.

440-4 Laying Pipe.

440-4.1 General: Bed the pipe firmly on the bottom of the trench, with the perforations down and joints securely made.

440-4.2 Corrugated Steel Pipe - Protection of Coating: Handle corrugated steel pipe in such a way that the zinc or aluminum coating will not be bruised or broken. Do not use pipe showing bruises or breakage of the zinc or aluminum coating.

440-4.3 Protection of Drain Inlet: Protect the influent end of the pipe in a manner which will prevent any soil from entering the drain.

440-4.4 Lateral Connections: Make lateral connections with prefabricated wyes, tees, elbows, etc., as required.

440-4.5 Underdrain Inspection Box: Construct underdrain inspection boxes in accordance with Standard Plans, Index 440-002 and the Plans.

440-4.6 Underdrain Cleanout Structures: Construct underdrain cleanout structures of in-line wye fittings and stub for access where called for in the Plans.

440-4.7 Underdrain Outlet Pipe: Use non-perforated pipe. Construct underdrain bends in accordance with Standard Plans, Index 440-002.

440-5 Placing Filter Material and Backfilling.

440-5.1 Placing Material: After laying the pipe and obtaining the Engineer's approval, backfill the trench with filter material to the lines shown in the Plans.

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440-5.2 Compaction of Filter Material and Protection of Pipe: Place and compact the filter material around the pipe and for the full width of the trench, in layers not exceeding 6 inches in thickness. Take special care to avoid displacement or damage to the pipe.

440-5.3 Backfill Above Filter Material: For all types of pipe, backfill the portion of the trench above the filter material with suitable pervious material. Place and compact the material in layers not exceeding 4 inches in thickness.

440-6 Type V Underdrain Construction.

To prevent clogging of Type V underdrain from construction sediments, initially excavate the associated stormwater facilities to rough grade. After the contributing drainage area is stabilized, construct the underdrains and excavate the stormwater facilities to achieve the final elevation.

440-7 Method of Measurement.

The quantities to be paid for will be the length, in feet, of underdrain, which includes underdrain cleanout structures, measured in place, along the centerline and gradient of the underdrain, completed and accepted. The quantities to be paid for will be the length, in feet, of outlet pipe measured in place, along the centerline and gradient of the outlet pipe, completed and accepted. The quantity of underdrain inspection boxes to be paid for will be the number completed and accepted.

No separate measurement or payment will be made under this Section for underdrains associated with box culverts or the Standard Plans, Index 400-289.

440-8 Basis of Payment.

Price and payment will be full compensation for all the work specified in this section, including all materials, disposal of materials, pipe and fittings, stubbing into drainage structures, and all excavation except the volume included in the items for the grading work.

Payment will be made under:

Item No. 440- 1-	Underdrain - per foot.
Item No. 440- 70-	Underdrain Inspection Box - each.
Item No. 440- 73-	Underdrain Outlet Pipe - per foot.

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SECTION 443
FRENCH DRAINS

443-1 Description.

Construct french drains, utilizing one of the authorized types of pipe, with coarse aggregate, or ballast rock when specified, and filter fabric.

443-2 Materials.

443-2.1 Pipe: Unless a particular type is specified in the Plans, pipe furnished may be any of the following types:

1. Concrete Pipe (Bell & Spigot): Slotted or perforated concrete pipe may be used. Meet the requirements of Section 449 for concrete pipe. Do not use gaskets. Fully insert the spigot in the bell, and bring home. Conform to Standard Plans, Index 443-001 for slotted pipe. Use perforated pipe having perforations equally located 360 degrees around the pipe. Use pipe having not less than 30 round perforations, 3/8 inch each, per square foot of inside pipe surface. Extend perforations to within 6 inches of the bell or spigot area. The Engineer will permit other perforations not less than 5/16 inch nor more than 3/8 inch in the least dimension if they provide an opening area not less than 3.31 in^2/ft^2 of pipe surface.

2. Corrugated Aluminum Alloy Culvert Perforated Pipe: Meet the requirements of Section 945. Use perforated pipe having perforations equally located 360 degrees around the pipe. Locate perforations either on the inside crests or on the neutral axis of all corrugations except that perforations are not required within 4 inches of each end of each length of pipe or in a corrugation where seams are located.

Provide pipe having not less than 30 round perforations, 3/8 inch each, per square foot of pipe surface. The Engineer will permit other perforations not less than 5/16 inch nor more than 3/8 inch in the least dimension if they provide an opening area not less than 3.31 in^2/ft^2 of pipe surface.

3. Corrugated Steel Perforated Pipe: Meet the requirements of Section 943. Meet the perforation requirements as specified in (2) above.

4. Bituminous Coated Corrugated Steel Perforated Pipe: Meet the requirements of Section 943. Meet the perforation requirements as specified in (2) above. Place the perforations prior to the bituminous coating. The Engineer will accept the minimum opening of not less than 3.31 in^2/ft^2 of pipe if 50% of the opening area is maintained after coating.

5. Corrugated High-Density Polyethylene (HDPE) Perforated Pipe: Meet the requirements of Section 948. Meet the perforation requirements as specified in (2) above.

6. Polyvinyl Chloride (PVC) Perforated Pipe: Meet the requirements of Section 948. Meet the perforation requirements as specified in (2) above.

7. Corrugated Polypropylene Perforated Pipe: Meet the requirements of Section 948. Meet the perforation requirements as specified in (2) above.

443-2.2 Coarse Aggregate: Meet the requirements of 901-1.4 for No. 4 stone.

443-2.3 Select Fill: Use select fill meeting the requirements of Section 911.

443-3 Excavating Trench.

Excavate the trench in accordance with Section 125 unless specific trench excavation procedures are described in the Plans.

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Carefully excavate the trench to such depths as required to permit the filter fabric, coarse aggregate and the pipe to be placed in accordance with the details shown in the Plans.

443-4 Laying Pipe.

Lay all pipe conforming with the lines and grades specified in the Plans and in accordance with these Specifications. Unless otherwise specified in the Plans, set the pipe with a 36 inch minimum cover and a maximum cover of 66 inches.

443-5 Placing Coarse Aggregate and Backfilling.

After placing the pipe and without disturbing the pipe, carefully place the coarse aggregate around the pipe to a depth shown in the Plans. Fold the filter fabric over the coarse aggregate. Backfill and compact as described below.

443-5.1 French Drains Under Pavement: Fill the area above the coarse aggregate with select fill material meeting the requirements of this Section. Place and compact the select fill according to the requirements for pipe as specified in Section 125. The Department will allow use of additional coarse aggregate over the top of the pipe instead of select fill material. In this case, the filter fabric shall be extended to wrap the additional course aggregate. The top of the coarse aggregate shall not be higher than the bottom of the base, unless shown in the Plans. The Department will not pay additional costs associated with substituting coarse aggregate for select fill.

443-5.2 French Drains not Under Pavement: Fill and compact the area above the coarse aggregate according to the requirements for pipe in Section 125, unless specific procedures are described in the Plans as specified in Section 125.

443-6 Method of Measurement.

The quantity of french drains to be paid for under this Section will be the length in feet, measured in place, completed and accepted as specified on Standard Plans, Index 443-001 for french drains.

443-7 Basis of Payment.

The quantities determined as provided above will be paid for at the Contract unit price per foot for french drains. Such prices and payments will be full compensation for all the work specified in this Section and will include all materials and all excavation, and will also include sheeting or shoring, if required, the disposal of surplus material, pavement restoration, backfilling and tamping, but will not include payment for items paid for elsewhere in the specifications.

Payment shall be made under:

Item No. 443- 70- French Drains - per foot.

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SECTION 446
EDGEDRAIN (DRAINCRETE)

446-1 Description.

Construct edgedrain (draincrete), and edgedrain outlet pipe as shown in the Plans and Standard Plans, Index 446-001. Use any one of the types of pipe listed in 446-2, unless a particular type is specifically required within the Contract Documents. Use only perforated pipe, and do not use open joints.

446-2 Materials.

Meet the following requirements:

Portland Cement Concrete – Class NS* .....Section 347
Coarse Aggregate.....Section 901
Portland Cement.....Section 921
Water.....Section 923
Polyvinyl-Chloride Pipe.....Section 948
Polyethylene Pipe.....Section 948
Filter Fabric**.....Section 985

*For draincrete, the concrete requirements of Section 347 are modified as follows:

Use Type I or II portland cement (no supplementary cementitious materials permitted).

Composition:

Grade of coarse aggregate (stone).... #57, #67 or #89
Maximum Water/Cement ratio 0.38
Minimum cement factor..... 385 lb/yd^3 of Draincrete
Maximum Slump Range ..... Not Applicable
Fine Aggregate.....None
Admixtures.....None

Do not use materials which contain hardened lumps, crusts, or frozen matter, or are contaminated with dissimilar material.

**Use products listed on the Department's Approved Products List (APL).

446-3 Control of Quality.

446-3.1 Concrete Design Mix: Submit the proposed design mix prior to production, on the Concrete Mix Design form, for the Engineer's approval. Use only draincrete design mixes having prior approval of the Engineer. Do not change the design mix component materials except as per 446-3.2.

The Department will verify the proposed mix design and may witness the trial batching. Meet the unit weight requirements as determined in accordance with FM 5-530, and the drain rate in accordance with FM 5-570. Also, provide one of the following with the design mix submittal:

1. Evidence from three sets of production data, either from Department acceptance tests or independently verifiable commercial mixes, that draincrete produced in accordance with the proposed design mix meets the requirements of this Section.

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2. Test data from a single trial batch of 0.10 yd^3 minimum is required, which demonstrates that the draincrete produced using the proposed mix, designated ingredients, and designated water-cement ratio meets the requirements of this Section.

446-3.2 Batch Adjustment - Materials: Meet the theoretical yield requirements of the approved mix design. Inform the Engineer of any adjustments to the approved mix design. Note any batch adjustments and record the actual quantities incorporated into the mix, on the concrete Delivery Ticket/Certification form.

446-3.3 Delivery Certification: Furnish to the Engineer a complete Delivery Ticket/Certification form with each batch of draincrete prior to unloading at the site.

446-4 Construction.

446-4.1 Excavating Trench: Meet the requirements of Section 440.

446-4.2 Laying Pipe: Meet the requirements of Section 440.

446-4.3 Placement of Draincrete: Obtain the Engineer's approval before placing the draincrete. Deliver the draincrete to the site of placement in a freshly mixed unhardened state. Deposit draincrete in the form or trench by a method approved by the Engineer, to ensure uniform distribution. Do not use vibrators. Avoid displacement or damage to the pipe or filter fabric.

446-5 Sampling and Testing.

446-5.1 General: The Engineer will take random samples of the draincrete at the point of placement to determine the drain rate in accordance with FM 5-570 to determine the drain rate. A minimum of two test cylinders will be made for each LOT. A LOT represents one day's production of each mix design.

446-5.2 Acceptance of Hardened Draincrete: Meet the minimum drain rate of 6 oz/second. Draincrete not meeting the drain rate requirement will be rejected.

Remove, and replace all rejected draincrete at no cost to the Department.

446-6 Method of Measurement.

The quantity of edgedrain (draincrete) to be paid for will be the length, in feet, measured in place, along the centerline and gradient of the edgedrain (draincrete), completed and accepted. The quantity of edgedrain outlet pipe to be paid for will be the length, in feet, measured in place along the centerline and gradient of the outlet pipe, completed and accepted.

446-7 Basis of Payment.

Price and payment will be full compensation for all work, including all materials, excavation, equipment, labor and incidentals necessary to complete the work.

Payment will be made under:

Item No. 446- 1-	Edgedrain (Draincrete) - per foot.
Item No. 446- 71-	Edgedrain Outlet Pipe - per foot.

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SECTION 449
PRECAST CONCRETE DRAINAGE PRODUCTS

449-1 Description.

Precast concrete drainage products hereinafter called products, may include but are not limited to, round concrete pipe, elliptical concrete pipe, underdrains, manholes, endwalls, inlets, junction boxes, three-sided precast concrete culverts, and precast concrete box culverts.

Ensure that all precast drainage products are designed and manufactured in accordance with the requirements of the Contract Documents.

Obtain precast concrete pipes, box culverts, and drainage structures from a plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.

At the beginning of each project, submit a notarized certification statement to the Engineer from a company designated representative certifying that the plant will manufacture the products in accordance with the requirements set forth in the Contract Documents and Producer Quality Control (QC) Plan. The Quality Control Manager's stamp on each product indicates certification that the product was fabricated in conformance with the Producer QC Plan, the Contract, and this Section. Ensure that each shipment of precast concrete products to the project site is accompanied with a QC signed or stamped delivery ticket providing the description and the list of the products.

When the Producer Quality Control Program is suspended by the Department, accept responsibility of either obtaining products from a plant with an approved Quality Control Program, or await re-approval of the plant. The Engineer will not allow changes in Contract Time or completion dates as a result of the plant's loss of qualification. Accept responsibility for all delay costs or other costs associated with the loss of the plant's qualification.

449-2 Materials.

Ensure that the materials used for the construction of the precast drainage products have a certification statement from the source, showing that they meet the applicable requirements of the Specifications with the following modifications:

Reinforcing Bar	Section 415
Coarse Aggregate*	Section 901
Fine Aggregate*	Section 902
Portland Cement and blended cement	Section 921
Water	Section 923
Admixtures	Section 924
Supplementary Cementitious Materials	Section 929
Gasket Material	Section 942
Blended Hydraulic Cements	AASHTO M 240
Welded Wire Reinforcement	Section 931
Wire for Site Cage Machines	Section 931
Liner Repair Systems	Section 948

*For concrete pipes the gradation requirements of concrete aggregates as set forth in Sections 901 and 902 are not applicable.

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449-3 Construction Requirements.

Unless otherwise stipulated within the Contract Documents, meet the following requirements for concrete mix, product design, fabrication, transportation, and installation:

Three-Sided Precast Culverts.....Section 407
Precast Concrete Box Culvert.....Section 410
Pipe Culverts and Storm Sewers.....Section 430
French Drains.....Section 443
Inlets, Manholes, and Junction Boxes
.....Section 425 and ASTM C478
Underdrains.....Section 440 and ASTM C444
Steel Reinforced Round Concrete Pipe.....ASTM C76
Reinforced Elliptical Concrete Pipe.....ASTM C507
Non-reinforced Concrete Pipe .....ASTM C985

Meet the special requirements for the applicable pipes as described in 449-4 and 449-5.

449-4 Concrete Pipe.

449-4.1 Special Requirements for Steel Reinforced Concrete Pipe: Use pipe meeting the requirements of ASTM C76 with the modifications as described in 449-4.2. Use Special Designed pipe meeting the requirements of ASTM C655. Use Class S pipe meeting the requirements of ASTM C655. Ensure all pipes are properly marked.

449-4.2 Modifications to ASTM C76 and ASTM C507: The following supersedes the provisions of ASTM C76 and ASTM C507:

1. Ensure all materials used in concrete are certified from the source and conform to the requirements of 449-2.
2. Ensure all Joint Reinforcement requirements are in accordance with the Standard Plans.
3. When membrane curing compounds are used, ensure that the requirements of 925-2 are met and the membrane curing compounds are applied in accordance with 400-16 immediately after the pipe has been removed from the form.
4. Ensure the manufacturer has a suitable apparatus for testing each product in accordance with ASTM C497 and performs all tests outlined in ASTM C497 when requested by the Engineer.
5. Ensure that the variation of laying lengths of two opposite sides of pipe is not more than 1.04% of the diameter, with a maximum of 1/2 inch in any length of pipe, except where beveled-end pipe for laying on curves is specified.
6. Ensure that the type of wall markings is included on all precast pipes.
7. Ensure all repairs are made in accordance with Section 449-5.4.

449-4.3 Special Requirements for Non-Reinforced Concrete Pipe: Ensure the requirements of ASTM C985 are met with the following exception: Modify material requirements set forth in ASTM C985 with the material requirements set forth in 449-2. Ensure all pipes are properly marked.

449-4.4 Special Requirements for Reinforced Elliptical Concrete Pipe: Use elliptical concrete pipes conforming to the requirements of ASTM C507, except for the exceptions and modifications as specified in 449-4.2. Ensure the requirements of Table I of ASTM C507 for standard elliptical pipe, the requirements of Class HE-III and Class HE-IV of Table I of ASTM C507 for standard elliptical pipe and special elliptical pipe, respectively are met and the joint design requirements set forth in Article 7 of ASTM C443 are met.

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449-4.5 Concrete Underdrain Pipe: Use perforated concrete pipe for underdrains meeting the requirements of ASTM C444, with the following modifications:

1. Strength of finished pipe: Underdrain pipe will not be required to be reinforced, and will not be tested for strength of the finished pipe. Approval of the strength of the finished pipe will be based on visual inspection and check.

2. Perforations: The perforations must be molded into the pipe at the time of fabrication, and any undue chips, fractures, incurred thereby, either in the interior of the pipe or on the periphery, which are sufficient to significantly impair the strength or efficiency, will be cause for rejection of the pipe.

Ensure the perforations are circular, and of the diameter called for below, with a tolerance of plus or minus 1/16 inch. Furnish all pipe included in any single order, or for any single installation operation, such diameter is reasonably uniform.

Table 449-1
Schedule of Perforations For Concrete Underdrain Pipe

Internal Diameter of Pipe	Diameter of Perforations *(Design)	Number of Rows	**Approximate distance between Rows	**Spacing within Rows
6 inches	3/8 inch	4	4 inches	5-6 inches
6 inches	1/4 inch	4	4 inches	4-5 inches
8 inches	3/8 inch	4	5 inches	5-6 inches
8 inches	1/4 inch	4	5 inches	4-5 inches

*1/16 inch fabrication tolerance, over and under.
**Perforations to be staggered in alternate rows. The spacing between rows must be uniform.

449-4.6 Rejection of Concrete Pipe: Specific causes for rejection of concrete pipe, in addition to any failure to meet the general requirements specified in the Contract Documents, are as follows:

1. Failure to meet the requirements listed in ASTM C76 for permissible variations in dimensions with the modifications outlined in 449-4.1 and 449-4.2.

2. Occurrence of defects listed in ASTM C76.

449-5 Requirements for Pipe Joints When Rubber Gaskets Are to Be Used.

449-5.1 Design of Joint: Use pipe joint of the bell-and-spigot type or the double spigot and sleeve type, meeting the requirements called for in the Standard Plans. Ensure the joint is so proportioned that the spigot, or spigots, will readily enter the bell or sleeve of the pipe.

Ensure the joint ring forms for forming the joint surface are made of either heavy steel, cast iron, or aluminum, and accurately machined to the dimensions of the joint. They must be a true circular form within a tolerance of 1/32 inch. Dimensional checks of joint ring form will indicate for each size pipe a length of spigot, or tongue, not more than 1/8 inch shorter than the bell, or groove, depth. The pipe will be so manufactured that joint surfaces are concentric with the inside of the pipe within a tolerance of 3/32 inch. The shape and dimensions of the joint must be such as to provide compliance with the following requirements:

1. The joint must be so dimensioned that when the gasket is placed on the spigot it will not be stretched more than 20% of its original length, or the maximum stretch length that is recommended by the manufacturer, whichever is lower.

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2. The space provided for the gasket must be a groove in the spigot end of the pipe and such space, when the joint is made, it cannot be more than 110% of the volume of the gasket.

3. The joint must be designed so that when the outer surface of the spigot and the inner surface of the bell come into contact at some point on the periphery, the diametric deformation in the gasket at the point of contact cannot be greater than 50% of the normal gasket diameter, and the diametric deformation in the gasket at a point opposite the contact point cannot be less than 20% of the normal gasket diameter.

4. When the pipes are joined, there must be parallel surfaces on both the bell and the spigot, extending from the outside edge of the gasket toward the bell face for a distance of not less than 3/4 inch. These parallel surfaces cannot be farther apart than 1/8 inch, when the spigot is centered in the bell. The tapers on these surfaces cannot exceed three degrees.

5. The inside surface of the bell at the end of the bell must be flared to facilitate joining the pipe sections without damaging or displacing the gasket.

449-5.2 When Rubber Gaskets are Used: Ensure that the pipe joints have been tested at the plant hydrostatically and shown to meet the requirements of Section 6.2 of the Materials Manual, which is available at the following URL: https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/Section62V2.shtm.

449-5.3 When Profile Rubber Gaskets are Used: Ensure the joint design meets the requirements set forth in Article 7 of ASTM C443.

449-5.4 Tolerances in Imperfections, and Permissible Repairs for Joint of Concrete Gasketed Pipe: Ensure that all surfaces of near-contact of the jointed pipes are free from air holes, chipped or spalled concrete, laitance, and other such defects.

Pipes showing minor manufacturing imperfections or handling injuries to the bell or spigot may be acceptable if such defects are acceptably repaired as prescribed below.

Individual air holes (trapped air), or spalled areas with a length of up to one-half the pipe radius, or 12 inches whichever is less, may be repaired by careful use of a hand-placed, stiff, pre-shrunk, 1-to-1 mortar of cement and fine sand, and with no additional preparation other than a thorough washing with water of the defect. Curing will be done either by moisture curing under wet burlap or by application of an approved membrane curing compound. Such repaired pipe which is sound, properly finished and cured, and which otherwise conforms to specification requirements will be acceptable.

Exposed reinforcing and minor spalling in the spigot groove may be accepted if repaired in the following manner: The spalled areas will be chipped back to solid concrete. Exposed reinforcing will be cleaned of all laitance and scale. The entire area is to be coated with an approved epoxy at a thickness of 5 to 10 mils. The coating must be smooth and conform to the shape of the groove. The epoxy must be a Type F-1 as specified in Section 926.

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SECTION 450
PRECAST PRESTRESSED CONCRETE CONSTRUCTION

450-1 Description.

Fabricate, store, transport and erect precast/prestressed concrete members prestressed by the pretensioning method. Pretensioned precast prestressed concrete products are products prestressed by the pretensioning method. In this method, steel or fiber reinforced polymer (FRP) components are stressed and anchored; the concrete for the product is then cast and cured, and finally the stress in the steel or FRP components is released from the anchorages to the concrete through bond, after the concrete has attained its specified release strength.

A precast prestressed concrete plant, hereinafter called plant, is an independent operating facility capable of performing all the operations necessary to fabricate precast/prestressed concrete products.

Obtain precast/prestressed products from a plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.

When the Producer's Quality Control Program is suspended, accept responsibility of either obtaining precast/prestressed products from a precast/prestressed concrete plant with an accepted Quality Control Program, or await re-approval of the Producer Quality Control Program. The Engineer will not allow changes in Contract Time or completion dates as a result of the concrete plant's Quality Control Program suspension. Accept responsibility for all delay costs or other costs associated with the plant's Quality Control Program suspension.

450-2 Quality Control Program.

450-2.1 General: Develop a Producer Quality Control Program as specified in Section 105.

Meet the requirements of the accepted Quality Control Program, Contract Documents, and Precast/Prestressed Concrete Institute (PCI) Manual for Quality Control for Plants and Production of Structural Precast Concrete Products (MNL-116). The requirements of the Contract Documents will govern, when there is a discrepancy between the PCI Manual and the Contract Documents.

Accept responsibility for performing daily Quality Control (QC) inspections of all phases of work ensuring all materials and workmanship incorporated into the product meet the requirements of the Contract Documents. Also, maintain a daily activity report detailing the results of the daily Quality Control Program activities. Ensure these daily reports and minutes of the weekly meetings with the Engineer and the plant's production personnel are maintained at the plant. During the weekly meetings, discuss the results of the QC inspections.

Ensure a QC inspector is present during concrete placements and performs inspection during all fabrication of precast prestressed concrete products, including the inspection of the operations before, during and after the placement of concrete.

450-2.2 Plant: Ensure each plant has an onsite QC Manager or designee meeting the requirements of Section 105 at all times during fabrication.

450-2.3 Tolerances:

Inspect all prestressed concrete products within five working days of detensioning to ensure their dimensions (other than sweep and camber) conform to the specified tolerances and to determine if there are any deficiencies.

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Inspect the product for conformance with the product dimension tolerances shown in Appendix B of PCI Manual MNL-116, except as modified herein.

Apply the tolerances with respect to the theoretical positions and dimensions shown in the Plans. Apply the same tolerances for U-Beams as those specified for I-Beams, when inspecting the product for conformance with dimension tolerances.

For Florida U-Beam diaphragms, the tolerances are:

1. Plus 1 inch and minus 1/2 inch for the thickness of intermediate diaphragms.
2. Plus or minus 3 inches for the location of intermediate diaphragms, relative to design plan positions.
3. Plus 3 inches and minus 1/2 inch for the thickness of the end diaphragms.

The tolerance for beam strand sheathing is plus or minus 2 inches.

Ensure the tolerance on all miscellaneous shaping including, but not limited to, chamfers, miters, bevels, keys, tapers, radii, holes, inserts, and block outs is within plus or minus 1/8 inch of the control dimension of the shape.

The tolerances represent the total allowable tolerance that will be accepted in the finished product. Do not apply tolerances shown for the overall dimensions of a member to violate the tolerances shown for positions of reinforcing and prestressing steel or FRP. Apply the tolerances during and after the fabrication of prestressed products. Do not reduce the concrete cover for reinforcing steel, FRP reinforcing, prestressing steel, FRP prestressing strands, or any other metallic or polymeric objects specified in the Plans more than 1/4 inch. Do not reduce the concrete cover for reinforcing steel, FRP reinforcing, prestressing steel, FRP prestressing strands, or any other metallic or polymeric objects when the cover specified in the Plans is minimum cover.

Limit sweep to 1/2 inch for U-Beams and Inverted T-Beams.

The maximum allowable sweep for I-Beams and piles is 1/8 inch for every 10 feet, and will be determined by the following equation:

Sweep (in) = (0.0125 in/ft) x Length (ft) of beam or pile

Measure and record the sweep and camber of the beams immediately after detensioning and monthly. Beyond 120 days after casting, monthly sweep and camber measurements may be reduced to quarterly if there are no identified issues with the beam, and if the sweep and camber measurements are in tolerance. Once the reduced frequency is applied, camber and sweep shall be measured no more than 7 calendar days prior to shipping. Keep the measurement records on file for review upon request by the Engineer.

Notify the Engineer immediately when the sweep or camber exceeds the specified tolerances.

If the actual camber is less than 50% of the predicted camber at release provided by the Plans, move the dunnage towards the center of the beam to a maximum of 5% of the total length at each end to induce camber.

If the camber is outside of the design camber shown in the Plans by plus or minus 1 inch, take appropriate actions to accommodate the product in the structure.

If the sweep exceeds the tolerance specified, immediately propose measures to the Engineer to bring the sweep of the product back to within tolerance. Special storage conditions for the purpose of removing excessive sweep will not be restricted by requirements of this Section.

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450-2.4 Product Certification: Ensure the QC inspector inspects all completed products at the plant not less than 24 hours before shipment to verify that all Contract Documents requirements are met. Upon verification that all Contract Document requirements have been met and all necessary repairs have been satisfactorily completed, the product will be stamped with the approved QC Manager stamp identified in the Producer QC Plan.

With each monthly request submitted for payment, attach a certification stating that the listed precast prestressed products have been produced under the Producer QC Plan and meet the Contract Document requirements. Ensure the certification is signed by a legally responsible person of the plant and is submitted on the plant's letterhead.

450-2.5 Documentation: Ensure that a system of records is maintained in each plant which will provide all information regarding the certification and testing of prestressing steel, FRP prestressing strands, reinforcing steel, FRP reinforcing, concrete materials and concrete, curing materials, embedded items, tensioning, concrete proportioning, pre-placement, placement, post-placement inspections, curing, and disposition of products. Include in the record keeping all the deficiencies found as a result of the inspection and testing. Keep certified test reports for all materials incorporated into the production of precast prestressed concrete products.

Ensure that the record of tensioning operations is maintained and reflects the identification of the bed, type of fabricated products, the complete Financial Project Identification Number, jack identification number, date prestressing strands were stressed, temperature at the time of stressing, and signature of the qualified tensioning machine operator.

Ensure the proposed method and format for documenting required information is included in the Producer QC Plan.

Maintain records until all the precast prestressed products for a project have been fabricated then submit required records to the Engineer. Ensure records are available at all times for the Engineer's inspection.

450-2.6 Quality Assurance Inspection and Testing: The Engineer will perform periodic inspections, sampling, and testing to ensure of the quality and acceptability of the materials, methods, techniques, procedures and processes being utilized in the fabrication of precast prestressed concrete products.

450-3 Materials.

450-3.1 General: Meet the following requirements:

Concrete	Section 346
Steel Strands*	Section 933
Carbon Fiber Reinforcing Polymer (CFRP) Strands*	Section 933
Steel Prestressing Bars	Section 933
Steel Accessories	Section 933
Steel Spirals	Section 931
Reinforcing Steel and Metal Welded Wire Reinforcement	Sections 415 and 931
FRP Reinforcing	Sections 415 and 932
FRP Spirals**	Section 932
Embedded Ducts	Section 960
Membrane Curing compounds***	Section 925
Epoxy Resin Compounds	Section 926
Burlap	Section 925

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Curing Blanket 400-16
Penetrant sealer*** .....Section 413
Methacrylate .....Section 413
Epoxy Injection of Cracks .....Section 411

* Do not use strands from more than one source in any individual prestressed element, with the exception of the partially tensioned strands (dormant strands).

** The FRP spirals cannot be used in combination with steel prestressing strand.

*** Use membrane curing compounds and sealers that are compatible with coating or other materials that are applied to concrete surface.

Use inserts in accordance with the recommendations of the manufacturers and within their certified capacities and application qualifications. Do not use aluminum inserts.

Use draped strand devices of sufficient rigidity having adequate support to retain the position of the strand unchanged under the induced load. Do not allow the devices to induce friction to the strands such that the required jacking force and elongation cannot be attained.

450-3.2 Strand Chucks and Splice Chucks: For pretensioning, use strand chucks that are capable of anchoring the strands without slippage after seating and ensure against strand failure within the grips at loads less than 95% of ultimate tensile strength of the prestressing strand.

Submit manufacturer's certification that splice chucks used to transmit the prestressing force from one prestressing strand to another are capable to hold at least 95% of the ultimate tensile strength of the prestressing strand.

Do not use wedges that become worn, cracked, deformed, or that allow dead end seating in excess of 3/8 inch. Use components from the same manufacturer to make up chucks and to provide proper wedge fit.

Use chucks as complete units. Clean, inspect, and lubricate the chucks between each use. Use wedges and housing that are compatible and made for the specific type and size of prestressing strand used. Ensure proper fit and proper seating of wedges on the strands.

The Engineer will allow one splice per strand subject to the following:

1. Splices are located outside the concrete products (except for precast piling where up to two splices are permitted to be used in each pile, so long as they are not located in the same vertical cross section, perpendicular to longitudinal axis of the pile).

2. Strands which are being spliced have the "lay" or "twist" in the same direction.

450-4 Material Acceptance and Testing.

450-4.1 Concrete: Perform the QC sampling and testing of concrete in accordance with the requirements of Section 346.

450-4.2 Reinforcing, Welded Wire Reinforcement and Prestressing Strand for Pretensioning:

450-4.2.1 General: Identify all reinforcing steel, welded wire reinforcement and prestressing strand for pretensioning by LOTs. A LOT of reinforcing steel or welded wire is a shipment of material from the same manufacturer and heat. A LOT of prestressing steel is a shipment of material of the same size, production grade and heat from the same manufacturer. A LOT of FRP reinforcing bars or prestressing strands is a shipment of material of the same size, fiber lot and resin batch from the same manufacturer.

Acceptance of reinforcing bars, welded wire reinforcement and prestressing steel for pretensioning is based on manufacturer's certification and the Department's

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verification tests. The sampling for verification testing will be performed by the Department at each plant, on at least one LOT every six months. Additional samples may be taken at the manufacturing source of reinforcing bars, welded wire reinforcement and prestressing strands.

When products contain the material that has failed to meet the requirements of 450-3, reject the unused material of the failed LOT. The Engineer may require an engineering analysis of the products which contain the failed material, in accordance with Section 6.

450-4.2.2 Steel Reinforcing and Welded Wire Reinforcement: Obtain and maintain for each LOT a certified mill analysis, physical property test report and the manufacturer's assigned LOT number with the heat of the material represented. Verify that the report represents the steel received and that the steel meets the Contract Documents requirements. Reject all unidentified reinforcing steel or welded wire reinforcement received at the plant or job site.

Submit the manufacturer's certified mill analysis and provide three, 7 foot long, randomly selected samples from the designated LOT of reinforcing steel and three randomly selected samples from the designated LOT of welded wire reinforcement when requested by Engineer. Ensure each sample of welded wire reinforcement covers an area of four intersections of transverse and longitudinal bars. Ensure the transverse wires of each piece of welded wire reinforcement extend approximately 6 inches to both sides.

450-4.2.3 Fiber Reinforced Polymer (FRP) Reinforcing: Meet the requirements of 932-3.

450-4.2.4 Steel Prestressing Strand for Pretensioning: Obtain and maintain for each LOT of material received, the manufacturer's assigned LOT number, certified test values for specified material properties together with a representative load-elongation curve and the modulus of elasticity value based upon strand nominal area. Submit and support by records maintained by the strand manufacturer, production tolerances applied in selection of the reported strand modulus. Verify that documents submitted represent the shipment received and meets the Contract Documents requirements.

Reject all unidentified prestressing steel received at the plant or job site.

Submit the manufacturer's certified mill analysis and provide three, 5 foot long randomly selected samples from the designated LOT of material when requested by the Engineer.

450-4.2.5 Fiber Reinforced Polymer (FRP) Prestressing Strand for Pretensioning: Meet the requirements of 933-5.2.2.

450-4.2.6 Strand Chucks and Splice Chucks: Obtain and maintain certified test results certifying that the material meets the requirements of 450-3.

450-4.2.7 Steel Accessories: Use only steel accessories meeting the requirements of 450-3.

450-4.2.8 Ducts: Obtain and maintain certified test results certifying that the material meets the requirements of 450-3.

450-5 Shop Drawings.

Submit shop drawings for all pretensioned prestressed concrete products containing FRP bars, FRP strands, or stainless steel strands. Submit shop drawings for all other pretensioned prestressed concrete products when the Contract Documents do not contain all the detailed information necessary to fabricate and erect the pretensioned prestressed concrete product. Ensure the submitted shop drawings meet the requirements of the Contract Documents.

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Obtain prior approval of any adjustments to the shop drawings which will result in a net change of prestressing force within the product. Shop drawings are not required to depict negligible, supplemental reinforcement used to facilitate fabrication of products if the additions do not affect the performance of the product.

In lieu of shop drawings, submit the following to the Engineer:

1. The Framing Plan with product designations for all superstructure components.
2. Strand detensioning schedule.
3. Tensioning and elongation calculations.
4. Details of supplemental reinforcement that remains as part of the finished product.
5. Drawings, details and spacing for embedded items associated with fall protection systems used on beams.
6. When proposing to use materials and/or methods that differ from the requirements of the Contract Documents, submit full plan details and Specifications for the alternate materials and methods. Ensure the alternate materials and methods meet the following requirements:

a. The provisions of the Contract Documents.

b. The AASHTO LRFD Bridge Design Specifications, edition with interims as referenced in Plans.

c. The recommendations of the material manufacturer.

d. Any materials change proposed by the Contractor and approved by the Engineer.

e. Net compressive stress in the concrete due to prestressing acting alone, after all losses, is not less than or 5% greater than that provided by the stranding shown in the Plans.

f. Ultimate strength of the structure with the proposed changes is not less than the ultimate strength of the original design.

g. The provisions of the Departments Structures Design Guidelines.

450-6 Forms.

450-6.1 General: Use metal side and bottom forms, unless otherwise specified in the Contract Documents. For members with special shapes such as corner sheet piles, wood forms are permitted. Slab beams, slab units and sheet piles may be cast on concrete surfaces meeting the profile dimensional tolerances of 450-6.3. Apply release agents in accordance with the manufacturer's recommendations. Liquid membrane curing compounds may be used to prevent bonding of slab products and sheet piles to the existing concrete surface, when applied in two or more coatings. Ensure the last application of liquid membrane is applied immediately before placement of the slab or sheet pile.

For all beam members, use side forms designed to be removed without damaging the top flange of the beam. Remove the forms horizontally away from the beam by a method that prevents any contact of the form with the top flange after release of the form. Do not subject the top flange to any vertical force at any time. Include the form details and method of removal in the Producer QC Plan.

For all Florida I-Beams, use forms that do not have more than two horizontal joints.

Use void forms of a type for which service adequacy has been demonstrated, having sufficient strength to provide stability during handling and placing and to withstand

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hydrostatic pressures and other forces imposed upon them during concrete placement. Use form material that is neutral with respect to the generation of products harmful to the physical and structural properties of the concrete. Ensure that the presence of the form materials does not cause any detrimental effect to the concrete or other materials within the member. Positively vent all voids to the outside of the member. For end headers and inside forms, other materials capable of resisting the pressure from concrete are permitted, except that end headers used with CFRP strands must be either timber headers or steel headers with rubber grommets to protect the CFRP strands from damage.

Use end headers so designed that they can be placed and maintained in correct position between the side forms. Hold the headers in place with devices capable of being removed or loosened after the concrete has attained its initial set allowing free form expansion during curing methods that involve heat. Use end headers with openings conforming to the prestressing strand pattern to permit passage of the prestressing strand. Locate the openings accurately within 1/8 inch of planned location of prestressing strand elements.

Construct circular openings for strands a maximum of 1/4 inch larger than the nominal strand diameter. Construct square or rectangular openings a maximum of 1/4 inch larger, horizontally and vertically, than the nominal strand diameter. Ensure that all headers are mortar tight.

450-6.2 Supports: Use forms of sufficient thickness, with adequate external bracing and stiffeners, which are anchored to withstand the forces due to placement and vibration of concrete. Ensure that joints in forms are mortar tight. Support bottom forms on concrete pallets with metal stiffeners, wales or shims. Do not use timber elements between the bottom metal form and concrete pallets.

450-6.3 Alignment: Make and maintain during their use, forms and centering true to the shapes and dimensions for the product being produced. Plumb, align, and secure forms for each product in position before each reuse.

Apply the following tolerances to form alignment and pallets or beds used in prestressed construction:

1. Horizontal Alignment (horizontal deviation of side forms either side of a vertical plane within the length of a product) = 1/8 inch,
2. Vertical Alignment (vertical deviation of the bed or pallet from a horizontal plane within the length of a product) = 1/8 inch,
3. Vertical joints (offset between adjacent form sections) = 1/8 inch.
4. Horizontal joints (offset between adjacent form sections) = 1/16 inch.

450-6.4 End Header Locations:

450-6.4.1 General: Provide a minimum of 18 inches of exposed strands from the end header to the stressing anchorage for all products. Provide a minimum of 18 inches of exposed strands between adjacent ends of all products except 24-inch square and smaller piles. Provide a minimum of 6 inches of exposed strands between adjacent ends of 24-inch square and smaller piles.

450-6.4.2 Cold Weather: Provide a distance of at least 5 feet from the end header to the stressing anchorage, when the ambient temperature is expected to be below 55ºF between the time of tensioning and detensioning. When the ambient temperature is expected to be below 55ºF between the time of tensioning and detensioning and the product's exposed strands between the stressing anchorages are not protected, maintain a 25 foot minimum free length of stressed strands, between the end header and the stressing anchorage at each end of a bed line. When cold

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weather concrete conditions as specified in 450-10.1 are in effect, protect all exposed strands between stressing anchorages regardless of length. When the products and strands between stressing anchorages are protected, provide protection adequate to maintain the ambient temperature of the air around the strands at or greater than 55ºF until the products are detensioned or 24 hours after placing concrete, whichever is less.

450-6.5 Surface Conditions: Use clean, rust free form surfaces against which concrete is to be cast. Inspect forms and, if necessary, recondition them.

450-6.6 Form Ties: Ensure that no form wires or metal pieces are left within 2 inches of the surface of the finished concrete.

450-6.7 Corners, Angles and Joints: Ensure corners and angles are chamfered, mitered, or rounded with a radius of 3/4 inch, unless otherwise specified or shown in the Plans. Provide smooth mortar tight joints between panel forms within the alignment tolerances.

450-6.8 Form Release Agent: Before placing concrete, treat the facing of all forms with a form release agent in accordance with the manufacturer's requirements. Ensure the application of form release agents does not contaminate prestressing strands and/or reinforcing steel.

450-7 Protection and Placement of Prestressing Strand.

450-7.1 Protection of Prestressing Strand: Maintain and store prestressing steel above the ground surface on platforms, skids, or other supports, to prevent contamination from below, and protect them from mechanical injury. Do not use any packaging or wrapping material that retains moisture at the bottom of the reel. Clean contaminated prestressing strand before use or otherwise reject it. Handle prestressing strand carefully to prevent nicks or kinks. Do not expose prestressing strand to temperatures greater than 165ºF at any time prior to concrete placement. Do not expose CFRP prestressing strand coupler assemblies to temperatures greater than 120°F at any time. Do not use arc welding equipment, including welding electrode lines, within 2 feet of prestressing strand. Do not perform welding on forms that have been set in place after the prestressing strand is placed in the bed. Reject prestressing strand that has sustained any physical damage at any time.

450-7.2 Placing Prestressing Strand: Use care during placement of prestressing strand to avoid physical damage and contamination. Reject damaged strands. Do not use prestressing strand containing nicks, kinks, or former chuck grip marks. Do not use prestressing strand showing evidence of scale formation or which has become pitted. Remove and replace any damaged prestressing strand in the bed.

450-7.3 Cleanliness of Prestressing Strand: Inspect the prestressing strand for any evidence of contamination. Use strand that is free of deleterious materials such as grease, oil, wax, dirt, paint (except that used for marking identification) or other similar contaminants. Remove any contaminants detected from the strand before proceeding with fabrication activities. Rust on prestressing steel that can be removed by light rubbing is acceptable. Streaks or spots which may remain after rust removal are acceptable if no pitting is present.

450-7.4 Debonded Strands: Install debonding material (sheathing) according to the prestressing strand locations and lengths shown in the Plans, and manufacturer's instructions, except as modified herein. Do not install sheathing over the full length of a product. Extend the sheathing through the header. Tape and tie the sheathing at the terminus located at the inside of the member. The tape must be strong enough to hold the sheathing closed.

Use non-slit tubular or two-part sheathing that is high-density plastic. The sheathing must have a minimum wall thickness of 0.025 inch, and an inside diameter exceeding the maximum outside diameter of the strand by 0.020 inch to 0.150 inch. Tape the entire length

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of seams to ensure mortar tightness when using two-part sheathing. The sheathing and tape must not react with concrete, coating, steel, or FRP components.

Slit tubular sheathing may be used to repair minor defects such as breakages or punctures in non-slit tubular sheathing, rectifying an improperly debonded strand, or incorrect debonded length of a strand. Tape the entire length of the slit tubular sheathing seam and tie the ends to ensure mortar tightness.

450-8 Tensioning Equipment and Operations.

450-8.1 Equipment: Use a hydraulic jacking system that is adjustable to the automatic application and sustaining of a predetermined load, together with a pressure transducer or load cell built into the hydraulic system. Connect such pressure gage or transducer to a dial or digital readout and printer (manual recording of the tensioning operations is permitted) which will provide an instantaneous readout and record of the applied load in pounds. Use a jacking system with the capacity to induce the required load. Base the use of this system on demonstrated accuracy and repeatability of plus or minus 2% of anticipated load verified through comparison with loads indicated by an independent load cell.

Calibrate all jacking systems before using and repeat calibration at intervals not exceeding 12 months. Calibrate and recalibrate in accordance with the equipment manufacturer's recommendations, by qualified calibration agency or by plant personnel under the supervision of a Specialty Engineer.

Calibrate gages, jacks and pumps as a system in the same manner they are used in tensioning operations with the cylinder extension in the approximate position that it will be in actual use at final jacking force. In multi-strand tensioning systems, gages may be calibrated against a master gage of known accuracy, provided that the other units of the system are calibrated against the same master gage. Ensure calibrations cover the load ranges that will be used during production. Verify the accuracy setting of the automatic cutoff valves by running the desired cutoff load. Ensure a certified calibration curve accompanies each tensioning system. Load readings can be used directly if the calibration determines a reading is within plus or minus 2% tolerance of anticipated load. Ensure calibration of load cells or proving rings used to calibrate jacking systems are on compression force testing equipment that has been calibrated in accordance with ASTM E74.

When any jack or gage appears to be giving erratic results, or if the jack force and elongation do not compare within specified limits and differences cannot be justified while work is in progress, recalibrate the equipment. Also verify the accuracy of the equipment after internal jacking system repairs or when gage and jacking units are switched.

Calibrate or recalibrate in accordance with ASTM E4 using equipment that is calibrated in accordance with ASTM E74. After calibration or recalibration is completed, prepare a certificate and have it signed by the person responsible for the verifications as outlined in ASTM E4 and ASTM E74. Ensure that the calibration report includes, the serial number of the equipment that is calibrated, calibration chart in a graph or tabular form, calibration date, temperature, full range of readings before and after calibration, National Institute of Standards and Technology's (NIST's) traceable number of calibration device, method of calibration, calibration agency, and laboratory or Engineer supervising the calibration.

Verify the accuracy of the jacking and recording system a minimum of once each week during tensioning operations by either an independently calibrated load cell, or by comparison with calculated strand elongation. When weekly verification is to be performed by comparison with calculated strand elongation, check a minimum of ten strands and the difference

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in the indicated load and the load determined from the elongation must agree within 5% of the computed theoretical load values. If the differences are greater than 5%, suspend the tensioning operation, evaluate the tensioning operation by qualified personnel, and correct any deficiencies before proceeding.

When weekly verification is done by load cell, perform a minimum of five spot checks to the maximum anticipated load. Use a load cell or proving ring calibrated in accordance with ASTM E74 and the accuracy of the force must be traceable to NIST. Maintain records of readings obtained from the force recording system and verifying standard. Ensure the weekly verification record includes the serial number of the equipment, verification date, verification agency, NIST traceable number of calibration standard, and name of the person making the spot checks. The load reading from the recording system must agree within plus or minus 2% of the anticipated load indicated by the load cell or proving ring that are calibrated annually.

450-8.2 Operations:

450-8.2.1 General: The tensioning operations consist of the application of the final force or load required by the Plans and with adjustments for abutment rotation, bed shortening, anchorage header movement, live end seating, dead end seating, splice chuck seating, friction in the jacking system and any other elements as applicable for the type of bed and anchorage used. Also, adjust the force when the temperature differential between the ambient temperature at time of stressing and the expected concrete temperature at time of placement is greater than 25ºF. Increase the force at the rate of 1% for each 10ºF increment that the ambient temperature at time of stressing is below the expected concrete temperature at time of placing. Decrease the force at the rate of 1% for each 10ºF that the ambient temperature at time of stressing is above the expected concrete temperature at the time of placing. Do not allow the stress in the steel prestressing strand to exceed 80% of the specified tensile strength of the strand, after seating. Do not allow the stress in the CFRP prestressing strand to exceed 70% of the specified tensile strength of the strand, after seating. During each tensioning operation, for the verification of the live and dead end seating, check the seating of at least 4 strands or a minimum of 10% of the total number of strands, whichever is greater. Maintain a record of the tensioning operation.

Compensation for temperature differential and abutment rotation are not required for self-stressing beds. However, adjust the final load for the effects of bed shortening due to the load from all the strands.

If the placement of concrete is delayed for more than seven calendar days after the completion of the stressing operation, check and adjust the final strand load as necessary before placement of concrete and maintain a record of the stressing operation.

Accomplish tensioning by either single strand tensioning or multiple strand tensioning, and ensure that it is symmetrical about the vertical axis of the product. Tensioning methods, in general, consist of tensioning to the required loads indicated by the jacking system, or tensioning to the required load while monitoring the elongation of the prestressing strand.

Production personnel will perform tensioning operations under supervision of a QC Inspector/Technician in accordance with Section 105 for prestressed concrete plant quality control personnel, or certified personnel may perform tensioning operations directly.

450-8.2.2 Single Straight Strand Tensioning: Apply an initial force of 5% to 25% of the final force to eliminate slack in the system. When single straight strand tensioning is

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used, tension the prestressing strand until the required final force is attained. Measure and record the force and elongation.

450-8.2.3 Multiple Straight Strand Tensioning: Apply the initial uniform tensioning load to each individual strand before the application of full tensioning load to the group of strands. The amount of the initial load will be influenced by the length of the casting bed and the size of strands in the group to be tensioned. The minimum initial tensioning load will be 5% of the required final load. Increase the magnitude of this load if deemed necessary but do not allow it to exceed 25% of the required final load. Then tension the strands by multiple strand tensioning to final load by pulling to elongation and checking against the jack load. Allow the required elongation to control the tensioning. The actual jack load must agree within 5% of the required load.

For uniform application of load to strands, the face of anchorage at final load must be in a plane parallel to its position under initial load. Verify this by measurement of movement on opposite sides of the anchorage and check its plumb position before and after application of the final load. During tensioning, allow the anchorage to move without restraint.

450-8.2.4 Draped Strand Tensioning: Tension draped strands by either partial tensioning and subsequent strains or by final tensioning in draped position.

Partial stressing and subsequent strains applies when the strands are tensioned through a combination of applied jack loads and strand uplift. To verify the final force, place a load cell between the tensioning anchorage and anchor chucks at the dead end on at least two draped strands. Other methods as approved by the Engineer may be used to verify the final force in the dead end. Apply an initial force of 5% to 25% of the final force to eliminate slack in the system. After application of the initial force, establish reference marks for measuring elongation. Apply a pre-calculated jacking force and measure elongations on a minimum of four strands. The average measured elongation must agree within 5% of the theoretical elongation for strand force measured by jack load, or the factors contributing to the difference must be identified and corrected before proceeding. Allow the load indicated by the jacking system to control the tensioning for the pre-calculated load. Obtain the required final force by lifting or depressing the strand simultaneously at all pickup or hold down points or in an approved sequence as shown on the shop drawings. On each different bed setup, after lifting or depressing the strands to their final position, check the final force at the dead end of at least two strands on the bed. If the load is below the required tensioning force by more than 5%, adjust it to the final load.

When the final stressing is performed in the draped position, apply the tensioning load in two increments with the strands being held in their draped positions. To verify the final force, place a load cell between the tensioning anchorage and anchor chucks at the dead end on at least two draped strands. Other methods as approved by the Engineer may be used to verify the final force in the dead end. Bring each strand to an initial tension of 5% to 25% of the final load before the application of the required final load. After application of the initial load, establish reference marks for measuring elongation. Then tension the strands to final load and measure the elongation. Allow the load indicated by the jacking system to control the tensioning for the initial and final loads. The measured elongation must agree within 5% of the theoretical elongation for the strand force measured by jack load, or the factors contributing to the difference must be identified and corrected before proceeding. When the jacking is performed at one end of the bed, check the applied load on two draped strands at the other end of the bed. If

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the load on the end opposite the jacking end is below the required value by more than 5%, adjust the load to the required final load.

450-8.2.5 Wire Breakage:

450-8.2.5.1 Steel Prestressing Strand: Limit wire breakage to 2% of the total area of the strands in any product and verify that breakage is not indicative of a more extensive distress condition, otherwise reject the defective strand. Replace individual strands with more than one wire failure.

450-8.2.5.2 Fiber Reinforced Polymer (FRP) Prestressing Strand: Replace individual strands with any wire failure.

450-8.2.6 Position of Prestressing Strand: Position prestressing strand as shown in the Plans within the tolerances allowed in 450-2.3. Fix the required vertical and horizontal position of each prestressing strand at the ends of each product and at intervals within each product not exceeding 30 feet. Use the method of fixing the prestressing strand shown in the Producer QC Plan. When blocks are to be used for supporting prestressing strand, use those cast from concrete of the same concrete class or higher as used in the prestressed product. When the product's mix design requires a highly reactive pozzolan, use blocks cast from concrete of the same mix design. Stagger the location of blocks with an offset of 12 inches or greater and do not stack them.

450-9 Placement of Reinforcing Bars and Other Embedded Materials.

450-9.1 Reinforcing Bars and Supports: Tie and/or support in position all reinforcing steel in each product with other reinforcing bars in a manner that will accurately position the reinforcing bars throughout the fabrication process. Use types of ties and methods of tying recommended by the CRSI, including lacing. Do not tie reinforcing bars to debonded prestressing strands within the limits of the sheathing material.

Tie or lace beam stirrup bars at a minimum of three points. Tie reinforcing bars, other than stirrup bars in beam ends, at a minimum of every other intersection. Either tie or lace spirals in piling at all four corners in the 1 inch pitch area, at the top corners and bottom center in the 3 inch pitch area, and at the top corners in the center area. Tie the bottom center in the pile center area as necessary to maintain concrete cover. Bend all ties away from the form surface to provide maximum concrete cover.

When shown in the Plans, weld reinforcing steel in accordance with the requirements of AWS Structural Welding Code D 1.4. Do not weld in the prestressing bed.

450-9.2 Other Embedded Materials:

450-9.2.1 Inserts and Lifting Devices:

450-9.2.1.1 Placement: Locate inserts and lifting devices in accordance with the tolerances listed in 450-2.3. For stainless-steel or FRP reinforced products, use only non-metallic or stainless-steel (Type 304 or 316) inserts and lifting devices.

450-9.2.1.2 Corrosion Protection: Provide corrosion protection for embedded metal lifting devices that would remain exposed after lifting operations are complete as indicated below:

1. For recessed lifting devices, backfill block-outs with a Type F epoxy compound meeting the requirements of Section 926 for a minimum distance of 2 inches beyond the perimeter of the device. If the block-out extends less than 2 inches beyond the perimeter of the device, extend the epoxy compound beyond the block-out along the concrete surface.

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2. For flush or protruding lifting devices, cut the lifting devices back to a minimum depth of 1 inch below the concrete surface and patch with a Type F epoxy compound meeting the requirements of Section 926.

If Type 304 or 316 stainless steel lifting devices are used, non-shrink grout meeting the requirements of Section 934 may be used to backfill the block-out within its limits.

For all square prestressed piling, concrete sheet piling and concrete poles, cut and patch lifting devices before transporting from the casting yard.

450-9.2.2 Placement of Bearing Assemblies: Set bearing assemblies designed to transmit reaction forces to the concrete in the position shown in the Plans. Place bearing plate assemblies or shoes which are to be cast in a product within appropriate tolerances as provided in 450-2.3. Check the assemblies for position after stripping from the forms.

450-10 Concrete Operations.

450-10.1 Temperature Restrictions:

450-10.1.1 Cold Weather Concreting: When the temperature of the surrounding air is expected to be below 40ºF within 24 hours after placing concrete, the temperature of the plastic concrete as placed must be 55ºF or greater. Maintain the temperature of the concrete after placement at or above 55ºF for the first 24 hours or until detensioning, whichever occurs first. For piles and other members with a minimum section dimension of 12 inches or more, maintain the temperature of the concrete after placement at or above 50°F for the first 24 hours or until detensioning, whichever occurs first. Make arrangements for heating, covering, insulating or housing the concrete work in advance of placement and maintain the required temperature without adversely affecting the concrete due to concentration of heat. Do not use direct fired heaters during the first 24 hours after concrete placement, unless actions are taken to prevent exposure of the concrete to exhaust gases which contain carbon dioxide. Continuously monitor the temperature of the concrete or the ambient air around the product until the product is detensioned. Monitor by the use of thermocouples located in the product cross-section or temperature recording devices located under the enclosure. Provide one thermocouple or temperature recording device for each 200 feet of bed length or part thereof. Locate the thermocouples within the products cross-section as shown in the Producer QC Plan or as approved by the Engineer. Record the monitored temperatures determined by each thermocouple. Review the recorded temperatures to ensure that they are within the specified limits. Initially calibrate recording devices or thermocouples and recalibrate them at least annually in accordance with the manufacturer’s recommendations.

450-10.1.2 Hot Weather Concreting: Meet the requirements of Section 346 for temperature requirements and special measures for mixing concrete in hot weather.

Apply mist of water to prestressing strands, steel reinforcing, FRP reinforcing, and steel forms just before placing the concrete when the hot weather concreting special measures are in effect and the temperature of steel forms or reinforcing steel is greater than 120ºF.

450-10.2 Protection of Concrete from Adverse Conditions or Weather: Have protection materials available before the concrete placement begins to cover the products in the event of rain or other adverse conditions during the placement of concrete. Protection materials may be tarps, curing blankets, or other impervious material that will not puncture when placed over protruding reinforcing and/or form elements. Include the method and materials for protection in the Producer QC Plan.

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450-10.3 Concrete Placement:

450-10.3.1 General: Check forms, reinforcing bars, prestressing strand, vent pipes, anchorages and other embedded items for compliance with the Contract Documents before placing concrete. Place concrete in accordance with 400-7, except as modified herein.

For concrete operations conducted at night, provide enough lighting to allow visual inspection of the interior of the forms during the complete concrete placement operation.

Convey concrete by the use of buckets, conveyors, pumps, troughs, or other equipment specifically designed for concrete conveyance, provided the placement method consistently produces quality concrete with no segregation or separation of the mix. Locate the concrete conveyance equipment within 12 inches of the top of the forms or surface of the concrete to minimize the free fall of the concrete.

Multiple placements may be used within a bedline, provided compliance with 450-11.1 is maintained.

450-10.3.2 Requirements for Successive Layers: Except for self-consolidating concrete (SCC), place concrete as described in 450-10.3.2.1 through 450-10.3.2.5 as shown in the Producer QC Plan or as approved in writing by the Engineer.

In any progressive concrete placement operation, do not allow the time between successive placements onto previously placed concrete to exceed 20 minutes, unless the previously placed concrete has not yet stiffened, as evidenced by the continued effective use of vibration.

450-10.3.2.1 AASHTO Type II, Florida I-Beam 36 and Double T-Beams, Piling, Slab Beams and Precast Slab Units (Except Voided Piling and Slabs): Place concrete in one or more layers or lifts. If more than one layer is used for Double T-Beams, end the first layer such that the top of the concrete is slightly below the bottom of the flange.
end the first layer such that the top of the concrete is slightly below the bottom of the flange.

450-10.3.2.2 AASHTO Type III, Type IV and Florida I-Beams 45 and 54 and Voided Units (Slabs and Piling): Place concrete in a minimum of two horizontal layers. The thickness of the first layer will be such that the top of the concrete is just above the top of the bottom flange. In voided units, end the first layer slightly above the middle height of the void.

450-10.3.2.3 All Beams 63 Inches or Deeper: Place concrete in a minimum of three horizontal layers. The thickness of the first layer will be such that the top of the concrete is slightly above the top of the bottom flange. The thickness of the second layer will be such that the top of the concrete is slightly above the bottom of the top flange.

450-10.3.2.4 Pretensioned I-Beams Containing Longitudinal Post-Tensioning Ducts: Place concrete in one continuous lift beginning in the end block zone and progressing to the other end. Do not allow the progression of the concrete placement to proceed until previously placed concrete is properly consolidated, and the rate of advancement equals the ability to fill the forms. In progression of the placement, deposit concrete within the forms on the surface of previously placed concrete.

450-10.3.2.5 Florida U-Beams: Place the concrete in Florida U-Beams in a minimum of two horizontal layers. The thickness of the first layer shall be such that the top of the concrete is above the top of the bottom flange.

450-10.4 Vibration of Concrete: Except for SCC, consolidate concrete in steel reinforced products by internal or external vibration, or combination of these methods. For SCC,

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meet the requirements of Section 8.4 of the Materials Manual for production batch verification. For CFRP strand reinforced products, use SCC without the use of vibration. If further consolidation is needed, manual rodding is permitted.

Design external form vibrators for the specific use. Design forms used in conjunction with external vibration and build them to effectively transmit vibration to the concrete mass. Mount and operate form vibrators in compliance with the vibrator manufacturer's recommendations, a copy of which must be on file at the plant. Secure vibrators to the form mounts by positive locking devices so that maximum vibration is transmitted into the form. Modify or replace external form vibrator systems that are demonstrated to be ineffective. Operate vibrators at each mount location for the time necessary for complete concrete consolidation. Do not allow progressive points of vibration to exceed twice the visually effective radius of vibration. Keep forms equipped with external vibrators clean, and free of any buildup of hardened concrete.

Ensure internal vibrators are available before concrete placement is started. Use an internal vibrator with a head of such size that proper vibration of the concrete will be secured without causing movement of the prestressing strand or reinforcing bars. The vibrating frequency range must be 8,000 to 15,000 impulses per minute. Have at least one standby vibrator available on-site. Insert the vibrator in the concrete at points spaced to ensure uniform vibration of the entire mass of the concrete. Do not allow points of insertions to be further apart than the radius over which the vibrator is visibly effective. Allow the vibrator to sink into the concrete by its own weight and penetrate into the underlying layers sufficiently so that the layers are thoroughly consolidated. After the concrete is thoroughly consolidated, slowly withdraw the vibrator to avoid formation of holes.

Revise the existing placement and consolidation procedure to improve the consolidation of the concrete, if the existing placement and consolidation procedure has produced unacceptable surface defects such as honeycombing, aggregate or mortar pockets, or excessive air bubbles.

450-10.5 Finishing:

450-10.5.1 General: When concrete incorporating silica fume is used, screed and finish with a continuous water fog mist maintained above the concrete. Do not apply the mist directly toward the concrete. A monomolecular finishing aid approved by the Engineer may be applied in accordance with the manufacturer's recommendation.

450-10.5.2 Beams: Rough float the top surface of the beam and then scrub it transversely with a coarse brush or metal tine to produce a roughened surface for bonding. For the other external surfaces of prestressed beams, unless otherwise specified, apply a General Surface Finish in accordance with 400-15.1. Remove mortar leakage and stains to produce beams with a uniform appearance.

450-10.5.3 Piling: Unless a Class 5 Applied Finish Coating is specified, apply a general surface finish as specified in Section 400 to pile surfaces, except that pointing with mortar will not be required for chips and bug holes with a depth less than 1/4 inch and a diameter of less than 3/4 inch. All other general surface finish requirements will apply, including the pointing of material form tie cavities with mortar. Surface finish deficiencies that meet the definition of noncomplying prestressed products must be corrected in accordance with 450-12. Miter or round the top corners similar to the corner radius of the pile forms. Surfaces exposed during casting must have a steel trowel finish.

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450-10.5.4 Slabs and Double-T Beams: When the Plans show the top surface of prestress slab units, slab beams, or Double T-Beams units to be the riding surface, apply a Class 4 floor finish in accordance with Section 400. When the Plans show the surface to be overlaid with asphalt or concrete, rough float the top surface and then scrub it transversely with a coarse brush to remove all laitance and to produce a roughened surface for bonding. For the other external surfaces of slabs and Double T-beams, unless otherwise specified, apply a General Surface Finish in accordance with 400-15.1.

450-10.6 Curing: Cure prestressed concrete for a minimum duration of 72 hours. If forms are loosened upon setting of concrete and/or removed before the 72 hour curing period is complete, expand the curing to cover the newly exposed surfaces by either coating with curing compound or extending the continuous moist cure area. Maintain concrete surface moisture at all times until curing is begun. If a water sheen is not present, apply supplemental moisture by misting or prevent water sheen loss on flat work by use of an evaporation retarder.

After the finishing operations have been completed and as soon as the concrete has hardened sufficiently to permit the application of curing material without marring the exposed surface, cover the exposed surfaces of all prestressed concrete products by one of the following procedures or other alternate curing methods. Alternate curing methods must be approved by the Engineer. Base alternate curing methods upon a demonstrated ability to retain surface moisture of the concrete and to control curing temperatures within acceptable limits. Discontinue use of any alternate curing method other than those included herein upon any indication of noncompliance with this Specification.

450-10.6.1 Continuous Moisture: Place burlap on the surface and keep it continuously saturated for the curing period by means of soil soakers, leaking pipes, or automatic sprinklers. Do not apply moisture manually. If side forms are removed during the curing period, extend the burlap to completely shield the sides of the product. Water flow may be metered to cycle repetitively for five minutes on and five minutes off during the 72 hour curing period. When it is not practical to apply moisture or curing compound inside the voided piles, cover their ends with wet burlap to prevent moisture loss.

450-10.6.2 Membrane Curing Compound: Apply a Type 2 white pigmented curing compound to all surfaces in a single-coat, continuous operation, at a uniform coverage as recommended by the manufacturer but not less than 1 gallon per 150 square feet. Apply the curing compound on the concrete surfaces that are still damp but have no free standing water. Allow surfaces covered by the membrane curing compound to remain undisturbed for the curing period. Recoat any cracks or other defects in the membrane seal which are detected during the curing period upon discovery.

If side forms are loosened during the curing period, remove them at that time and immediately coat the formed surfaces with either a Type 1 clear, or Type 2 white pigmented membrane curing compound. Maintain the surface seal for the remainder of the curing period. Bottom surfaces must be similarly coated after removal of the forms. Remove membrane curing compound to applied surfaces of concrete products to which other concrete is to be bonded by sandblasting or water-blasting until all traces of membrane curing compound are removed.

When the curing compound is applied by spraying, use a compressor driven sprayer of sufficient size to provide uniform spray at the nozzle. Keep all nozzles clean to ensure a uniform application of compound. For compressor driven sprayers, provide a calibrated reservoir which will allow the quantity of applied materials to be accurately determined.

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Maintain standby equipment in case of mechanical failure. If a mechanical failure occurs, a hand held pump-up sprayer may be used to apply curing compound to the remainder of the products cast in the day's production. Suspend additional concrete placements until the mechanical sprayer is functioning properly.

450-10.6.3 Curing Blankets: Curing blankets may be used for curing the top surfaces of products. Do not use curing blankets which are torn or punctured. Securely fasten edges to provide as tight a seal as practical. Allow curing blankets to remain in place for the curing period. Should the system fail to maintain a moist condition on the concrete surface, discontinue the use of curing blankets and take immediate corrective action to prevent further loss of concrete moisture.

450-10.7 Accelerated Curing:

450-10.7.1 General: Use low-pressure steam curing, radiant heat curing or continuous moisture and heat curing. Submit steam and/or radiant heat curing procedures for CFRP strand products for approval. If accelerated curing is completed before the curing period has elapsed, continue curing for the remaining part of the curing period in accordance with one of the curing methods above.

If accelerated curing is used, furnish and use temperature recording devices that will provide accurate, continuous, and permanent records of the time and temperature relationship of the enclosure and concrete throughout the entire curing period. Place the temperature recording sensors at a minimum of two locations, spaced approximately at or near the third point of bed length, to measure the temperatures of the enclosure and concrete. Initially calibrate recording thermometers and recalibrate them at least annually in accordance with manufacturer's recommendations. Place the sensors at the center of gravity of the bottom flanges for beams. Place the sensors at the center of gravity of the cross sections perpendicular to the length for solid piles or poles, and at the midpoint of the wall thickness for voided piles or poles.

When the ambient air temperature is equal to or higher than 50ºF, start the accelerated curing by supplying or retaining moisture and the application of the heat, following the initial set period of concrete. Determine the initial set time in accordance with ASTM C403. During the application of heat, do not allow the temperature rise in the concrete product to exceed 36ºF per hour. The maximum curing temperature of the enclosure or concrete must not exceed 150ºF. Maintain the maximum curing temperature uniform throughout the enclosure, with variation of not more than 20ºF from the maximum peak temperature until concrete reaches the required release strength. Allow the concrete element to cool gradually at the maximum cooling rate of 50ºF per hour and continue the cooling at this rate until the concrete temperature is 40ºF or less above the ambient temperature outside the curing enclosure.

When the ambient air temperature is below 50ºF cure the concrete in two stages. Start the accelerated curing of the first stage during the preset period by applying heat to increase the temperature of concrete at the maximum rate of 10ºF per hour. The total temperature gain of concrete during the initial set period cannot exceed 40ºF higher than the placement temperature, or 104ºF, whichever is less. Upon obtaining the initial set, continue curing as stated above for ambient temperature of 50ºF or higher. To prevent moisture loss on exposed surfaces during the preheating period, cover products as soon as possible after casting or keep the exposed surfaces wet by misting or wet blankets. Use enclosures for heat curing that allow free circulation of heat about the product and that are constructed to contain the heat with minimum moisture loss. The use of tarpaulins or similar flexible covers may be used provided they are kept

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in good repair and secured in such a manner to prevent the loss of heat and moisture. Use enclosures that cover the entire bed from stressing abutment to stressing abutment, including all exposed stranding, except when using CFRP strands. When using CFRP strands, follow the manufacturer's instructions.

450-10.7.2 Low-Pressure Steam: The steam must be in a saturated condition. Do not allow steam jets to impinge directly on the concrete, test cylinders, or forms. Cover control cylinders to prevent moisture loss and place them in a location where the temperature is representative of the average temperature of the enclosure.

450-10.7.3 Curing with Radiant Heat: Apply radiant heat by means of pipe circulating steam, hot oil or hot water, or by electric heating elements. To prevent moisture loss during curing, keep the exposed surfaces wet by misting or wet blankets.

450-10.7.4 Continuous Moisture and Heat: This method consists of heating the casting beds in combination with the continuous moisture method described above. Do not allow the heating elements to come in direct contact with the concrete or the forms. The initial covering of burlap and the continuous application of moisture will be as described in 450-10.6.1. An auxiliary cover in addition to the burlap for retention of the heat will be required over the entire casting bed. Support this cover a sufficient distance above the product being cured to allow circulation of the heat.

450-10.8 Curing Requirements for Silica Fume Concrete: Use either a 72 hour continuous moisture curing or a (12-24) hour low-pressure steam curing in accordance with 450-10.7. Upon completion of the low-pressure steam curing, continue curing for the remaining part of the 72 hour curing period by application of the curing compound, continuous moisture curing, or use of the curing blankets.

If 72 hour continuous moisture is used, begin curing silica fume concrete immediately after the finishing operation is complete and keep a film of water on the surface by misting until the curing blankets are in place. No substitution of alternative methods nor reduction in the time period is allowed. After completion of the 72 hour curing period, apply a membrane curing compound to all concrete surfaces. Apply curing compound according to 450-10.6.

450-10.9 Form Removal: Do not remove forms sooner than six hours after casting and not until the concrete strength is sufficient to avoid structural damage. For AASHTO Type V, Type VI, Florida I-Beams, and Bulb I-Beams, do not remove the forms supporting the top flange concrete sooner than 12 hours after casting unless the release strength has been reached.

450-11 Detensioning.

450-11.1 General: The required concrete strength at which the prestressing force may be transferred to the concrete in a product will be a minimum of 4,000 psi, unless specified otherwise in the Plans. Verify the release strength by compressive strength cylinder tests or other approved means, no later than 24 hours after casting and every 24 hours thereafter until release strength is developed.

In lieu of every 24 hour testing, estimate the strength development of concrete using the maturity method in accordance with ASTM C1074, the pulse velocity method in accordance with ASTM C597, or any other nondestructive test method acceptable to the Engineer, until the time of the detensioning.

Before detensioning, verify the concrete release strength by testing the compressive strength test cylinders. Make a minimum of two compressive strength release test cylinders daily for each individual mix or for each LOT, or fraction thereof, of a given concrete

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mix design where the daily consumption exceeds this volume or when non-continuous batching or dissimilar curing is used. The release strength test, representing the LOT, is the average compressive strength of two test cylinders, cured under conditions similar to the product or match-cured test specimens, which are match cured until the time of release.

For products cured using accelerated curing, release the prestressing force immediately after terminating the accelerated curing process. After the detensioning operation is completed, continue to 72 hour curing period using one of the methods listed in 450-10.6. For products cured using methods other than accelerated curing, release the prestressing force within a detensioning time limit, not to exceed five calendar days after the verification of release strength by compressive strength cylinder test or other approved strength gain monitoring system.

For all products in a casting line, use the same test method for determining their release strengths. Ensure the detensioning time limit is included in the Producer QC Plan. Cure concrete cylinders used for detensioning strength tests in the same manner and location as the prestressed concrete products they represent.

For I-Beams, when side forms are loosened upon setting of concrete or removed before the 72 hour curing period is complete, the top flange dormant strands may be released after the concrete reaches a compressive strength of 2,000 psi.

Production personnel will perform detensioning operations under the supervision of a QC Inspector/Technician in accordance with Section 105 for prestressed plant quality control personnel, or certified personnel may perform detensioning operations directly.

450-11.2 Method of Stress Transfer: In all detensioning operations, keep the prestressing forces nearly symmetrical about the vertical axis of the product and apply them in a manner that will minimize sudden shock or loading. Remove or loosen forms, ties, inserts, or other devices that would restrict longitudinal movement of the products along the bed. Release hold-downs for products with draped strands in a sequence as shown in the Plans or Producer QC Plan. Cut dormant strands (partially tensioned strands) before releasing any fully tensioned strands. Release fully bonded strands next, beginning with the lowest row and moving upwards, followed progressively by strands having the minimum length of tubular sheathing through to those strands having the maximum length of tubular sheathing.

Transfer prestressing forces to the concrete by either single strand release or multiple strand release.

450-11.3 Single Strand Detensioning: Detension the strand by using a low-oxygen flame in accordance with a pattern and schedule provided in the approved shop drawings, or Producer QC Plan, or described in 450-5. Heat with a low-oxygen flame played along the strand for a minimum of 5 inches. Heat strands in such a manner that the failure of the first wire in each strand will occur after the torch has been applied for a minimum of five seconds.

Release strands in all prestressed products simultaneously and symmetrically about the vertical axis at both ends of the bed and at all intermediate points between products to minimize sliding of products. Strands in piles, sheet piles, slabs, and AASHTO Type II Beams may be detensioned at the intermediate areas after detensioning both ends.

For CFRP strands coupled with steel strands, detension the steel strands first using the flame cutting process described above. At intermediate locations where CFRP strands are continuous between adjacent precast components, flame or shear cutting of the strands is not allowed.

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450-11.4 Multiple Strand Detensioning: In this method, detension all strands simultaneously by hydraulic dejacking. The total force is taken from the header by the jack, then released gradually. Do not allow the overstress required to loosen the anchoring devices at the header to exceed the force in the strand by 5%. After detensioning, strands at all points may be cut progressively from one end of the bed to the other using equipment and methods described above.

450-11.5 Cutting Strands and Bars: Upon completion of the detensioning operation, cut steel strands to required length, using an oxygen flame or mechanical cutting device. Do not use electric arc welders to cut bars or steel strands. Upon completion of the detensioning operation, cut CFRP strands to the required length using a mechanical cutting device. Do not use flame or shear cutting to cut CFRP strands.

450-11.5.1 Beams: For beam ends that will be permanently encased in concrete diaphragms, cut strands to 2.5 inches plus or minus 0.5 inch beyond the end of the product or as specified in the Plans. For beams with ends that will not be encased in permanent concrete diaphragms, mechanically cut strands a minimum of 1/8 inch below the concrete surface.

450-11.5.2 Piles: Mechanically cut strands flush with the concrete surface. For top (head) of fender piles and pile ends not embedded under final conditions, burn the strands a minimum of 1 inch below the concrete surface and clearly mark the pile to identify the top (head) end.

450-11.5.3 Poles: Mechanically cut strands to a minimum of 1/8 inch below the concrete surface.

450-11.6 Protecting Ends of Strands: Prepare the concrete surfaces and apply Type F-1 epoxy in accordance with the manufacturer's recommendations.

450-11.6.1 Beam Ends that will not be Permanently Encased in Concrete Diaphragms:

1. Remove any corrosion product from all accessible surfaces at the cut end of the strands.

2. Apply two layers of epoxy to the exposed beam ends (including clipped and chamfered surfaces) at the applicable time frame below:

a. For beams without debonded strands, at least 3 calendar days prior to shipping but no later than 50 calendar days after detensioning.

b. For beams with debonded strands, at least 3 calendar days prior to shipping, or between 42 and 50 calendar days after detensioning, whichever occurs first.

3. As an option to item 2b, the epoxy may be applied in two steps as follows:

a. To the upper area of the beam end within 4 inches of the outer stands of the bottom strand group any time after detensioning.

b. To the remaining area that includes the bottom strand group between 42 and 50 calendar days after detensioning. Ensure that the entire beam end is fully coated at least 3 calendar days prior to shipping.

Ensure that the first epoxy layer is cured before applying the second layer. The finished thickness of the epoxy coating must be a minimum of 1/16 inch and form a vertical flat plane without deviations or localized depressions from recessed strands or other defects.

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Ensure that the epoxy coating is cured per the manufacturer's recommendations prior to shipping the products.

Any modifications to the time limits above must be approved by the Engineer.

450-11.6.2 Beam Ends that will be Permanently Encased in Concrete Diaphragms:

1. Cut the strands in accordance with 450-11.5.1.
2. Seal openings between strand and sheathing for debonded strands with 100% silicone sealant within fourteen calendar days of detensioning, and cure per the manufacturer's recommendations.

450-11.6. 3 Piles: Apply epoxy patches to all recessed strands.

450-11.6. 4 Poles: Coat entire face of tip (top) and butt (bottom) ends with epoxy.

450-12 Noncomplying Prestressed Products.

450-12.1 General: When a precast prestressed concrete product does not comply with the requirements of this Section or is damaged, use the following provisions for evaluating and dispositioning of deficiencies. However, when precast prestressed concrete products have been installed, the disposition of concrete cracks shall be in accordance with Section 400. Apply these provisions in all cases that clearly fall under the circumstances described in Section 400. Consider situations not covered by these specific circumstances on their individual merits. Consider and apply the following where practical.

Make all major repairs that require a repair proposal under the observation and the satisfaction of the QC Manager or designee.

450-12.2 Identification of Defects: The QC Manager, or QC inspectors under direction of the QC Manager, will examine all deficiencies within the time limit specified in 450-2.3 and 450-2.4, to determine the applicable provisions and requirements of this Article and which course of action is appropriate.

1. If the QC Manager or designee determines that a deficiency is a cosmetic or minor defect, as stated 450-12.3, appropriate repairs may be executed in accordance with 450-13.
2. If the deficiency is major as defined in this Section, and is repairable for acceptance, submit a completed Noncomplying Prestressed/Precast Concrete Component Data Sheet (Form No. 700-030-10) to the Engineer within 30 days of the defect identification.

Submit an Engineering Analysis Scope in accordance with 6-4 for approval, to address the deficiency. A previously approved Engineering Analysis Report (EAR) may not be applied to a current major repair without the approval from the original engineer who signed and sealed the previously approved EAR.

Make major repairs under the observation of and to the satisfaction of the QC Manager. The Engineer reserves the right to witness the repairs.

The disposition of deficiencies and repair methods provided herein must at no time, and under no circumstances, be used as an excuse for or applied in such a manner so as to relieve the Contractor of his responsibility for QC. The number and type of deficiencies evaluated under this Specification will, however, be used in evaluating the Contractor's QC.

The Engineer may require a credit on any products with deficiencies that require an EAR and are accepted for use in the structure. Bear the costs of repairs and any actions taken to rectify deficiencies at no expense to the Department.

450-12.3 Common Defects in Precast Prestressed Concrete Products:

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450-12.3.1 Surface Deficiencies: Surface deficiencies are defined below and include spalls, chips, bug holes, surface porosities, honeycombs, and shallow surface cracks.

Regardless of the types of deficiencies, when the total surface area of all deficiencies within a single product exceeds 1.0% of the product's area that will be exposed to the environment, the deficiencies are considered major.

450-12.3.1.1 Bug Hole: A bug hole is a void caused by air that is entrapped against the form and that has an area up to 3.0 square inches and a depth up to 1.5 inches. Treat any bug hole with a dimension exceeding either of these dimensions as a honeycomb. The Engineer will not require repair of any bug hole with a depth less than 0.25 inch and less than 0.75 inch in diameter, unless otherwise indicated in the Plans or Specifications.

450-12.3.1.2 Spall: A spall is a depression resulting when a fragment is detached from a larger mass by impact, action of weather, by pressure or by expansion within the larger mass.

A cosmetic spall is a circular or oval depression not greater than 1.0 inch in depth nor greater than 3.0 square inches in area, and must be repaired in accordance with 450-13.2.

With the exception of spalls in the bearing areas and edges of the top flange, a minor spall is defined as a spall not larger than 2.0 square feet and no deeper than one inch plus the sum of the concrete cover and the diameter of the bar in the first layer of reinforcing. Repair minor spalls in accordance with 450-13.4.

Repair cosmetic and minor spalls as described above, except for spalls with visually exposed reinforcing steel, prestressing strand, inserts, or weldment surfaces, which require repair in accordance with 450-13.5

Spalls located at the edges of the top flange are considered minor spalls as follows:

1. A spall on one edge of the top flange, without a coincident spall on the other edge of the top flange, is considered a minor spall if the total longitudinal length of the defect does not exceed 10 feet and any lateral dimensions of the spall measured perpendicular to the longitudinal axis of the beam are not greater than 25% of the width of the top flange.

2. Coincident spalls on opposite edges of the top flange are considered minor spalls if the total length of the defects within both spalls does not exceed 10 feet and any lateral dimensions of the spalls at a given location measured perpendicular to the longitudinal axis of the beam are not greater than 25% of the width of the top flange.

Spalls are considered major when they are located in the extended bearing area of the beams as defined in 450-12.3.5, or if any depression exceeds the dimensions that are described for minor spalls.

450-12.3.1.3 Chip: A chip is the local breaking of the corners or edges of the concrete with the resulting void containing angular surfaces. Repair chips in accordance with 450-12.3.1.2.

450-12.3.1.4 Surface Porosity: Surface porosity is considered a minor defect and is the localized porosity of a formed surface due to medium scaling. Medium scaling is defined as the loss of surface mortar up to 3/8 inch in depth and exposure of concrete aggregate. Repair surface porosity in accordance with 450-13.3.

450-12.3.1.5 Honeycombing: Honeycombing is voids in the concrete, loss of fines or other material from between the aggregate particles, the inclusion of air pockets

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between aggregate particles, or larger volumes of lost material. Remove honeycombing in its entirety to sound concrete before establishing the classification of the defect.

Minor honeycombing is a void no deeper than concrete cover and no larger than 2.0 square feet in area after the removal of unsound material. Repair minor honeycombing in accordance with 450-13.6.

Major honeycombing is a void deeper than concrete cover regardless of the surface area, or shallower but with a surface area greater than 2.0 square feet that results after the removal of unsound material.

450-12.3.1.6 Shallow Surface Cracks: Shallow surface cracks are considered a minor defect, and are defined as the separation of the formed or finished surface up to 0.25 inch in depth.

Remove the affected material and repair the surface in accordance with 450-13.3.

450-12.3.2 Segregated Appearance in Hardened Concrete: Segregation of hardened concrete is considered a major defect. When hardened concrete segregation is evident, evaluate in accordance with FM 5-617.

450-12.3.3 Cold Joints: A cold joint is a plane of weakness in concrete caused by a batch of concrete setting before the next batch is added, so that the two batches fail to bond. A cold joint is considered a major defect and requires an EAR.

450-12.3.4 Formed Surface Misshaping: Formed surface misshaping is the visual and measurable deficiency or excess of material from the specified tolerance on any surface of a product.

1. Pile Ends: Make square pile ends which are outside this Section's tolerances by grinding in accordance with 450-13.7, or any other means of removal as approved by the Engineer. Reshape the chamfer if more than 0.25 inch from the cast pile end is removed and such removal affects the chamfer dimension.

2. Pile Chamfers**:** Reshape chamfers outside of this Section's tolerances to within the tolerances in accordance with 450-13.7.

3. Other Surfaces: Any deficiency exceeding the plan dimensions for size, length, squareness, designated skew, plumbness, and the like by up to twice the specified plus (+) tolerance may be corrected by grinding to within the allowable tolerance in accordance with 450-13.7. Any deficiency exceeding the specified minus (-) tolerance or twice the specified plus (+) tolerance will be considered major.

450-12.3.5 Bearing Area Flaws: Consider the bearing area to extend from the end of the product to 3 inches beyond the edge of the bearing contact area for the full product width.

Do not allow the bearing plate or bearing area plane of precast prestressed concrete beam and slab units to deviate from a true plane by more than 1/8 inch when tested in all directions with a steel straightedge. In the event that a 100% true plane is not achieved, the Engineer will accept a surface having not less than 80% of its area in a true plane provided the deviations are evenly distributed. Remove minor convex projections by grinding with an abrasive stone. The Engineer will accept minor depressions, provided that they amount to not more than 20% of the bearing area, are evenly distributed over the entire bearing area, and are not deeper than 1/8 inch.

450-12.3.6 Cracks: A crack may appear before or after detensioning and may or may not cause separation throughout the product thickness or depth. Identify cracks by the

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classifications and locations described below and subject them to the disposition required by the identified crack.

If the total surface length of all cracks within a single product, regardless of their width and depth, located between the end zones exceeds one-quarter of the product's length, the cracks are considered major. Establish crack sizes subsequent to release of all pretensioning forces.

The Engineer will reject any pile that is cracked to the point that a transverse or longitudinal crack extends through the pile, shows failure of the concrete as indicated by spalling of concrete on the main body of the pile adjacent to the crack, or which in the opinion of the Engineer will not withstand driving stresses. Occasional hairline surface cracking caused by shrinkage or tensile stress in the concrete from handling will not be cause for rejection.

450-12.3.6.1 Locations of Cracks: Regardless of cause and for the purposes of this Specification, cracks will be identified as occurring in either critical or non-critical locations of the product in accordance with the following criteria and conditions:

450-12.3.6.1.1 Critical Location Cracks: Critical locations of cracks are any locations in which a crack would tend to open under stresses occurring at any time during the service life of the structure, or which may reduce the ultimate capacity or fatigue life of the product. Specifically, critical locations of cracks are any locations in a product not defined and not included in 450-12.3.6.1.2 as non-critical. Cracks in critical locations require engineering evaluation and disposition in accordance with 450-12.

450-12.3.6.1.2 Non-Critical Location Cracks: Non-critical locations of cracks are defined by the position within a product's length, the position within a product's depth, and the orientation of the crack.

1. Piles**:** Surface cracks in any direction and of a length not exceeding twice the width of the pile.

2. Simple Span Pretensioned Concrete Beams: End zones (within a distance of three times the depth of the product from the end):

a. Horizontal or diagonal cracks at either or both ends in the top flange and web of the product, not in the plane of nor intersecting any row of prestressing strands, and extending from the end of the product for a length not to exceed the product's depth.

b. Vertical cracks extending through the top flange not to exceed one-half of the product's depth after detensioning.

c. Mid-span region (between end zones): Vertical cracks extending through the top flange and web of the product.

d. Any Location: Horizontal crack at the interface of the web and top flange which is not longer than the product's depth.

e. Intermediate diaphragms of Florida U-Beams: cracks at any location.

3. Simple Span Double T-Beams:

a. End zones (within a distance of twice the depth of the product from the end): One horizontal crack at either or both ends and in the top flange of the product, not in the plane of nor intersecting any row of prestressing strands, and extending from the end of the product for a length not to exceed half the product's depth.

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b. Mid-span Region (between end zones): Vertical cracks extending through the top flange and not exceeding half the web depth of the product.

c. Any Location: Horizontal crack at the interface of the web and top flange which is not longer than the product's depth.

4. Pretensioned I-Beams Containing Longitudinal Post-Tensioning Ducts:

a. End zones (within a distance of twice the depth of the beam from the end): Vertical cracks in the bottom half of the beam within an end zone with no post-tensioning anchorages and where the post-tensioning ducts are located in the top of the beam at the location of a permanent substructure support. Horizontal or diagonal cracks at either or both ends in the top flange and web of the product where no post-tensioning anchorage zone is present.

b. Mid-span Region (between quarter points): Vertical cracks in the web and top flange of the beam provided the beam is to be supported at each end in its final position in the structure.

c. Any Location: Horizontal cracks not longer than the beam's depth and only at the interface of the web and top flange provided the beam is to be supported at each end in its final position in the structure.

5. Post-Tensioned Beams for Drop-In Spans:

a. Pier Sections: Horizontal or diagonal cracks at either or both ends in the top flange and web of the product.

b. Drop-In Sections: Same as simple span pretensioned concrete beams.

c. End Sections: At end of beam with post-tensioning anchorages: same as pretensioned I-Beams containing longitudinal post-tensioning ducts. At end of beam adjacent to pier sections: same as for simple span pretensioned concrete beams.

6. Simple Span Prestressed Slab Beams and Slab Units:

a. End Zones (within a distance of twice the depth of the product from the end): One horizontal crack at either or both ends in the top half of the product, which is not in the plane of nor intersecting any row of prestressing strands, and extending from the end of the product for a length not to exceed half the product's depth.

b. Any Location (after detensioning): Vertical cracks in the top half of the product's depth.

7. Pretensioned Concrete Poles:

a. Longitudinal cracks - Any location: The length of each crack must be less than twice the base width of the pole, or transverse or diagonal cracks perpendicular to or at an inclined angle to the longitudinal direction of the pole.

b. Edge cracks: Cracks exhibiting at the edge and extending across one or two adjacent planes of a square pole, less than 2.0 inches of total length across all planes.

450-12.3.6.2 Classification and Treatment of Cracks: Cracks in precast prestressed components, excluding piling, will be identified according to their width, and surface appearance, and classified as follows:

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450-12.3.6.2.1 Cosmetic Cracks: Cracks located in non-critical locations on product which are less than 0.006 inch wide. Based on the environmental classification of the site where the product will be located, treat cosmetic cracks as follows:

1. Slightly or moderately aggressive environment: Do not treat cracks.

2. Extremely aggressive environment: After detensioning, apply penetrant sealer in accordance with Section 413.

450-12.3.6.2.2 Minor Cracks: Cracks located in non-critical locations on products which are between 0.006 and 0.012 inch wide, inclusive. Based on the environmental classification of the site where the product will be located and the final elevation of the product on the site, treat minor cracks as follows:

1. Slightly aggressive environment: Do not treat the cracks.

2. Moderately aggressive environment:

a. For products that will be located at an elevation of more than 12 feet above the existing ground level or above mean high water elevation: Do not treat cracks.

b. For products that will be located at an elevation within 12 feet above the existing ground level or above mean high water elevation: Apply a penetrant sealer on the cracks after detensioning in accordance with Section 413.

3. Extremely aggressive environment:

a. For products that will be located at an elevation of more than 12 feet above the existing ground level or above mean high water elevation: Apply a penetrant sealer on the cracks after detensioning in accordance with Section 413.

b. For products that will be located at an elevation within 12 feet above the existing ground level or above mean high water elevation: Inject epoxy into the cracks after detensioning in accordance with Section 411.

450-12.3.6.2.3 Major Cracks: Cracks, regardless of environmental classification, located in critical locations on products or cracks in non-critical locations of the product that are greater than 0.012 inch wide. Major cracks are considered major defects and require an EAR in accordance with Section 6 to determine the disposition of the affected product

450-12.3.6.2.4 Cracks in the Riding Surface: Repair cosmetic and minor cracks in the top surface of components which will become the riding surface (with no overlays), once in service, regardless of the environmental classification as follows:

1. Epoxy inject cracks wider than 0.006 inch in accordance with Section 411, unless the Engineer approves the sealing of cracks with high molecular weight methacrylate in accordance with Section 413.

2. Seal cracks that are 0.006 inch wide or less by applying a penetrant sealer in accordance with Section 413.

450-13 Repair Methods and Materials.

450-13.1 General: Before beginning the repairs of bug holes, spalls, chips, surface porosity, and honeycomb, remove all laitance, loose material, form oil, curing compound and any other deleterious matter from the repair area. Repair cosmetic or minor deficiencies by methods specified herein. Submit alternative repair methods as needed.

For each project, maintain the record of deficiencies and their repair methods. Ensure the record includes information about product description, unit serial number, date cast,

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defect description including dimensions, repair method and materials, defect discovery date, and signature of producer's QC Manager indicating concurrence with the information.

Use materials for concrete repair that will meet or exceed the strength requirement of the concrete class used. Cure repaired surfaces for the full 72 hour curing time or for the curing time as recommended by the manufacturer of the repair material. Ensure the repaired surfaces have a surface texture, finish and color which matches the appearance of the unaffected surrounding area of the product.

450-13.1.1 Product Acceptance on the Project: Use only materials listed on the Approved Product List (APL), in accordance with the following Sections:

Epoxy Compounds (Type F) …….. Section 926
Materials for Concrete Repair……. Section 930
Non-shrink Grout…… Section 934

450-13.2 Cosmetic Surface Filling: Repair areas to be filled with an approved non-shrink grout or material for concrete repair. Mix, apply, and cure the material in accordance with the manufacturer's recommendations. Coating of the prepared surface with epoxy compound before placement is not required.

450-13.3 Surface Restoration: Maintain the surface continuously wet for a minimum of three hours before application of repair material. Repair areas to be restored with a mortar mix consisting by volume of one part cement, 2.5 parts sand that will pass a No. 16 sieve, and sufficient water to produce a viscous slurry mix or repair areas to be restored with an approved non-shrink grout or material for concrete repair. Mix, apply, and cure the material in accordance with the manufacturer's recommendations. Cure areas repaired with a mortar mix in accordance with 450-10.6. Coating of the prepared surface with epoxy compound before placement is not required.

450-13.4 Cutting and Filling: Carefully cut all feathered edges of the area to be repaired back perpendicular to (or slightly undercut from) the surface and to the depth of sound concrete or to a minimum depth of 1/2 inch, whichever is deeper. Coat the prepared surface with an approved epoxy bonding compound applied in accordance with the manufacturer's recommendations. Fill the cutout area with an approved non-shrink grout, material for concrete repair, or epoxy mortar. Mix, apply, and cure in accordance with the manufacturer's recommendations. Firmly consolidate the material in the cutout area.

450-13.5 Restoration of Surfaces and Edges: When reinforcement is exposed, remove concrete from around the items to provide a 1-inch clearance all around. When less than one-half the reinforcement diameter is exposed, a positive connection utilizing anchor screws may be proposed in lieu of 1-inch clearance all around. Do not damage the reinforcement. Form surfaces and edges to the original dimensions and shape of the product. Coat the prepared surface with an approved epoxy bonding compound applied in accordance with the manufacturer's recommendations. Restore surfaces and edges with an approved non-shrink grout, material for concrete repair, or epoxy mortar. Mix, apply, and cure in accordance with the manufacturer's recommendations. Firmly consolidate the material in the area to be repaired. Restore surfaces and edges to the original dimensions and shape of the product.

450-13.6 Removal and Restoration of Unsound Concrete: Carefully cut the area of unsound concrete to be repaired back perpendicular to (or slightly undercut from) the surface and to the depth of sound concrete or to a minimum depth of 1 inch, whichever is deeper. When reinforcement is exposed, remove the concrete from around the items to provide a 1-inch clearance all around. When less than one-half the reinforcement diameter is exposed, a positive

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connection utilizing anchor screws may be proposed in lieu of 1-inch clearance all around. Do not damage the reinforcement. Coat the prepared surface with an approved epoxy bonding compound applied in accordance with the manufacturer's recommendations. Fill the area to be repaired with an approved non-shrink grout, concrete repair material, or epoxy mortar. Mix, apply, and cure in accordance with the manufacturer's recommendations. Firmly consolidate the material in the area to be repaired. Restore surfaces and edges to the original dimensions and shape of the product.

450-13.7 Surface Grinding: Grind off misshaped formed surfaces with an abrasive stone. Apply two coats of penetrant sealer in accordance with the requirements of Section 413, to any surfaces which are not subsequently encased in concrete, immediately after grinding has been accepted. Do not apply a penetrant sealer to any surfaces to be subsequently encased in concrete.

450-13.8 Treatment of Cracks: Treat cracks in accordance with 450-12.3.6.

450-14 Handling, Storage, Shipping and Erection.

450-14.1 Handling: All products which are pretensioned may only be handled after transfer of the prestressing force. For products that are prestressed by a combination of pretensioning and post-tensioning do not handle before sufficient prestress has been applied to sustain all forces and bending moments due to handling. Exercise care in handling to prevent damage to products. Lift and move products so as to minimize stresses due to sudden changes in momentum.

Calculate pick up and dunnage points. Pick up products only at points designated as pickup points as shown on the Plans or shop drawings. Maintain all beams in an upright position at all times.

Evaluate the temporary stresses and stability of beams during their handling. The temporary stresses induced into the products during handling must be within the acceptable stresses at release listed in the Department's Structures Design Guidelines. Take appropriate action to increase the stability of products during handling when the factor of safety against lateral buckling instability is below 2.0. Include the expected fabrication tolerance for sweep in the analysis. The analysis procedure provided by the PCI or similar procedures may be used for the stability evaluation.

Verify lifting devices for capacity in lifting and handling products, taking into account various positions during handling. Keep multiple component lifting devices matched to avoid non-compatible use. When a product has multiple lifting devices, use lifting equipment capable of distributing the load at each device uniformly to maintain the stability of the product. When the lifting devices are grouped in multiples at one location, align them for equal lifting.

Take appropriate steps to prevent the occurrence of cracking. When cracking occurs during handling and transportation, revise handling and transporting equipment and procedures as necessary to prevent cracking for subsequent products.

450-14.2 Storage: Store precast prestressed beams, Double T-Beams, slab beams and slab units on only two points of support located within 18 inches of the end of the product or as calculated. Support skewed beams, Double T-Beams, slab beams or slab units within 18 inches of the end of the full product section or as calculated. Do not support slab beams on the outer 6 inches of the product width. Support other products on an adequate number of supports so as to keep stresses in the products within the allowable stresses at release listed in the Department's Structures Design Guidelines. Locate multiple supports (more than two) within 1/2 inch of a

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horizontal plane through the top surface of the supports. Adequately brace beams as necessary to maintain stability.

All supports must be level and on adequate foundation material that will prevent shifting or differential settlement which may cause twisting or rotation of products. Immediately pick up products in storage that have rotated or twisted and adjust the supports to provide level and uniform support for the product.

Support prestressed products that are stacked by dunnage placed across the full width of each bearing point and aligned vertically over lower supports. Move dunnage points in accordance with 450-2.3 with the approval of the QC Manager. Do not use stored products as a storage area for either shorter or longer products or heavy equipment.

Where feasible, base the selection of storage sites, storage conditions and orientation upon consideration of minimizing the thermal and time-dependent creep and shrinkage effects on the camber and/or sweep of the precast pretensioned products.

Continuous application of water during the initial 72 hour moist curing period may be interrupted for a maximum of one hour to allow relocation of precast prestressed concrete elements within the manufacturing facility. Keep the moist burlap in place during relocation of the element.

450-14.3 Shipping: Do not ship precast prestressed concrete products to the project site prior to the completion of the 72 hour curing period and attainment of the required 28-day strength. Verification of the shipping strength test, before 28 days, is permitted by testing compressive strength cylinders that are cured under the conditions similar to the product or by testing temperature match cured cylinders.

The use of maturity method, ASTM C1074, pulse velocity method in accordance with ASTM C597, or any other nondestructive test method acceptable to Engineer, is permitted to estimate the strength before its verification by test cylinders. The shipping strength test is the average compressive strength of two test cylinders. Do not ship products until accepted and stamped by the QC Manager or the inspectors under the direct observation of the QC Manager or designee.

In the case of elements repaired due to major defects, notify the Engineer at least 72 hours in advance of shipping to verify compliance with the Specification.

At the beginning of each project, provide a notarized statement to the Engineer from a responsible company representative certifying that the plant will manufacture the products in accordance with the requirements set forth in the Contract Documents and Producer QC Plan.

The QC Manager’s stamp on each product indicates certification that the product was fabricated in conformance with the Producer QC Plan, the Contract, and the Specifications. Ensure that each shipment of prestressed concrete products to the project site is accompanied with a signed or stamped delivery ticket providing the description and the list of the products.

Evaluate the temporary stresses and stability of all products during shipping and locate supports, generally within 18 inches from the beam end, in such a manner as to maintain stresses within acceptable levels. Include impact loadings in the evaluation. Do not support slab beams on the outer 6 inches of the product width.

450-14.4 Erection: Erect precast prestressed products without damage. Meet the handling and storage requirements of 450-14.1 and 450-14.2 for field operations. Before casting diaphragms and the deck slab, do not allow the horizontal alignment of prestressed concrete beams to deviate from a straight line connecting similar points of beam ends by more than the

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sweep tolerances specified in 450-2.3. Adequately brace beams as necessary to maintain stability.

450-15 Measurement and Payment.

450-15.1 General: The work specified in this Section will be measured and paid for as shown below for the particular item involved. Precast prestressed concrete members are acceptable to the Department for full payment when all requirements of the Contract Documents have been met. No partial payments will be made for precast prestressed concrete members until the 28-day strength requirement, along with other applicable Specification requirements, have been met.

450-15.2 Prestressed Concrete Piling: Payment will be made at the Contract unit price per foot for the particular type of piling, measured and paid for as specified in Section 455, including the provisions for cutoffs and splices.

450-15.3 Prestressed Concrete Beams: Payment will be made at the Contract unit price per foot for Prestressed Beams, complete in place and accepted. Final pay lengths will be plan quantity based on casting lengths, as detailed in the Plans, subject to the provisions of 9-3.2.

450-15.4 Prestressed Concrete Slab Units and Slab Beams: Payment will be made at the Contract unit price per foot for the units, complete in place and accepted. Final pay lengths will be plan quantity based on casting lengths, as detailed in the Plans, subject to the provisions of 9-3.2.

450-16 Basis of Payment.

Price and payment will be full compensation for all work and materials specified in this Section, including reinforcement, pretensioning strand, embedded ducts, hardware, inserts and other materials as required, to fabricate, transport and place the product into its permanent position in the structure.

Payment for the items will be made under the following:

Item No. 450- 1-	Prestressed Beams - per foot.
Item No. 450- 2-	Prestressed Beams: Florida I-Beams - per foot.
Item No. 450- 3-	Prestressed Slab Units - per foot.
Item No. 450- 4-	Prestressed Beam U-Beams - per foot.
Item No. 450- 8	Prestressed Beams: Florida Slab Beam – per foot.
Item No. 450- 88-	Prestressed Slab Units Transversely Post-Tensioned - per square foot.

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SECTION 451
PRESTRESSED SOIL ANCHORS

451-1 Description.

Construct prestressed soil anchors consisting of a high strength steel tendon anchored to the retaining wall on one end and to the soil on the other end through a bulb of pressure injected portland cement concrete grout. Test each anchor by prestressing to the load indicated in the Contract Documents before locking off to the retaining wall.

Select the prestressed soil anchor type and the installation method, and determine the bond length and anchor diameter. Assume responsibility for installing prestressed soil anchors that develop the load-carrying capacity indicated in the Plans in accordance with 451-7.

Provide corrosion protection for permanent prestressed soil anchors. The Engineer will not require corrosion protection for temporary prestressed soil anchors. Protect anchor tendons from corrosion as shown in the Plans in accordance with 451-8.

451-2 Definitions.

1. Anchorage Devices: The anchor head wedges or nuts which grip the prestressing steel.

2. Bearing Plate: The steel plate which distributes the prestressed soil anchor force to the structure.

3. Bond Length: The length of the prestressed soil anchor which is bonded to the ground and transmits the tensile force to the soil or rock. For a compression prestressed soil anchor, the bond length will be different from the tendon bond length.

4. Factored Design Load: The maximum anticipated load that will be applied to the prestressed soil anchor during its service life after completing stressing and testing. The factored design load includes appropriate load factors to ensure that the overall structure has adequate strength for its intended use.

5. Fine-grained Soils: Soils with at least 50% of the material smaller than the No. 200 sieve size.

6. Tendon: The complete anchor assembly, excluding grout, consisting of anchorage and prestressing steel with sheathing and coating when required.

7. Coupling: The means by which the prestressing force may be transmitted from one partial-length of prestressing tendon to another.

8. Sheathing: Enclosure around the prestressing steel to avoid temporary or permanent bond between the prestressing steel and the surrounding grout or to provide corrosion protection.

9. Coating: Material used to protect against corrosion or lubricate the prestressing steel.

10. Anchor Grout: Portland cement grout that is injected into the anchor hole to provide anchorage at the bond length of the tendon.

11. Proof Load: Temporary loading of an anchor to its factored design load for testing purposes.

12. Transfer (Lock-Off) Load: Prestressing force in an anchor after proof loading immediately after the force has been transferred from the jack to the stressing anchorage.

13. Stressing Anchorage: That portion of assembly not within the earth fill.

14. Alignment Load: A small load maintained on an anchor during testing sufficient to keep the testing equipment positioned.

15. Performance Test: Incremental test loading and unloading of a prestressed anchor recording the movement of the tendon at each increment.

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16. Proof Test: Incremental loading of a prestressed anchor recording the movement of the tendon at each increment.

17. Creep Test: A test to determine the movement of the tendon at constant load during a certain period of time.

18. Lift-Off Reading: A check made to determine that the actual transfer load is within 10% of the desired transfer load. This check is made immediately after transferring the load to the stressing anchorage.

19. Residual Movement: The non-elastic (non-recoverable) movement of an anchor measured during soil anchor testing.

20. Elastic Movement: The recoverable movement of an anchor measured during soil anchor testing.

21. Prestressed Soil Anchor: A system, referred to as a tieback or a ground anchor, used to transfer tensile loads to soil or rock. A prestressed soil anchor includes all prestressing steel, anchorage devices, bearing plates, grout, coatings, corrosion protection, sheathings and couplers if used.

22. Minimum Specified Ultimate Tensile Strength: The minimum breaking strength of the prestressing steel as defined by the specified standard.

23. Tendon Bond Length: The length of the tendon which is bonded to the anchor grout.

24. Total Anchor Length: The unbonded length plus the tendon bond length.

25. Unbonded Length: The length of the tendon which is not bonded to the grout. The grout surrounding the unbonded length is a void filler and provides corrosion protection.

26. Service Load: The load anticipated to be applied to the prestressed soil anchor during its service life after completing stressing and testing in order to limit deflection. The service load does not include load factors.

27. Test Stressing Length: The unbonded length plus the length extending through the jack up to the anchorage devices during any anchor acceptance test (i.e. Performance Test, Proof Test or Creep Test).

451-3 Qualifications.

The Contractor or subcontractor performing the work described in this Section shall have installed prestressed soil anchors for a minimum of five years. At the preconstruction conference, the Contractor shall submit a list containing at least five projects, completed within the last five years, where the Contractor has installed prestressed soil anchors. Include a brief description of each project and a reference for each project listed. As a minimum, include with the reference an individual's name and current phone number.

Prior to the start of work, the Contractor shall submit a list identifying his engineer, drill operators, and on-site supervisors who will be assigned to the project. Include in the list a summary of each individual’s experience.

Assign a Specialty Engineer to supervise the work with at least five years of experience in the design and construction of permanently-anchored structures. Do not use manufacturers' representatives in order to meet the requirements of this Section. Provide drill operators and on-site supervisors that have a minimum of one year experience installing permanent prestressed soil anchors with the Contractor’s organization.

The Engineer will approve or reject the Contractor’s qualifications and staff within 15 working days after receipt of the submission. Do not start work on any prestressed soil anchor wall system or order materials until receiving approval of the qualifications. The Engineer may suspend the prestressed soil anchor work if the Contractor or subcontractor substitutes

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unqualified personnel for approved personnel during construction. If work is suspended due to the substitution of unqualified personnel, the Contractor is fully liable for additional costs resulting from the suspension of work and the Department will not allow any adjustment in Contract Time resulting from the suspension of work.

451-4 Materials.

451-4.1 General: Meet the following requirements:

Concrete .....Section 346
Prestressed Construction.....Section 450
Structural Steel and Miscellaneous Metals .....Section 460

451-4.2 Prestressing Steel: Use prestressed soil anchor tendons fabricated from single or multiple elements of one of the following prestressing steels, unless otherwise shown in the Plans:

1. Steel bars meeting the requirements of AASHTO M 275.
2. 7-wire, low-relaxation strands meeting the requirements of AASHTO M 203.
3. “Compact” 7-wire, low-relaxation strands meeting the requirements of ASTM A779.

451-4.3 Anchorage Covers (include for temporary anchors only when shown in the Plans): Use exposed anchorage covers fabricated from steel or ductile cast iron with a minimum thickness of 0.10 inches. Ensure that the cover is securely attached to the anchorage device or bearing plate. If the cover is to be grease filled, ensure the cover forms a permanent watertight enclosure for the anchorage device.

451-4.4 Anchorage Devices: Use anchorage devices capable of developing 95% of the minimum specified ultimate tensile strength of the prestressing steel tendon. Use anchorage devices that meet the static strength requirements of Section 3.1.6(1) and Section 3.1.8(1) of the Post Tensioning Institute “Guide Specification for Post-tensioning Materials”. Use couplers for tendon sections capable of developing 95% of the minimum specified ultimate tensile strength.

451-4.5 Cement Grout: Use grout for anchorage consisting of a pumpable mixture of portland cement meeting the requirements of Section 921, sand, water, and admixtures. The Contractor may use admixtures which control bleed, improve flowability, reduce water content, and retard set in the grout subject to the approval of the Engineer. The Contractor may only add expansive admixtures to the grout used for filling sealed encapsulations, trumpets, and anchorage covers. Do not use accelerators. Use admixtures compatible with the prestressing steels and mixed in accordance with the manufacturer's recommendations.

Do not perform strength testing as system performance will be measured by proof-testing each anchor. The Department may require cylinder testing if the Contractor uses admixtures or irregularities occur in anchor testing. Cast a set of three 4 inches x 8 inches grout cylinders for each LOT in accordance with ASTM C31, except fill the cylinder molds in one layer without rodding. Use grout that attains a minimum compressive strength of 3,400 psi within seven days, when tested in accordance with ASTM C39.

451-4.6 Bearing Plate: Use bearing plates fabricated from steel meeting the requirements of AASHTO M 270 or ASTM A709.

451-4.7 Bondbreaker: Use bondbreaker fabricated from a smooth plastic tube or pipe having the following properties:

1. Resistant to chemical attack from aggressive environments, grout, or grease
2. Resistant to aging by ultra-violet light
3. Fabricated from material non-detrimental to the tendon

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4. Capable of withstanding abrasion, impact, and bending during handling and installation

5. Enable the tendon to elongate during testing and stressing

6. Allow the tendon to remain unbonded after lock-off.

451-4.8 Centralizers: Use centralizers fabricated from plastic, steel, or material that is nondetrimental to the prestressing steel. Do not use wood. Ensure that the centralizer is able to support the tendon in the drill hole, and position the tendon so a minimum of 0.5 inches of grout cover is provided over the tendon bond length. In addition, locate the upper centralizer a maximum of 5 feet from the top of the tendon bond length, and locate the lower centralizer a maximum of 12 inches from the bottom of the tendon bond length. The Engineer will not require centralizers on pressure injected tendons if the Contractor installs the anchor in coarse grained soils using grouting pressures greater than 150 psi. The Engineer will not require centralizers if the Contractor installs the anchors and grouts them through a hollow stem auger and maintains the hole full of stiff grout (slump less than 9 inches) during extraction of the auger.

451-4.9 Corrosion Inhibiting Grease (include for temporary anchors only when shown in the Plans): For corrosion inhibiting grease, meet the requirements of Section 3.2.5 of the Post Tensioning Institute Specification for Unbonded Single Strand Tendons.

451-4.10 Heat Shrinkable Tubes: Use heat shrinkable tubes fabricated from a radiation cross-linked polyolefin tube internally coated with an adhesive sealant. Prior to shrinking, ensure that the tube has a nominal wall thickness of 24 mils. Ensure that the adhesive sealant inside the tube has a nominal thickness of 20 mils.

451-4.11 Sheath (include for temporary anchors only when shown in the Plans): Use a sheath as part of the corrosion protection system for the unbonded length portion of the tendon fabricated from one of the following:

1. A polyethylene tube pulled or pushed over the prestressing steel. Use polyethylene Type II, III, or IV as defined by ASTM D1248 or approved equal, with a minimum wall thickness of 60 mils, plus or minus 10 mils.

2. A hot-melt extruded polypropylene tube. Use polypropylene cell classification PP 210 B5554211 as defined by ASTM D4101 or approved equal, with a minimum wall thickness of 60 mils, plus or minus 10 mils.

3. A hot-melt extruded polyethylene tube. Use polyethylene high density Type III as defined by ASTM D3350 and ASTM D1248 (or approved equal), with a minimum wall thickness of 60 mils, plus or minus 10 mils.

4. Steel tubing meeting the requirements of ASTM A500, with a minimum wall thickness of 0.20 inches.

5. Steel pipe meeting the requirements of ASTM A53, Schedule 40 minimum.

6. Plastic pipe meeting the requirements of ASTM D1785, Schedule 40 minimum.

7. A corrugated tube meeting the requirement of the tendon bond length encapsulation.

451-4.12 Spacers: Use spacers to separate elements of a multi-element tendon and which permit grout to flow freely up the drill hole. Use spacers fabricated from plastic, steel, or material which is nondetrimental to the prestressing steel. Do not use wood. The Contractor may use a combination centralizer-spacer.

451-4.13 Tendon Bond Length Encapsulations (include for temporary anchors only when shown in the Plans): When the Contract drawings require the tendon bond length to be

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encapsulated to provide additional corrosion protection, use encapsulation fabricated from one of the following:

1. High density corrugated polyethylene tubing meeting the requirements of AASHTO M 252, with a minimum wall thickness of 30 mils
2. Deformed steel tubing or pipes with a minimum wall thickness of 25 mils
3. Corrugated, PVC tubes manufactured from rigid PVC compounds meeting the requirements of ASTM D1784, Class 13464-B.

451-4.14 Trumpet (include for temporary anchors only when shown in the Plans): Use a trumpet to provide a transition from the anchorage to the unbonded length corrosion protection fabricated from a steel pipe or tube meeting the requirements of ASTM A53 for pipe or ASTM A500 for tubing. Use a trumpet that has a minimum wall thickness of 0.125 inches for diameters up to 4 inches and 0.20 inches for larger diameters.

451-4.15 Water: Use potable water for mixing grout.

451-4.16 Grout Tube: Use a grout tube fabricated from a high density polyethylene tube, or a PVC pipe, or a steel pipe with a 0.5 inches minimum inside diameter.

451-5 Tendon Fabrication.

Provide tendons that are either shop or field fabricated. Fabricate the tendon as shown on the approved shop drawings.

Ensure that tendons are free of dirt, rust, or any other deleterious substance. Degrease the bond length.

Handle and protect tendons, prior to installation, in a manner to avoid corrosion and physical damage. The Engineer will consider damage such as abrasion kinks, welds and weld splatters, cuts, and nicks which impair the proper performance of the tendon cause for rejection.

Sheath tendons in the stressing length to prevent contact of the anchor tendon with the drill hole wall. The Contractor may use sheathing that consists of tubes surrounding individual tendon elements or a single tube surrounding the elements altogether.

The Contractor may use sheathing material of either steel, plastic, or any other material nondetrimental to the high strength prestressing steel. The Contractor may use tape to prevent grout from entering under the sheath on individually sheathed elements.

Select the type of tendon to be used. Unless otherwise shown in the Plans, size the tendon so the factored design load does not exceed 80% of the minimum specified ultimate tensile strength of the tendon. Increase the tendon size by the sacrificial steel thickness shown in the Plans. In addition, size the tendon so the maximum test load does not exceed 90% of the minimum yield strength of the tendon.

Assume responsibility for determining the bond length necessary to develop the design load indicated in the Plans or the shop drawings. Use a minimum bond length of 10 feet in rock and 15 feet in soil. Ensure that the minimum tendon bond length is 10 feet.

451-6 Installation.

451-6.1 General:

451-6.1.1 Drilling: Core drilling, rotary drilling, percussion drilling, auger drilling, or driven casing may be used. At the ground surface, locate the drill hole within 12 inches of the location shown in the Plans or the approved shop drawings. Locate the drill hole so that the longitudinal axis of the drill hole and the longitudinal axis of the tendon are parallel. In particular, do not drill the prestressed soil anchor hole in a location that requires the tendon to be bent in order to connect the bearing plate to the supported structure. At the point of entry,

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install the prestressed soil anchor within plus or minus 3 degrees of the inclination from horizontal shown in the Plans or the approved shop drawings. At the point of entry, make the horizontal angle formed by the prestressed soil anchor and the structure to within plus or minus 3 degrees of a line drawn perpendicular to the plane of the structure unless otherwise shown in the Plans or approved shop drawings. Do not allow the prestressed soil anchors to extend beyond the right-of-way or easement limits shown in the Plans.

451-6.1.2 Tendon Insertion: Insert the tendon into the drill hole to the desired depth. When the tendon cannot be completely inserted, remove the tendon from the drill hole, and then clean or redrill the hole to permit insertion. Do not drive or force partially inserted tendons into the hole.

451-6.1.3 Installation of Trumpet and Anchorage: When corrosion protection is required, extend that portion of the corrosion protection surrounding the unbonded length of the tendon, up beyond the bottom seal of the trumpet or 12 inches into the trumpet if no trumpet seal is provided. If the protection does not extend beyond the seal or sufficiently far enough into the trumpet, extend the corrosion protection, or lengthen the trumpet.

When required, ensure that the corrosion protection surrounding the unbonded length of the tendon does not contact the bearing plate or the anchor head during testing and stressing. If the protection is too long, trim the corrosion protection to prevent contact.

Place the bearing plate and anchor head so the axis of the tendon is perpendicular to the bearing plate within plus or minus 3 degrees and the axis of the tendon passes through the center of the bearing plate.

If using grout protected tendons, electrically isolate the bearing plate, anchor head, and trumpet from the surrounding concrete, soldier pile, or any metallic element embedded in the structure.

Completely fill the trumpet with corrosion inhibiting grease or grout. Trumpet grease may be placed any time during construction. Place trumpet grout after the prestressed soil anchor has been tested and stressed. Demonstrate to the Engineer that the procedures selected for placement of either grease or grout will produce a completely filled trumpet.

For permanent soil anchors, cover all anchorages permanently exposed to the atmosphere with a corrosion inhibiting grease-filled or grout-filled cover. Demonstrate to the Engineer that the procedures selected for placement of either grease or grout will produce a completely filled cover. If the Plans require restressable anchorages, use corrosion inhibiting grease to fill the anchorage cover.

451-6.2 Anchor Grouting: Provide grouting equipment that produces a grout free of lumps and undispersed cement. Use a positive displacement grout pump equipped with a pressure gauge to monitor grout pressures. Ensure that the pressure gauge is capable of measuring pressures of at least 150 psi or twice the actual grout pressures used, whichever is greater. Size the grouting equipment to enable the grout to be pumped in one continuous operation. Ensure that the mixer is capable of continuously agitating the grout.

Inject the grout from the lowest point of the drill hole. Grout may be pumped through grout tubes, casing, hollow-stem-augers, or drill rods. The grout may be placed before or after insertion of the tendon. Record the quantity of the grout and the grout pressures. Control the grout pressures and grout takes to prevent excessive heave or fracturing.

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Except where indicated below, the grout may be placed above the top of the bond length at the same time as the bond length grout but may not be placed under pressure. Ensure that the grout at the top of the drill hole does not contact the back of the structure or the bottom of the trumpet.

If the prestressed soil anchor is installed in a fine-grained soil using drill holes larger than 6 inches in diameter, place the grout above the top of the bond length after testing and stressing the prestressed soil anchor. The Engineer will allow the entire drill hole to be grouted at the same time if it can be demonstrated that the particular prestressed soil anchor system does not derive a significant portion of its load-carrying capacity from the soil above the bond length portion of the prestressed soil anchor.

If using grout protected tendons for prestressed soil anchors anchored in rock, use pressure grouting techniques. For pressure grouting, seal the drill hole, and inject grout until a 50 psi grout pressure (measured at the top of the drill hole) can be maintained on the grout for five minutes.

Upon completion of grouting, the grout tube may remain in the hole, but it must be filled with grout.

After grouting, do not load the tendon for at least three days.

Record the following data concerning the grouting operation:

1. Type of mixer
2. Water/cement ratio
3. Types of additives (if any)
4. Grout pressure
5. Type of cement
6. Strength test samples (if any)
7. Volume of first and second stage grout

451-7 Prestressed Soil Anchor Testing and Stressing.

451-7.1 General: Test each prestressed soil anchor. The Engineer will select the prestressed soil anchors to be performance tested and those to be creep tested, and at his discretion, may increase or decrease the number of tests.

Perform creep testing and performance testing at the beginning of the anchor installation, prior to installation of the remaining soil anchors, unless directed otherwise by the Engineer. In projects with multiple anchor row levels, the Engineer may request performance and creep testing at the beginning of the installation of soil anchors for subsequent levels. The purpose of these initial tests is to verify the Contractor's installation procedures, the performance of the bond length, and the calibration of testing equipment.

Perform creep testing as follows:

1. as shown in the Plans
2. on 5% of the prestressed soil anchors.

Perform performance testing as follows:

1. as shown in the Plans
2. on 10% of the prestressed soil anchors or a minimum of three, whichever is greater.

Perform proof tests on all prestressed soil anchors, not subjected to a performance test or a creep test. Record the results of each test on form 700-020-04 Soil Anchor Forms. Submit a separate form for each test. Submit the test results to the Engineer on a weekly basis within one week of testing. Do not apply a load greater than 10% of the factored design load to

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the prestressed soil anchor prior to testing. For the maximum test load, do not exceed 90% of the minimum yield strength of the tendon. Simultaneously apply the test load to the entire tendon. Do not perform stressing of single elements of multi-element tendons.

Provide testing equipment that consists of:

1. a dial gauge or vernier scale capable of measuring to 0.001 inch to measure the ground anchor movement. Use a movement-measuring device that has a minimum travel equal to the theoretical elastic elongation of the total anchor length at the maximum test load and that has adequate travel so the prestressed soil anchor movement can be measured without resetting the device.

2. a hydraulic jack and pump to apply the test load. Use the jack, with a minimum ram travel of not less than the theoretical elastic elongation of the total anchor length at the maximum test load, and a calibrated pressure gauge, graduated in 100 psi increments or less, or calibrated load cell with readout box, to measure the applied load. Ensure that the jack and pressure gauge are calibrated by an independent firm as a unit, and that the calibration is performed within 60 calendar days of the date submitted.

3. Provide an electrical resistance load cell and readout to be used when performing a creep test. Load cell may also be used in performance and proof tests, at the Contractor's discretion. Ensure that the load cell is calibrated by an independent firm and that the calibration is performed within 60 calendar days of the date submitted. Obtain the Engineer's approval of the calibration before testing commences.

4. Keep a calibrated reference pressure gauge at the site in possession of the Engineer. Ensure that the reference gauge is calibrated with the test jack and pressure gauge.

5. Place the reference pressure gauge in series with the pressure gauge during each performance test and creep test.

6. Place the stressing equipment over the prestressed soil anchor tendon in such a manner that the jack, bearing plates, load cells and stressing anchorage are axially aligned with the tendon and the tendon is centered within the equipment.

If, during the performance of any load test (proof, performance, or creep), the load determined by the load cell or the load determined by the reference gauge differs by more than 10% from the load determined by the pressure gauge when the pressure gauge measures 80% of the Factored Design Load (0.80 DL), suspend the test, unload the anchor being tested, recalibrate the load cell, jack, pressure gauge, and reference pressure gauge, and repeat the test at no expense to the Department. Obtain the Engineer's approval of the recalibration data prior to resuming testing.

If, at any time, a pressure gauge, reference pressure gauge, or load cell is repaired or replaced, obtain the Engineer's written approval of calibration data of the repaired or the new measuring device (load cell or pressure gauge, or reference gauge) prior to resuming testing. Perform additional performance tests, at no expense to the Department, on the first two soil anchors using the repaired or new measuring device to verify the calibration of the equipment.

451-7.2 Criteria for Performing a Performance Test and a Proof Test: Raise the load from one increment to another immediately after recording the prestressed soil anchor movement. Measure and record the prestressed soil anchor movement to the nearest 0.001 inch with respect to an independent fixed reference point at the alignment load and at each increment of load. Monitor the load with a pressure gauge or load cell. At load increments other than the maximum test load, hold the load just long enough to obtain the movement reading.

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Hold the maximum test load for at least 10 minutes. Pump the jack as necessary in order to maintain a constant load. Start the load-hold period as soon as the maximum test load is applied, and measure and record the prestressed soil anchor movement, with respect to an independent fixed reference, at 1, 2, 3, 4, 5, 6, and 10 minutes. If the prestressed soil anchor movement between 1 minute and 10 minutes exceeds 0.04 inches, hold the maximum test load for an additional 50 minutes. If extending the load-hold, record the prestressed soil anchor movements at 15 minutes, 20, 25, 30, 40, 50 and 60 minutes.

451-7.2.1 Performance Test: Perform the performance test by incrementally loading and unloading the prestressed soil anchor in accordance with the following schedule:

Performance Test Schedule	
Load	Load
AL	AL
0.20 DL*	0.20 DL
AL	0.40 DL
0.20 DL	0.60 DL
0.40 DL*	0.80 DL
AL	0.90 DL*
0.20 DL	AL
0.40 DL	0.20 DL
0.60 DL*	0.40 DL
AL	0.60 DL
0.20 DL	0.80 DL
0.40 DL	0.90 DL
0.60 DL	1.00 DL*
0.80 DL*	Reduce to lock-off load
AL - is the alignment load. DL - is the prestressed soil anchor factored design load.	

Plot the prestressed soil anchor movement versus load for each load increment marked with an asterisk (*) in the performance test schedule, and plot the residual movement of the tendon at each alignment load versus the highest previously applied load.

451-7.2.2 Proof Test: Perform the proof test by incrementally loading the prestressed soil anchor in accordance with the following schedule:

Proof Test Schedule	
Load	Load
AL	0.80 DL
0.20 DL	0.90 DL
0.40 DL	1.00 DL
0.60 DL	Reduce to lock-off load

Compare the proof test results to the performance test results. If there is any significant variation from the performance test results, perform a performance test on the next anchor.

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Plot the prestressed soil anchor movement versus load for each load increment in the proof test.

451-7.3 Criteria for Performing a Creep Test: Perform the creep test by incrementally loading and unloading the prestressed soil anchor in accordance with the performance test schedule given above. At the end of each loading cycle, hold the load constant for the observation period indicated in the creep test schedule below. Use the following times for reading and recording the prestressed soil anchor movement during each observation period: 1, 2, 3, 4, 5, 6, 10, 15, 20, 25, 30, 40, 50, 60, 75, 90, 100, 120, 150, 180, 210, 240, 270, and 300 minutes as appropriate. Start each load-hold period as soon as applying the test load. Pump the jack as necessary in order to maintain a constant load.

Plot the prestressed soil anchor movement and the residual movement measured in a creep test as described for the performance test above, and plot the creep movement for each load-hold as a function of the logarithm of time.

Creep Test Schedule	
Load	Observation Period (minutes.)
AL	
0.20 DL	10
0.40 DL	30
0.60 DL	30
0.80 DL	40
0.90 DL	60
1.00 DL	300

451-7.4 Lock-Off: Upon satisfactory completion of all testing, reduce the load to the lock-off load, and transfer the load to the anchorage device. Use a lock-off load that is 80% of the prestressed soil anchor service load. The Contractor may completely unload the prestressed soil anchor prior to lock-off. After transferring the load and prior to removing the jack, take a lift-off reading. Use a lift-off reading that is within 10% of the specified lock-off load. If the load is not within 10% of the specified lock-off load, reset the anchorage, and take another lift-off reading. Repeat this process until obtaining the desired lock-off load.

451-7.5 Cutting of Tendon Protrusions: After an anchor has been accepted by the Engineer, saw cut the portion of the anchor tendon extending beyond the anchorage. Take care not to damage the tendon or the tendon anchorage.

451-7.6 Prestressed Soil Anchor Load Test Acceptance Criteria: The Engineer will accept a performance or proof-tested prestressed soil anchor with a 10 minute load hold if the:

1. Prestressed soil anchor carries the maximum test load with less than 0.04 inches of movement between 1 minute and 10 minutes; and

2. For performance tests, net movement at the maximum test load cycle (movement between alignment load after 0.90 DL and the final movement reading at 1.00 DL) exceeds 80% of the theoretical elastic elongation of the test stressing length. For proof tests, net movement at the maximum test load (movement between alignment load and the final movement reading at 1.00 DL) exceeds 80% of the theoretical elastic elongation of the test stressing length.

The Engineer will accept a performance or proof-tested prestressed soil anchor with a 60 minute load hold if the:

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1. Prestressed soil anchor carries the maximum test load with a deformation rate that does not exceed 0.08 inches in the last log cycle of time; and

2. For performance tests, net movement at the maximum test load cycle (movement between alignment load after 0.90 DL and the final movement reading at 1.00 DL) exceeds 80% of the theoretical elastic elongation of the test stressing length. For proof tests, net movement at the maximum test load (movement between alignment load and the final movement reading at 1.00 DL) exceeds 80% of the theoretical elastic elongation of the test stressing length.

The Engineer will accept a creep tested prestressed soil anchor if the:

1. Prestressed soil anchor carries the maximum test load with a creep rate that does not exceed 0.08 inches/log cycle of time; and

2. Net movement at the maximum test load cycle (movement between alignment load after 0.90 DL and the final movement reading at 1.00 DL) exceeds 80% of the theoretical elastic elongation of the test stressing length.

If the total movement of the prestressed soil anchors at the maximum test load does not exceed 80% of the theoretical elastic elongation of the test stressing length, replace the prestressed soil anchor at no cost to the Department.

Stop the creep test as soon as the creep rate exceeds 0.08 inches/log cycle of time. Incorporate prestressed soil anchors which have a creep rate greater than 0.08 inches/log cycle of time in the finished work at a load equal to one-half its failure load. The failure load is the load carried by the prestressed soil anchor after the load has been allowed to stabilize for 10 minutes without exceeding 0.04 inches of movement between 1 and 10 minutes.

When a prestressed soil anchor does not satisfy the load test acceptance criteria, the Contractor may modify the design and/or the construction procedures. These modifications may include, but are not limited to, installing replacement prestressed soil anchors, reducing the factored design load by increasing the number of prestressed soil anchors, modifying the installation methods, increasing the bond length or changing the prestressed soil anchor type. Obtain the Engineer's approval prior to making any modification which requires changes to the structure. Perform any modifications at no additional cost to the Department. The Department will not allow additional Contract Time for modifications. The Engineer will not allow retesting of the failed prestressed soil anchor except to determine the anchor failure load.

451-8 Corrosion Protection (include for temporary anchors only when shown in the Plans).

451-8.1 General: Protect prestressed soil anchors against corrosion using materials and procedures described herein. The following materials may be used independently or in various combinations:

1. Portland cement grout
2. Plastic pipe or tubing
3. Steel pipe or tubing
4. Greases specially compounded for post-tensioning
5. Bitumens
6. Heat shrinkable polyethylene tubing

Use corrosion protection materials with properties that are not detrimental to the prestressing steel and that prevent the intrusion of corrosive environments. Use coating materials that also have the following properties:

1. Free from cracks and not brittle or fluid over the entire anticipated range of temperature

2. Chemically stable for the life of the tendon

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3. Nonreactive with the surrounding materials such as concrete, tendons, or sheathing

4. Corrosion-inhibiting

5. Impervious to moisture

When acidic water can enter the bore hole during the period subsequent to the drilling and flushing operation and prior to tendon insertion and grouting, introduce chemical additives for neutralizing purposes. Maintain a minimum pH of 9.0 when the prestressing steel is in contact with this water. During prolonged periods, monitor the pH at regular intervals, and add additional neutralization as required. Concentrated sodium hydroxide and calcium hydroxide have proven effective for this purpose.

451-8.2 Protection Systems:

451-8.2.1 Bond Length:

1. When the Plans require grout protected prestressed soil anchor tendons, meet the following requirements:

a. Provide corrosion protection of the tendon bond length by the cement grout cover.

b. Use spacers along the tendon bond length of multi-element tendons to separate each of the individual elements of the tendon so the prestressing steel will bond to the grout. Position spacers so their center to center spacing does not exceed 10 feet. In addition, locate the upper spacer a maximum of 5 feet from the top of the tendon bond length, and locate the lower spacer a maximum of 5 feet from the bottom of the tendon bond length.

c. Use centralizers to ensure a minimum of 0.5 inches of grout cover over the tendon bond length. Position centralizers so their center to center spacing does not exceed 10 feet. In addition, locate the upper centralizer a maximum of 5 feet from the top of the tendon bond length, and locate the lower centralizer a maximum of 12 inches from the bottom of the tendon bond length.

d. The Engineer will not require centralizers on pressure-injected prestressed soil anchor tendons if the prestressed soil anchor is installed in coarse-grained soils using grouting pressures greater than 150 psi.

e. The Engineer will not require centralizers on hollow-stem-augured prestressed soil anchor tendons if the prestressed soil anchor is grouted through the auger and the hole is maintained full of a stiff grout, (9 inches slump or less) during extraction of the auger.

2. When the Plans require the tendon bond length to be encapsulated:

a. Protect the tendon bond length portion of the tendon against corrosion by encapsulating the tendon in a grout-filled corrugated plastic or deformed steel tube. Grout the tendon inside the encapsulation prior to inserting the tendon in the drill hole or after the tendon has been placed in the drill hole. Mix expansive admixtures with the encapsulation grout if the tendon is grouted inside the encapsulation prior to inserting it in the drill hole. Centralize the tendon within the tendon bond length encapsulation with a minimum of 0.10 inches of grout cover. Use spacers along the tendon bond length of multi-element tendons to separate the elements of the tendon so the prestressing steel will bond to the encapsulation grout.

b. Use centralizers to provide a minimum of 0.5 inches of grout cover over the tendon bond length encapsulation. Position centralizers so their center to center spacing does not exceed 10 feet. In addition, locate the upper centralizer a maximum of 5 feet

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from the top of the tendon bond length, and locate the lower centralizer a maximum of 12 inches from the bottom of the tendon bond length.

c. The Engineer will not require centralizers on encapsulated, pressure-injected prestressed soil anchor tendons if the prestressed soil anchor is installed in coarse-grained soils using grouting pressures greater than 150 psi.

d. The Engineer will not require centralizers on encapsulated, hollow-stem-augured prestressed soil anchor tendons if the prestressed soil anchor is grouted through the auger and the hole is maintained full of a stiff grout (9 inches slump or less) during extraction of the auger.

451-8.2.2 Unbonded Length: For the minimum unbonded length of the tendon, use 15 feet or as indicated in the Plans or the approved shop drawings, whichever is greater.

If grouting the entire drill hole (tendon bond length and unbonded length) in one operation, provide the corrosion protection of the unbonded length by a sheath completely filled with corrosion inhibiting grease or grout, or a heat shrinkable tube internally coated with an elastic adhesive. If using grease under the sheath, make provisions to prevent the grease from escaping at the ends of the sheath. With grease, completely coat the tendon, fill the void between the tendon and the sheath, and fill the interstices between the wires of the 7-wire strands. Ensure that the shop drawings show how to provide a transition between the bond length and the unbonded length corrosion protection. If the sheath is grout filled, provide a separate bondbreaker that prevents the tendon from bonding to the grout surrounding the unbonded length.

If providing grease-filled sheath corrosion protection and the drill hole above the bond length is grouted after locking off the prestressed soil anchor, grout the tendon inside a second sheath.

451-8.2.3 Anchorage and Trumpet: Use non-restressable anchorage devices except where indicated in the Plans. Provide restressable anchorages on those prestressed soil anchors designated as restressable in the Plans. Ensure that the post-tensioning supplier provides a restressable anchorage compatible with the post-tensioning system provided along with written recommendations concerning the restressing of the tendons.

If using strand tendons, submit written recommendations from the post-tensioning supplier for seating the wedges. Include with the recommendations the minimum load required to properly seat the wedges in the anchor head.

Size the bearing plates so that:

1. the bending stresses in the plate do not exceed the yield strength of the steel when applying a load equal to 95% of the minimum specified ultimate tensile strength of the tendon; and

2. the average bearing stress on the concrete does not exceed that recommended in Section 3.1.7 of the Post Tensioning Institute Guide Specification for Post-Tensioning Materials.

Weld the trumpet to the bearing plate. Provide a trumpet that has an inside diameter equal to or larger than the hole in the bearing plate. Ensure that the trumpet is long enough to accommodate movements of the structure during testing and stressing. For strand tendons with encapsulation over the unbonded length, provide a trumpet that is long enough to enable the tendon to make a transition from the diameter of the tendon in the unbonded length to the diameter of the tendon at the anchor head without damaging the encapsulation. Ensure that trumpets filled with corrosion-inhibiting grease have a permanent Buna-N synthetic rubber or

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approved equal seal provided between the trumpet and the unbonded length corrosion protection. Ensure that trumpets filled with grout have a temporary seal provided between the trumpet and the unbonded length corrosion protection or that the trumpet overlaps the unbonded length corrosion protection by a minimum of 12 inches and fits tightly over the unbonded length corrosion protection.

451-9 Submittals.

Prepare and submit Shop drawings and a design submission describing the prestressed soil anchor system or systems intended for use to the Engineer for review and approval 30 working days prior to the commencement of the prestressed soil anchor work. Include the following in the shop drawings and design submission:

1. A prestressed soil anchor schedule providing the following:
    a. Prestressed soil anchor number
    b. Prestressed soil anchor factored design load
    c. Type and size of tendon
    d. Minimum total anchor length
    e. Minimum bond length
    f. Minimum tendon bond length
    g. Minimum unbonded length
2. A drawing of the prestressed soil anchor tendon and the corrosion protection system. Include details for the following:
    a. Spacers and their location
    b. Centralizers and their location
    c. Unbonded length corrosion protection system
    d. Bond length corrosion protection system
    e. Anchorage and trumpet
    f. Anchorage corrosion protection system
3. Certificates of Compliance for the following materials, if used, stating that the material or assemblies to be provided will fully comply with the requirements of the Contract.
    a. Prestressing steel, strand or bar
    b. Portland cement
    c. Prestressing hardware
    d. Bearing plates
    e. Corrosion protection system

The Engineer will approve or reject the shop drawings and design submission within 30 working days after receipt of the submission.

Submit to the Engineer for review and approval or rejection mill test reports for the prestressing steel and the bearing plate steel. The Engineer may require the Contractor to provide samples of any prestressed soil anchor material intended for use on the project. The Engineer will approve or reject the prestressing steel and bearing plate steel within five working days after receipt of the test reports. Do not incorporate the prestressing steel and bearing plates in the work without the Engineer's approval.

Submit to the Engineer for review and approval or rejection calibration data for each test jack, pressure gauge, and reference pressure gauge to be used. The Engineer will approve or reject the calibration data within five working days after receipt of the data. Do not commence testing until the Engineer has approved the jack, pressure gauge, and reference pressure gauge calibrations.

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Submit to the Engineer within 20 calendar days after completion of the prestressed soil anchor work a report containing:

1. prestressing steel manufacturer's mill test reports for the tendons incorporated in the installation
2. grouting records indicating the cement type, quantity injected, and the grout pressures
3. prestressed soil anchors test results and graphs.

451-10 Tendon Storage and Handling.

Handle and store tendons in a manner to avoid damage or corrosion. The Engineer will consider damage to the prestressing steel as a result of abrasions, cuts, nicks, welds and weld splatter cause for rejection. Protect the prestressing steel if performing welding in the vicinity. Do not ground welding leads to the prestressing steel. Protect prestressing steel from dirt, rust, or deleterious substances.

The Engineer will allow a light coating of rust on the steel. If heavy corrosion or pitting is noted, the Engineer will reject the affected tendons.

Use care in handling and storing the tendons at the site. Prior to inserting a tendon in the drill hole, examine the tendon for damage to the encapsulation and the sheathing. If, in the opinion of the Engineer, the encapsulation is damaged, repair the encapsulation in accordance with the tendon supplier's recommendations. If, in the opinion of the Engineer, the smooth sheathing has been damaged, repair it with ultra high molecular weight polyethylene tape. Spiral wind the tape around the tendon to completely seal the damaged area at a pitch that ensures a double thickness at all points.

451-11 Method of Measurement.

Unless otherwise shown in the Plans, the quantity to be paid for will be the number of prestressed soil anchors, based on the maximum anchor spacing shown in the Plans, installed and accepted. For prestressed soil anchors that do not meet the acceptance criteria, the original prestressed soil anchor and any required additional work or prestressed soil anchors will be, in sum, considered to be one prestressed soil anchor for payment purposes.

451-12 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section, including furnishing the materials necessary to complete the anchors in place and accepted. The quantity of performance and creep tests to be paid for will be the number of tests performed on accepted anchors.

The cost of proof testing will be included in Item No. 451-70.

No payment will be made for tests performed on unaccepted anchors.

Payment will be made under:

Item No. 451- 70-	Prestressed Soil Anchors - each.
Item No. 451- 70- 1	Prestressed Soil Anchor (Performance Tests) - each.
Item No. 451- 70- 2	Prestressed Soil Anchors (Creep Tests) - each.

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SECTION 452
PRECAST SEGMENTAL BRIDGE CONSTRUCTION

452-1 Description.

Fabricate, store, transport and erect precast structural concrete superstructure and/or substructure segments on a prepared foundation, to the established lines and grades, in accordance with the design, dimensions and details shown on the Plans and in accordance with this Section.

Reinforcing steel, embedded items and all appurtenant items are included.

Base the bid on the design shown in the Plans.

The work in this Section does not include longitudinally post-tensioned beams upon which a concrete slab is cast-in-place.

452-2 Qualification of Contractor's Personnel.

Meet the requirements of Section 105.

When mixing, handling and applying an epoxy bonding agent, provide direct supervision by a person with knowledge and experience, or trained by a technical representative of the manufacturer in the use of this material. Arrange for a technical representative of the manufacturer to be at the site as an advisor at the beginning of this work.

Ensure that all personnel who will be working with an epoxy bonding agent are thoroughly familiar with the safety precautions necessary for use of this material.

452-3 Definitions.

The following definitions apply to segmental bridge construction:

452-3.1 Segment: A modular section of the superstructure and/or substructure consisting of a certain cross-section shape and length as detailed in the Plans.

452-3.2 Match Cast: A precast concrete fabrication process whereby a segment is cast against the preceding segment producing a matching interface which permits the re-establishment of the cast geometry at erection time. Match casting is accomplished by either the short line or long line casting method.

452-3.3 Short Line Casting: Casting segments one at a time in a casting cell between a bulkhead at one end and a previously cast segment at the other. The first segment is cast between the bulkhead and another, temporary bulkhead.

452-3.4 Long Line Casting: Casting segments on a casting bed of sufficient length to permit the cumulative casting of segments for the entire length of a span or cantilever between field closure pours without repositioning the segments on the casting bed. With this method, the first segment is cast between bulkheads and successive segments are cast between a movable bulkhead on one end and the previously cast segment on the other.

452-3.5 Casting Cell: A special formwork arrangement usually consisting of a fixed vertical bulkhead of the cross section shape at one end and adjustable soffit, side and core forms all designed and assembled into a machine for making a single superstructure segment. A casting cell for a substructure pier shaft segment consists of exterior and interior side forms and a soffit form of the cross section shape.

452-3.6 Wet Joint System: Where segments are made in a casting cell between two bulkheads and are not match cast. The segments are then erected in the superstructure with a narrow cast-in-place joint between each segment. (During erection, all the segments of a span or

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multiple spans are supported by falsework, truss or other technique until the joints have gained strength and the longitudinal post-tensioning installed to make them self supporting.)

452-3.7 Span by Span (Erection): Placing a specified number of segments on a temporary support system, aligned and post-tensioned longitudinally forming a completed span of the superstructure.

452-3.8 Balanced Cantilever (Erection): The segments are sequentially erected alternately on either side of the pier in cantilever to a point where a closure is cast-in-place.

452-3.9 Progressive Cantilever: (Erection): The segments are erected progressively in cantilever, in one direction, from one pier to the next, using temporary intermediate piers, or other systems as required to support the advancing cantilever between piers.

452-3.10 Casting Curve: The curve of casting geometry that has to be followed in the casting cell or bed for achieving the theoretical bridge profile and alignment after all the final structural and time dependent (creep and shrinkage) deformations have taken place. The casting curve is a combination of the theoretical bridge geometrical profile grade, alignment and the camber.

452-3.11 Camber: The amount by which the concrete profile at casting time must differ from the theoretical geometric profile grade to compensate for all structural dead load, post-tensioning, all long term and time dependent deformations (creep and shrinkage) including all the intermediate erection stages and effects. (The opposite of deflections).

452-3.12 Erection Elevation: The elevation at which a segment is set in the structure at the time it is erected. (This is profile grade corrected by the amount of deflection calculated to occur from that stage onwards.)

452-4 Shop Drawings, Calculations and Manuals.

452-4.1 General: Use methods and procedures providing adequate safety to the general public from construction/erection activities and/or falsework placed over or adjacent to traveled roadways, navigational or recreational waterways or any existing commercial, industrial or other facility.

452-4.2 Information Required: Submit integrated detailed shop drawings, calculations, manuals and other information, including, but not limited to, the following:

452-4.2.1 Segment Shop Drawings:

1. A schedule of materials for segment fabrication including concrete, reinforcing steel, prestressing steel, duct filler, and other similar items.
2. Each segment number and the direction of erection.
3. Segment dimensions including widths, lengths, thicknesses, tapers, fillets, radii, working points, post-tensioning, clearances, rebar dimensions and spacing, embedded items, holes, anchorage positions, and other similar items.
4. Post-tensioning hardware components meeting the requirements as outlined in Section 462.
5. The volume of concrete, weight of reinforcement and weight of post-tensioning in each precast segment and the total weight for reinforcement and post-tensioning for both the superstructure and substructure summarized and tabulated on the shop drawings.
6. Details and calculations for any localized strengthening for concentrated supports and loads or reactions from any special erection equipment placed in locations not already allowed for in the Plans.

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7. Details and supporting calculations for any modifications to segment geometry, cross section dimensions, or segment length including any required changes to reinforcing and post-tensioning.

8. Details of permanent and temporary embedded items including inserts, blockouts, temporary openings, holes, and other similar items; and any localized required strengthening and the materials and methods to fill and finish the holes.

452-4.2.2 Casting Yard:

1. Procedures for segment fabrication including layout of the casting yard, set up and operation of the casting cells, movable rain and sun shades, geometry control stations, the storage and handling of rebar cages. the preparation of as built geometry data, placing and finishing concrete, curing of concrete, form stripping, bond breaking, and other similar items.

2. Calculations and details for lifting, storage and stacking of segments. Additional strengthening of the segments to accommodate stacking will be at no expense to the Department.

3. Equipment for segments fabrication, including details of the forms and casting cells for the manufacture of the segments, surveying the segment, lifting and transportation of the segment in the yard, and other similar items.

4. Segment storage including layout of the storage area, method of supporting the segments, single or double stacking, placing erection marks and segment identification, and other similar items.

5. Segment transportation from the casting yard to the site.

452-4.2.3 Erection Manual: Meet the requirements in 452-8.

452-4.2.4 Manual for Geometry Control and Casting Curves: Meet the requirements in 452-6.3.

452-5 Materials.

452-5.1 General: Use materials which conform to this Section and the requirements prescribed in Division III, Materials, for the particular kind and type of material specified.

452-5.2 Concrete: Use concrete as specified in Section 346 except as specifically modified herein. Use No. 67 coarse aggregate in the concrete for segments.

Screenings are not allowed as a substitute for silica sand for use in concrete for Precast Superstructure Segments.

452-5.3 Reinforcing Steel: Use ASTM A615, Grade 60 reinforcing steel which meets the requirements of Section 415. When welding reinforcing steel, meet the requirements of the American Welding Society's Structural Welding Code D1.4. The Engineer may allow shop prepared welded reinforcing grillages. Field welding of reinforcing steel is not allowed.

452-5.4 Post-Tensioning Systems: Use post-tensioning hardware components meeting the requirements of Section 462 and used in field mock-up testing. Components are not interchangeable and must comply with the details of the approved shop drawings.

452-5.5 Epoxy Bonding Systems: Use only epoxy systems comprised of two components, a resin and a hardener, with each component distinctly pigmented so that mixing produces a third color similar to the color of the precast segments and are listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their products must submit an application conforming to the requirements of Section 6.

In its workable state, or open time, the epoxy bonding agent must function as a lubricant for joining the segments. In its hardened state, the epoxy bonding agent must provide a watertight seal between the precast concrete segments. The hardened epoxy bonding agent must

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provide intimate contact for stress transfer by completely filling all interstitial space between the match cast segment faces.

Do not use resin or hardeners from containers which are damaged or have been previously opened. Combining of resin and hardener from bulk containers will not be permitted; use only pre-proportioned, full containers of components.

Submit instructions, from the manufacturer, for the safe storage, handling, mixing, and application of the materials.

452-6 Casting Requirements.

452-6.1 General: Ensure that all materials, details, and procedures are as specified herein, as noted in the Plans, or as directed by the Engineer.

Do not begin casting segments until the Engineer approves the relevant shop drawings, calculations, casting manuals, concrete forms and concreting operations and the post-tensioning system components and layout if different from that on the Plans. (Approval of post-tensioning stressing elongations and forces for field erection operations is not required at this stage but is required prior to erection.)

To use wet joints to join cantilevers or for corrective measures, obtain the Engineer's written approval.

Give each segment an erection mark indicating its location, orientation and order in the erection sequence. Match mark abutting edges of adjacent segments. Show erection marks on the erection plans or in the erection manual.

452-6.2 Forms: Take responsibility for the design and engineering of the forms as well as their construction. Form all exposed formed surfaces of each element of the structure with the same material to produce similar concrete surface textures, color, and appearance. Obtain the Engineer's approval of forms prior to initiating casting operations. Build the details shown on the Plans or as amended by approved shop drawings into the forms.

Repair worn, damaged, or otherwise unacceptable forms and obtain the Engineer's approval before casting any segment.

Where sections of forms are joined, ensure that offsets in flat surfaces do not exceed 1/16 inches and that offsets with corners and bends do not exceed 1/8 inches.

Ensure that all joints in the forms and contact points with bulkheads and existing segments have good fitting seals to prevent loss of fine material and cement grout.

Check and inspect forms on a regular weekly basis to ensure proper alignment and geometric accuracy. Do not use forms which fail to meet the specified casting tolerances until such corrections are made to produce segments within the specified tolerances.

Use a small blockout at all locations where an external tendon enters or exits the face of the concrete at deviation blocks and diaphragms except at anchorage locations. The blockout will be approximately 2 inches larger in diameter or overall dimensions than the tendon duct and have a depth equal to at least the minimum prescribed concrete cover dimension shown in the Plans.

452-6.3 Casting Control (Geometry): Before commencing the casting operation, submit the proposed method of geometry control for all segment casting operations to the Engineer for approval. This submittal must be in the form of a "Casting Manual" and include but not necessarily be limited to:

1. All measuring equipment, procedures and the location of control points to be established on each segment.

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2. The location and values of all permanent benchmarks and reference points in the precasting yard.

3. A geometry control procedure for the vertical and horizontal alignment control for the precasting of segments; including survey controls and procedures, observations, checks, computational and/or graphical methods and correction techniques.

4. The casting curves which include the theoretical geometric horizontal alignment, profile grade and superelevation appropriately combined with the camber.

Ensure that the casting manual covers all geometry control operations necessary and is compatible with the chosen methods of casting and erection, including erection survey, elevation and alignment control. Prepare the manual in accordance with submittal requirements of this Section.

Do not begin casting without the Engineer's approval of the geometry control method.

In the precasting yard, use instruments for the geometry control which are mounted on a permanent platform of sufficient height to sight on all control points. In addition, establish and maintain permanent benchmarks and reference points throughout the casting operations.

During casting, make all corrections required in the geometry of the segments from the control points established on each segment.

With a match cast system, after casting and before bond breaking to separate the segments, check the position of the new cast and match cast segments again. If positions are not as desired, make corrections in the next segment. In general, and unless otherwise approved by the Engineer, make observations on the geometry control reference hardware cast into the segments (i.e. elevation bolts, alignment offsets and lengths) to a precision of plus or minus 0.001 foot.

During casting operations, produce and maintain on a daily basis a graphical plot of the vertical and horizontal "as cast" alignments along each vertical and horizontal control line to an exaggerated scale in order to clearly highlight variations. Depict these against both the theoretical geometric vertical and horizontal alignment casting curves on a continuous layout of an entire unit of the bridge between expansion joints. Maintain this plot in good condition so that it may be used and referenced during erection.

Keep all geometry control hardware cast into any segments, such as elevation bolts and alignment hairpins, in place during erection for reference and checking purposes. Remove the hardware after completion of erection of the unit in the bridge between expansion joints.

Use experienced personnel to operate the instruments and supervise the casting operation. Prior to the commencement of casting, obtain the Engineer's approval of the experience and/or qualifications of the supervisory and instrument operating personnel, particularly with regard to the observational precision required.

452-6.4 Preparation for Match Casting: When match casting is used, take great care in positioning of the match cast (previously cast) segment in relation to the segment to be cast. Ensure that the match cast segment is not twisted.

Ensure that all materials to be embedded in the concrete of the new cast segment are properly positioned and supported in order to maintain their position and withstand concrete placement and consolidation without damage. Make provisions for all projections, recesses,

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notches, openings, blockouts and the like in accordance with the Plans and approved shop drawings.

Cover the abutting surface of the match cast segment with a thin film of a bond breaker consisting of flax soap and talc, or other material approved by the Engineer. Use a soap and talc mixture consisting of five parts flax soap to one part talc. The Engineer will base acceptance of a material other than soap and talc prior to casting any segments by demonstration on a large specimen consisting of a precast piece and a new cast piece with a contact facial area of at least 4 square feet.

452-6.5 Embedded Items:

452-6.5.1 General: Embedded items must be in accordance with specifications for prestressed and post-tensioned construction and the requirements herein.

452-6.5.2 Embedded Post-Tensioning Ducts: Ensure that embedded ducts for post-tensioning tendons and bars are positioned accurately to their required alignment. Properly fabricate and identify all ducts so that proper positioning is assured and can be verified after casting.

Utilize positive methods to ensure that ducts will not be displaced or damaged during concrete placement and consolidation. Adequately secure all embedded post-tensioning ducts to the reinforcement cage at intervals not exceeding 30 inches for steel pipes and 24 inches for plastic ducts, (Small ducts and very flexible ducts may require closer supports). Any auxiliary ties and support bars needed for these purposes will be considered incidental and at no extra cost to the project. Prevent the concrete cover requirements from being violated by any auxiliary ties and support bars.

After installation in the forms, ensure that the ends of the ducts are sealed at all times to prevent entry of water, debris and fine material. Following each pour of concrete, demonstrate that all empty ducts are free of water and are unobstructed and undamaged.

Immediately prior to installation of the prestressing steel, again demonstrate to the satisfaction of the Engineer that all ducts are unobstructed and free of water and debris.

452-6.5.3 Anchorage Plates and Castings: Prior to placing concrete in the forms, fix all tendon anchorage plates and anchorage castings in their respective position in the forms, connected to their duct and sealed to prevent mortar intrusion. Ensure that anchorage plates and castings are rigidly fixed in the forms to maintain their correct alignment and position during concrete placement and consolidation.

452-6.5.4 Reinforcing Steel: Fabricate and place reinforcing steel in accordance with the Plans or as superseded by the approved shop drawings and as required herein.

Do not cut out or remove reinforcing steel to permit proper alignment of post-tensioning ducts. Replace any bar that cannot be fabricated to clear the ducts by additional bars with adequate lap lengths and submit the details to the Engineer for approval.

In the plane of the reinforcement parallel to the nearest surface of the concrete, ensure that bars do not vary from plan placement by more than 1 inch, nor by more than one-eighth of the spacing between bars, whichever is less. In the direction perpendicular to this plane of reinforcement, ensure that bars do not vary from plan placement by more than 1/4 inches. The top and bottom cover of reinforcing steel must be within 1/4 inches of the cover dimensioned in the Plans. The edge cover of the reinforcing steel must be within 1 inch of the cover dimensioned in the Plans.

452-6.6 Concrete Placement, Consolidation and Finishing:

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452-6.6.1 General: Do not deposit concrete into the forms until the entire set-up of the forms, reinforcement, ducts, anchorages and embedded items have been thoroughly inspected and checked. Do not place concrete until the Engineer is satisfied that all the above items have been properly inspected and checked, and the rate of producing and placing the concrete will be sufficient to complete the casting and finishing operations within the scheduled time, that experienced concrete finishers are available where required for finish work and that all necessary finishing tools and equipment are on hand at the site of the work and are in satisfactory condition for use.

During conveying and placement, protect concrete against undue drying or rise in temperature and inclement weather.

452-6.6.2 Concrete Placement Equipment: Use concrete placement equipment of a size and design which permits placing concrete within the specified time. Clean all equipment at the end of each operation or workday and, just prior to reuse, check the equipment again and clean off hardened concrete and foreign materials.

Place concrete by belt conveyors and by pumping in accordance with 400-7.6 and 400-7.7, respectively.

452-6.6.3 Concrete Placement Sequence:

1. Superstructure box segments: First place concrete in the central portion of the bottom slab between the inside edges of the internal web forms, leaving a narrow gap of 6 inches to 12 inches for inspection and consolidation of the bottom corners when the next load is placed in the webs. Then place the concrete in the bottom corners of each web to connect and consolidate with that already placed in the bottom slab. Then place concrete in the remainder of the webs in lifts not exceeding 24 inches at a time up to the top of the webs but not into the slab over the webs. Place concrete in the top slab in the outer wing and mid slab regions between webs before placing, completing and consolidating zones over the top of the webs.

2. Substructure and Pier Shaft Segments: Cast precast pier shaft segments vertically. Place the concrete in uniform lifts of approximately 24 inches to 36 inches and consolidate well.

3. Obtain the Engineer’s approval on any alternative sequences to the above, or for any other precast components.

452-6.6.4 Concrete Placement and Consolidation: Discharge individual loads of concrete into the forms, and place and consolidate in the required locations. After discharge into the forms, do not bodily move concrete from place to place within the forms by mechanical vibrators or other similar equipment.

Place and consolidate concrete with care so that post-tensioning ducts, anchorages and any other embedded items are maintained in their proper positions and are not damaged.

Consolidate all concrete using approved vibrators together with any other equipment necessary to perform the work as specified. Use internal vibrators having a minimum frequency of 8,000 vibrations per minute and sufficient amplitude to consolidate the concrete effectively. Provide at least two stand-by vibrators in working condition for emergency use in case of malfunction.

Use of external vibrators for consolidating concrete when the concrete is inaccessible for adequate consolidation by internal means. When external vibration is used, construct the forms sufficiently rigid to resist displacement or damage.

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Vibrate concrete in a manner which avoids displacement or damage to reinforcement, post-tensioning ducts, anchorages and other embedded items.

No construction joints are allowed within a segment, except as detailed in the Plans.

452-6.6.5 Finishing: Strike off the roadway surface of the segment with an approved mechanical screed operated by a self contained power source.

Furnish and use a straightedge at least 24 inches longer than the segment while finishing the concrete deck surface of superstructure box girder segments. Use the straightedge approximately parallel to the centerline of the segment to strike an accurate surface between the bulkhead and the top of the match cast segment at all positions across the segment width.

Give all other surfaces of segments and precast components a Class 3 Finish at the precast site in accordance with 400-15.

452-6.7 Curing:

452-6.7.1 General: Where casting cells are intended to operate on a short (daily) cycle and it can be demonstrated to the satisfaction of the Engineer that the required initial concrete strengths for the removal of the forms, application of prestress, moving and handling of the segments and that the final concrete strength can be achieved in a timely and consistent manner, then steam curing will not be required. However, take precautions to promote proper curing by methods approved by the Engineer and in accordance with Section 400. Such precautions must meet or exceed the following:

1. To prevent moisture loss, cover all exposed surfaces (those not in contact with a form or match cast segment) as soon as possible after casting with a moisture tight covering (wet curing blankets or other approved equal systems). Avoid spoiling the deck surface finish. Keep the cover on or within 12 inches of the deck surface.

2. Keep the moisture-tight covering substantially in place throughout succeeding operations such as geometry control survey, stripping of internal forms, wing forms and shifting of and working with a segment in a match cast position. Keep the concrete surface wet throughout these operations.

3. After stripping of the side and core forms, continue curing of the precast concrete by the application of a Type 2 (white pigmented) membrane curing compound as specified in 925-2 to all exposed surfaces (including segment exterior once exposed by removal from the form). Apply an approved debonding compound to match cast surfaces to serve both as a bond breaker and seal for curing.

4. Maintain the moisture tight covering for at least 72 hours.

As an alternative, steam curing may be used.

5. While the new cast segment is in contact with the match cast segment, cover the match cast segment with curing blankets, or other approved equal system, to minimize the effects of differential temperature between the segments.

452-6.7.2 Steam Curing: Meet the requirements of Section 400 modified by the following requirements when steam curing is used.

1. Provide a device or devices for simultaneously recording the temperature of three widely separated locations per casting cell. Locate the three temperature sensors near the top, middle and bottom of the enclosure or as otherwise approved by the Engineer. Identify the charts with the hours, dates and segment number and submit to the Engineer immediately after steam curing is completed unless otherwise approved.

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2. Apply an approved debonding compound to match cast surfaces to serve both as a bond breaker and seal for curing.

3. Expose match cast segments to the same curing environment (temperature and humidity) as the new cast segment until the new segment reaches the required strength to allow the removal of the forms.

452-6.8 Removal of Forms: Prior to removing the forms, protect the plastic concrete from adverse weather effects.

Keep supporting forms in place until the concrete has reached the required strength for form removal as specified in the Plans, in this Section, or as approved by the Engineer.

Test cylinders, made and cured in the same manner as the segment, to confirm the form release strength prior to removing form. With the Engineer's approval, a strength curve chart may be established to determine the time necessary for achieving the required form release strength, in accordance with the specifications for form removal.

Avoid cracking or damaging the segment when removing the forms, especially match cast surfaces and shear keys. Notify the Engineer of any damage which occurs and repair in an approved manner.

452-6.9 Test Samples: Provide additional test samples and testing for compressive strength on precast segments and field closure joints to control the construction activities and to ensure adequate strength of these components at various stages of their manufacture and assembly.

Make test cylinders, in accordance with Section 346, cured in the same manner as the structural components to ensure adequate compressive strength has been achieved in accordance with the plan requirements for the following conditions:

1. Prior to release of prestressing for components which are to be pretensioned.

2. Prior to form release and/or moving the components to storage.

3. Prior to post-tensioning transverse tendons if the component is less than 28 days old.

4. Prior to placing a component into position in the structure and/or stressing of longitudinal post-tensioning tendons if the component is less than 28 days old.

Determine the number of cylinders in accordance with the proposed method for casting, transporting and erecting the various components.

Submit the results of the compression testing of one or more test cylinders for controlling the time of execution of the various construction operations. Obtain the Engineer's approval for meeting the Specification requirements on casting, curing and testing of concrete test cylinders.

No direct payment will be made for the concrete testing. All costs for such testing will be included in the bid items for the various precast structural components.

452-6.10 Age at Erection: Unless otherwise approved by the Engineer, precast components must be at least 14 days old prior to incorporating into the structure.

452-6.11 Tolerances:

452-6.11.1 General: The following tolerances apply to the fabrication of precast components:

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Table 452-1	
(1) Superstructure Box Segments	
Width of Web	±1/4 inch
Depth of bottom slab	±3/16 inch
Depth of top slab	±3/16 inch
Overall depth of segment	±3/16 inch
Overall width of segment	±1/4 inch
Length of segment	±3/8 inch
Diaphragm dimensions	±3/8 inch
(2) Precast Box Pier Segments	
Height (Individual Element)	±1/4 inch
Width and Breadth (Individual Element)	±1/4 inch
Thickness (wall)	±1/4 inch
(3) All Fabricated Segments	
Ends (deviation from a plane per 20 ft width or depth	±1/4 inch per 20 ft not to exceed 1/2 inch.
Flat Surface (deviation from a plane at any location)	±0.025 in/ft not to exceed a total of 1/4 in.

452-6.11.2 Corrections: Control dimensions from segment to segment, including cast-in-place segments, and compensate for any deviations within a single segment or series of segments so that the overall dimensions of the completed structure meet the dimensions and overall erection tolerances shown in the Plans and allowed by this Section.

452-6.11.3 Repairs: Repair minor breakage, spalling, or honeycomb (not over 1 inch deep) by a method approved by the Engineer. Major breakage, spalling, or honeycomb in excess of 1 inch deep is subject to the Engineer's structural review. If found to be satisfactory, repair these areas using a method approved by the Engineer. Do not perform surface finishing or repairs on the matching joint surfaces of precast segments until after final erection of the segment, except as herein noted. If more than 20%, but less than 40% of the total contact surface of all shear keys in any single web is broken, spalled or honeycombed, grind the damaged areas to produce a cylindrical depression into sound concrete to a depth and width approximately equal to the shear key dimensions. Complete necessary repairs to shear keys damaged at the casting site prior to shipping the segment to the erection site. After erection of the segments adjacent to the damaged keys and prior to erection of additional segments, carefully pack the voids left by the depressions with an epoxy mortar as approved by the Engineer. With the Engineer's approval, an alternate method of repair may be used. The Engineer will consider the segment unsatisfactory for use if more than 40% of the total contact surface of all shear keys in any single web is broken, spalled or honeycombed. Use an Engineer approved method for repairing damaged alignment keys located in the top and bottom slabs. The Engineer will consider a segment unsatisfactory for use if more than 50% of the total contact surface of all alignment keys in any element of the slab (wing overhang, central portion between webs, etc.) is broken, spalled or honeycombed. Remove and dispose segments found to be unsatisfactory and not repairable after structural review and cast a new segment at no expense to the Department.

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452-7 Precast Segment Handling, Storage and Shipment.

Handle segments with care to prevent damage. Handle segments using only the devices shown on the shop drawings for this purpose. Store all precast segments level in the upright position. Firmly support all precast segments for storage and shipment on an approved three point bearing system which does not introduce a twist under self weight. Do not stack superstructure segments one upon another unless approved by the Engineer.

Prior to shipment the Engineer will thoroughly inspect each segment for damage. Thoroughly clean the faces of all joints of laitance, bond breaking compound and any other foreign material by light sand blasting prior to shipment. Make no repairs of minor spalls or chipped areas on the joint surfaces until after erection of the segment. Upon arrival at the bridge site the Engineer will inspect each segment again. If in the Engineer's opinion, any damage has occurred during shipment that will impair the function of the segment (structurally, aesthetically, etc.), the segment will be rejected. Replace any rejected segment with an approved segment at no cost to the Department. Provide firm support at bearing locations noted above. Fully secure the segments against shifting during transport. Provide a storage area of suitable stability for the segments to prevent differential settlement of the segment supports during the entire period of storage.

452-8 Erection.

452-8.1 Erection Manual: Before commencing erection operations, submit proposals for all segment erection operations to the Engineer for approval. This submittal must be in the form of an "Erection Manual" and include but not necessarily be limited to:

1. A detailed step-by-step sequence for the erection of each segment including all intermediate procedures relating to erection equipment, temporary and permanent post-tensioning and making of closures between spans and/or cantilevers and other required sequencing.
2. Positioning, use and sequencing of falsework, jacking and/or releasing of falsework, temporary towers, supports, tie-downs, counterweights, closure devices and the like.
3. Positioning, use and sequencing of erection equipment such as cranes, beam and winch devices, gantries, trusses and the like, both on and off the structure, including the movement, introduction and/or removal of any supports onto or connections with the structure. Include drawings and calculations for the structural effects of erection equipment on the structure.
4. Detailed scheduling of all temporary and permanent post-tensioning operations and sequences in accordance with the segment erection and closure operations and other required scheduling.
5. Stressing forces and elongations for post-tensioning.
6. Sequencing of filler injection operations.
7. A method for the field survey control for establishing and checking the erected geometry (elevations and alignments) with particular attention to the setting of critical segments such as, for example, pier segments for balanced cantilever erection. This information may be included in the Erection Manual or may be submitted later as a supplementary or separate document.
8. Any other relevant operations as required and applicable to the structure type and construction method.

Do not start erection without the Engineer's approval of the erection manual.

452-8.2 Erection Geometry Control:

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452-8.2.1 General: Numerical or graphical methods may be used for alignment control and checking during erection. Establish the key stages for checking of the erection in the erection manual and obtain the Engineer's review and approval. Key stages would include, for example, setting a pier segment during cantilever erection and various intermediate points during subsequent segment erection, at span closure and upon completion.

Prepare a table of elevations and alignments required at each key stage of erection in accordance with the Plans, as cast geometry, camber and erection elevations for establishing erection controls and submit to the Engineer for approval.

Carefully check elevations and alignments at each stage of erection and correct as required to avoid any possible accumulation of errors.

If geometric corrective measures are necessary, the Engineer will require the Specialty Engineer to develop the means and methods to ensure the epoxy joint remains watertight and free from localized stress concentrations. The Specialty Engineer will be required to submit the corrective measures to the Engineer for approval. Use shims made of ASTM A240 Type 304 wire cloth (roving) with a maximum of 1/8 inch thickness.

452-8.2.2 Span-by-Span and Wet Joint Erection: Position each span segment according to the final longitudinal alignment, grade, camber and cross-slope. Keep the horizontal and vertical alignment of the pier segment within 1/16 inches of that required by the approved erection plans.

Correct any deviation more than the tolerance allowed above using a method approved by the Engineer.

452-8.2.3 Balanced Cantilever and Progressive Cantilever Erection: Check the alignment and elevations of the cantilevers, using two independent surveys, within one hour of sunrise on each day that segments are to be erected. Check the measurements made by each survey and ensure they agree to within 1/4 inches. When measurements do not agree, discontinue erection of segments until discrepancies in measurements are resolved to the satisfaction of the Engineer.

Accurate positioning of the pier segments is very important as it will establish the line and grade for cantilevers in each direction. Position each pier segment according to the final longitudinal alignment, grade and cross-slope and ensure no further erection continues until and unless these segments are properly located on the piers by the means provided. Keep the horizontal and vertical alignments of the pier segment within 1/16 inch of the alignment values required to control points as established by the approved erection plans.

Check at each key stage of erection, in accordance with approved erection procedures, the ends of cantilevers for required elevations and alignment. Correct any deviation from the required alignment by a method approved by the Engineer.

452-8.3 Erection Tolerances:

1. Ensure that maximum differential between outside faces of adjacent segments in the erected position does not exceed 3/16 inches.

2. Ensure that transversely, the angular deviation from the theoretical slope difference between two successive segment joints not exceed 0.001 rad.

3. Ensure that longitudinally, the angular deviation from the theoretical slope change between two successive segments does not exceed 0.003 rad.

4. Dimensions from segment to segment will compensate for any deviations within a single segment so that the overall dimensions of the completed structure meets the

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dimensions shown in the Plans such that the accumulated maximum error does not exceed 1/1000 of the span length for either vertical profile and/or horizontal alignment.

Carefully check elevations and alignments at each stage of erection and correct as required to avoid any possible accumulation of errors.

452-8.4 Other Miscellaneous Erection Requirements:

452-8.4.1 Span-by-Span and Wet Joint Erection:

452-8 .4.1.1 Closure Joints: Use concrete meeting the same specifications and criteria as the concrete in the segments. Ensure that concrete reaches the minimum required strength as shown in the Plans or in the Specifications prior to stressing the continuity post-tensioning. Ensure that the closure joint forms provide tolerances as specified under 452-6.11 Tolerances.

452-8.4.1.2 Wet Joints: Where forming joints between segments using cast-in-place concrete, the above conditions for closure joints also apply to wet joints. In addition, the cast-in-place "Wet Joints" cannot be less than 3 inches wide, nor greater than 9 inches wide unless otherwise approved by the Engineer.

452-8.4.1.3 Formwork: Adequately support formwork at all wet joints and closure joints to take all loads applied and do not remove them until the concrete in the joints has reached its required strength and the longitudinal tendons have been tensioned.

452-8.4.2 Balanced Cantilever and Progressive Cantilever Erection:

452-8.4.2.1 Deformations: For computing deformations due to time dependent stress variations, the erection time assumptions are shown in the Plans.

Deformations due to creep and shrinkage and the concrete modulus of elasticity have been computed using the FDOT's Structures Manual edition noted in the Plans. Obtain the Engineer's approval for method of calculating the above parameters.

452-8.4.2.2 Temperature Restrictions: Meet the requirements of Section 926 for substrate temperatures, epoxy formulation and thermal controls where precast segments are jointed with epoxy. Measure the substrate temperature at the mid-depth of the top slab for box girder sections or 4 inches from the top surface for slabs and other sections.

452-8.4.2.3 Permissible Loads on Cantilever: During balanced cantilever erection, unbalance the cantilever by only one segment at any time. In addition to the unbalanced load due to one segment, the cantilevers are designed for loads applied by the erection equipment as listed in the Plans. Use alternate erection methods which comply with the assumptions in the Plans or otherwise approved by the Engineer.

452-8.4.2.4 Span Closure Joints: Use concrete for closure joints which comply with the same specifications and criteria as the concrete in the segments. Ensure that concrete reaches the minimum required strength as shown in the Plans or in the Specifications prior to stressing the transverse or continuity post-tensioning. Ensure that the closure joint forms provide tolerances as specified for precast segments.

452-8.4.2.5 Falsework and Formwork: Support falsework and formwork at closure pours by the cantilever ends or terminating segments of each series of segments to be joined. Secure cantilever together vertically, longitudinally, and transversely so that the applied loads will yield equal deflections to both cantilevers. Do not remove securing devices until the closure pour concrete has reached its required strength and longitudinal continuity tendons are tensioned. Submit calculations and details to verify that the devices and methods have adequate rigidity and do not impose excessive loads and stresses on the structure.

452-8.4.3 Precast Box Pier Construction - Erection Tolerances:

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1. Ensure that maximum differential between outside faces of adjacent segments in the erected position does not exceed 3/16 inches.

2. Ensure that the rotational angular deviation, measured about a vertical line, between two successive segment joints does not exceed 0.001 rad.

3. Ensure that the maximum angular deviation of a segment from a vertical line does not exceed 0.003 rad. and that the maximum overall deviation from the vertical, measured in any direction, does not exceed 0.01 inches per foot of height.

4. Ensure the base precast segment is within 1/2 inch of the Plan location.

452-8.5 Epoxy Jointing of Precast Segments: Furnish, mix and apply a two-component epoxy bonding system, meeting the requirements of this Section, to the match cast faces of joints between precast concrete superstructure and/or substructure segments in accordance with the Contract Documents

Prior to the use of epoxy on the project, conduct a site meeting with the Engineer and epoxy manufacturer to determine the proper formulations, storage and handling, mixing and application of the epoxy.

Have the necessary materials immediately available at the location of the segment joining, in the event that the segments must be separated and cleaned or epoxy reapplied.

Include in the erection manual required by this Section, details of erection and post-tensioning operations which assure that the time elapsing between mixing components of the first batch of epoxy bonding agent applied to the joining surfaces of precast concrete segments and the application of a compressive contact pressure across the joint do not exceed 70% of the open time for the particular formulation of epoxy bonding agent used. Also, include details of how the minimum, closing, contact pressure of approximately 40 psi will be applied uniformly to each joint to which epoxy is applied during the epoxy curing period. Contact pressure may be attained through combinations of weight and temporary and/or permanent post-tensioning.

452-8.5.1 Cleanliness of Surfaces to be Joined: Ensure that the application surfaces are free from oil, form release agent, laitance or any other deleterious material that would prevent the epoxy bonding agent from bonding to the concrete surface. Remove laitance by light sandblasting, wire brushing. Do not destroy the surface shape and profile of the mating surfaces.

Ensure that the surfaces have no free moisture on them at the time the epoxy bonding agent is applied. Free moisture will be considered present if a dry rag, after being wiped over the surface, becomes damp.

452-8.5.2 Substrate Temperatures and Epoxy Formulation: Apply the epoxy bonding agent only when the substrate temperature of both surfaces to be joined is between 40°F and 115°F. The formulation of the epoxy bonding agent must have an application temperature range that conforms to the substrate temperature of the surfaces being joined. If the mating surfaces have different substrate temperatures, then use the formulation for the higher temperature in hot weather periods. In cold weather periods, use the formulation for the lower temperature. Thermal control precautions may be taken in accordance with 452-8.5.5.

452-8.5.3 Mixing of Epoxy Bonding Agent: Mix the two components of the epoxy bonding agent in strict accordance with the manufacturer's instructions, using only full and undamaged containers. Only open the containers immediately before being combined and do not use any which have an expired shelf life. Thoroughly stir each container of component before combining the components. Combine the two components and thoroughly mix until a uniform

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color is achieved. Mix with a properly sized mechanical mixer operating at no more than 600 rpm or in accordance with the recommendations of the epoxy manufacturer.

Do not mix until the segments to be joined are within approximately 18 inches of their final position. Schedule mixing of the epoxy bonding agent so that the material in a batch is applied to the face of a joint within a maximum of 20 minutes after combining the components.

The Engineer, at his discretion, may require a dry run to check the fit of two surfaces before applying the epoxy.

452-8.5.4 Mating of Segments: Immediately after each mating surface is covered with epoxy bonding agent, bring the segments together and apply the specified compressive contact pressure in accordance with the approved erection procedures. The contact pressure may be increased at any time after the epoxy has taken an initial set. Do not reduce the contact pressure until the epoxy in the joint has properly hardened and cured. If the contact pressure is reduced, do not subject the joint to tensile stress.

A discernable bead line of extruded epoxy bonding agent must be apparent along the exposed edges of the joint. Fill all areas of the joint which do not show a bead of epoxy by dispensing additional epoxy, meeting the requirements of this specification, into the joint using a pneumatic gun with epoxy cartridges. Inject epoxy to a minimum depth of 1 inch.

Catch and retain epoxy which is squeezed out of the joint in areas over waterways, roadways, buildings, etc.

Clean all extruded epoxy bonding agent from external visible surfaces in a way not to damage or stain the concrete surface. Do not smear surplus extruded epoxy bonding agent over large areas (areas more than 1 inch from each side of the joint), visible surfaces or surfaces to which a cover coat, Class 5 applied finish coat or similar or texturing is to be applied later.

Immediately after the segments are joined, swab all embedded (internal) post-tensioning ducts or conduits passing through the joints to smooth out any extruded epoxy bonding agent.

If the time between combining the components of the epoxy bonding agent and applying the compressive contact pressure exceeds 70% of the minimum open time, immediately separate the segments and clean in accordance with 452-8.5.6.

452-8.5.5 Thermal Controls:

452-8.5.5.1 Cooling in Hot Weather: If the substrate temperature exceeds 115°F, do not proceed with epoxy jointing. The Contractor may take precautions to keep the mating substrate surfaces cool by shading or wetting with clean water, except that the above requirements for no moisture at the time of application must be strictly adhered to.

452-8.5.5.2 Artificial Heating in Cold Weather: If electing to erect segments in cold weather when the substrate temperature of the mating concrete surfaces is below 40°F, an artificial environment may be used to increase the substrate temperature subject to the following:

1. Make the artificial environment by an enclosure surrounding the joint through which warm air is circulated, or heating is provided by radiant heaters.
2. Raise the temperature of the concrete substrate across the entire joint surface to at least 40°F.
3. Prevent localized heating and the temperature of the substrate exceeding 95°F at any point on the surface. Direct flame heating of the concrete is not allowed.

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4. Maintain the temperature of the substrate surfaces between 40°F and 95°F for at least 24 hours after joining the surfaces.

5. The Contractor may propose, for review by the Engineer, an optional method of raising and maintaining the substrate temperature of the mating surfaces. Any optional method must meet the thermal restrictions above.

Epoxy jointing operations may proceed if the air temperature is above 45°F and rising and the limitations above are met.

452-8.5.6 Failure to Comply with Time Limits or Incomplete Jointing: If the time limit between mixing of the epoxy-bonding agent and the application of the contact pressure is exceeded, or if the joint is incompletely filled and sealed, separate the segments and remove all epoxy from the faces using spatulas and approved solvent. Do not re-apply epoxy until the faces have been properly cleaned and solvents dispersed, for a period of 24 hours.

452-8.5.7 Removal of Support to Segments:

452-8.5.7.1 Span-by-Span Erection: Ensure that precast concrete segments remain fully supported by the erection truss or system until at least 20 hours after mixing of the last batch of epoxy bonding agent applied to any joint in the span.

452-8.5.7.2 Cantilever Erection: Independent support to a newly erected cantilever segment may be removed when the epoxy bonding agent in the third previous mating joint has set. It is not necessary for the epoxy bonding agent in the new joint or the immediately previous joint to be set prior to removing the independent support of the new segment provided that the temporary and/or permanent post-tensioning has been installed to carry the load of the new and previous segment along with any applied construction loading as per the requirements of the erection system.

452-8.5.8 Record of Jointing: Record and submit to the Engineer on a weekly basis the following information:

1. General:
   a. Date and time of jointing,
   b. Segment numbers or spans jointed,
   c. Weather conditions
2. For each joint (identified by location or segment numbers):
   a. manufacturer's LOT number of epoxy bonding agent components.
   b. Temperature of the concrete on the joint surface at the middle of each segment when application of the epoxy bonding agent began.
   c. Time of mixing first batch of epoxy bonding agent applied to the joint and completion of application.
   d. Time of applying the required compressive contact pressure.
3. Details of any repairs performed including reason for repair, joint location, volume of epoxy used, method of application, etc.

452-8.6 Packed Mortar Joints for Joints or Bearings: Where designated on the Plans, place packed mortar after the joint or bearing has been set at the proper final elevation.

Pressure grouting may be allowed with the Engineer's approval of the materials and method to be used.

Mortar for packing consists of one part cement and one part fine aggregate, by volume, mixed with a non-shrink admixture as recommended by the manufacturer. Mix the dry

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elements thoroughly to a uniform mixture. Add water to produce a mealy, slightly adhesive mixture. Pack the mortar until a water sheen is produced on the surface of the mortar.

Build a form around the joint leaving one side open. Secure the form to withstand the required packing forces. Insert a small amount of mortar into the open joint to form a 2 inches thick bead on the opposite side of the form. Pack this bead by striking a special tool made of 1/2 inch by 2 inch steel having a length approximately 10 inches longer than the largest dimension of the joint being packed with a 2 pound hammer. Continue compaction until water begins to bleed out of the mortar. When bleeding has occurred, insert another bead of mortar and pack as described above. Continue this process until the joint is filled to the limits shown in the Plans.

452-9 Traffic Railing and Median Setting.

Prior to forming the concrete traffic railings, accurately establish the as-constructed gutter line elevations at intervals not exceeding 10 feet. Then form the base of the traffic railing and median to provide an inside vertical face which extends from the surface of the concrete structure to an elevation located 3 inches (or as shown in the Plans) above the theoretical gutter line elevations. Maintain the plan vertical height of the traffic railings as a minimum when variations exist between the plan profile and the actual profile of the gutter.

452-10 Bridge Deck Surface.

Provide a Class 4 Floor Finish in accordance with Section 400 for Long Bridges upon completion of superstructure segment erection and prior to opening to traffic. Install expansion joints in accordance with Section 400.

452-11 Watertight Decks.

Check all segment joints, closure joints and deck hole repairs to assure every location is watertight, upon completion of all milling and grinding activities on the riding surface. Repair all locations showing evidence of leaks by cutting a 3/8 inches wide x 5/8 inches deep groove along the leak interface. Clean and completely fill the groove with epoxy meeting the requirements of Section 926. Dispense the epoxy into the groove using a pneumatic gun and epoxy cartridges. Clean all excess epoxy bonding agent from external visible surfaces in a way not to damage or stain the concrete surface. Do not smear epoxy over areas located more than 1 inch from each side of the groove.

452-12 Method of Measurement.

Precast superstructure and substructure segment concrete, including cast-in-place concrete for closure and wet joint pours, will be measured by volume according to the quantities represented by the dimensions of the segments and cast-in-place pours on the Plans or approved shop drawings; whichever is the lesser.

All reinforcement in precast superstructure and substructure segments, cast-in-place closures and wet-joints will be measured by weight according to the quantities represented by the reinforcement details in the Plans or approved shop drawings; whichever is the lesser.

All permanent post-tensioning in the superstructure and substructure will be measured by weight according to the quantities represented by the details in the Plans or approved shop drawings; whichever is the lesser.

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452-13 Basis of Payment.

452-13.1 General: Payment will be in accordance with the following:

452-13.2 Precast Segments-Concrete: Payment for precast superstructure and substructure segment concrete will be at the Contract bid prices per cubic yard for the various classes of concrete called for.

Such prices and payments will be full compensation for manufacture, storage, transport, assembly and erection of the segments complete and in place, including filling all concrete blockouts and similar miscellaneous details. These prices and payments will also include the furnishing and the application of epoxy bonding agent and Class 5 applied finish coating when specified in the Plans, providing temporary and permanent segment access details, material testing, special erection equipment, temporary post-tensioning, tools, labor and incidental items necessary for completing the work in accordance with the Plans, Specifications and approved shop drawings.

Cast-in-place concrete for closure and wet joint pours will be paid for under these items which also include the cost of all formwork, closure devices and other temporary construction needed to make these closures and joints and cast-in-place segments or portions thereof as designated in the Plans.

Include the cost of providing a Class 4 floor finish on the bridge deck and approach slab surfaces in the cost of superstructure and approach slab concrete.

The Bridge floor grooving will be measured and paid for separately.

No additional payment will be made for extra concrete necessitated by approved modifications to the segments or structure needed to accommodate the Contractor's construction methods.

452-13.3 Precast Segments-Reinforcement: Payment for reinforcement in precast segments, closure pours, wet joints and other cast-in-place concrete joints and details will be at the Contract bid price per pound for reinforcing steel (superstructure) and for reinforcing steel (substructure).

No additional payment will be made for extra reinforcement necessitated by approved modifications to the segments or structure for the purposes of the Contractor's construction methods.

452-13.4 Precast Segments-Post-Tensioning: Payment for permanent post-tensioning will be in accordance with Section 462.

No additional payment will be made for extra permanent or temporary post-tensioning necessitated by approved modifications to the segments or structure for the purposes of the Contractor's construction methods, nor will payment be made for temporary tendons which are approved to be left in the structure, either stressed or unstressed, for the convenience of the Contractor's operations.

452-13.5 Precast Segments-Partial Payment: Partial payment for precast segments will be made at 65% of the bid price per cubic yard of concrete and per pound of reinforcement when the segment has been cast and accepted. Remaining payment will be made when the segment has been erected and accepted for incorporation into the structure. Payment for post-tensioning will be in accordance with Section 462.

452-13.6 Precast Segment-Non-Compliance: Any penalties or deductions for non-compliance with regard to concrete, reinforcement or post-tensioning will be applied to the work affected in accordance with the requirements of the respective specifications.

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452-13.7 Precast Segment Production: Preparatory operations for superstructure segment casting will be paid for separately at the Contract Lump Sum price for precast segment production. This item consists of the work necessary for establishing and putting into operation segment casting facilities. It includes preparatory work, operations, acquisition or lease of real property, acquisition or lease of segment manufacturing equipment, acquisition or lease of equipment for the handling, transport and storage of the segments, and all other work or operations which must be performed or costs incurred prior to the manufacture of the concrete segments, including engineering services such as shop drawings.

Partial payments will be made as indicated below:

1. Upon production of documentary evidence, such as paid invoices, canceled checks or similar executed financial instruments, the cost for the acquisition of the casting forms for the precast segments by purchase, lease or manufacture will be paid up to a limit of 25% of the Lump Sum Price bid.

2. When the first precast superstructure segment has been cast out of the first operable casting form and the segment is approved and accepted by the Engineer, 25% of the Lump Sum Price bid will be paid.

3. Thereafter, when each succeeding superstructure segment has been cast out of any operable casting form and approved and accepted by the Engineer, 5% of the Lump Sum Price bid will be paid for each segment up to a limit of 50% of the Lump Sum Price bid (i.e., 5% for each of the next ten acceptable segments).

The total Lump Sum Price bid under this item will not exceed the least of:

1. 12% of the sum of the amounts paid for the concrete in the precast segments only (i.e., excluding any cast-in-place concrete in joints, closures or designated cast-in-place segments) or

2. 5% of the Contract amount excluding mobilization and this item.

The balance of the Lump Sum Price not paid after completion of casting the first eleven satisfactory superstructure segments will be paid after completion of the erection of the first span or closure of the first pair of cantilevers, whichever occurs first.

452-13.8 Epoxy Jointing: No separate payment will be made for the work of epoxy jointing of precast concrete segments. The cost of this work will be included in payment for the various precast concrete items.

452-13.9 Payment Items:

Payment will be made under:

Item No. 400- 4- 39-	Class IV Concrete (Precast Superstructure Segments) - per cubic yard.
Item No. 400- 4- 40-	Class IV Concrete (Precast Substructure Segments) - per cubic yard.
Item No. 400- 8- 40-	Class V Concrete (Precast Substructure Segments) - per cubic yard.
Item No. 415- 1- 4-	Reinforcing Steel (Superstructure) - per pound.
Item No. 415- 1- 5-	Reinforcing steel (Substructure) - per pound.
Item No. 452- 70-	Precast Segment Production - lump sum.

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SECTION 455
STRUCTURES FOUNDATIONS

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A. GENERAL

455-1 General.

The Contractor may examine available soil samples and rock cores obtained during the soil boring operations at the appropriate District Materials Office.

455-1.1 Monitor Existing Structures: Monitor existing structures in accordance with Section 108.

455-1.2 Excavation: Complete all excavation of the foundations prior to installing piles or shafts unless otherwise authorized by the Engineer. After completing pile/shaft installation, remove all loose and displaced materials from around the piles/shafts, leaving a clean, solid surface. Compact the soil surface on which concrete is to be placed or which will support the forming system for the concrete to support the load of the plastic concrete without settling or causing the concrete to crack, or as shown in the Contract Documents.

455-1.2.1 Abutment (End Bent) Fill: Place and compact the fill before installing end-bent piling/shafts, except when driving specified test piling in end bents or the Plans show uncased piles through proprietary retaining wall fills.

When installing piles/shafts or casing prior to placing fill, take necessary precautions to prevent displacement of piles/shafts during placing and compacting fill materials within 15 feet of the piles/shafts or casing. Reference and check the position of the piles/shafts or casing at three approximately equal intervals during construction of the embankment.

Place embankment material in 6 inch compacted lifts in the 15 foot area around the piles/shafts or casing. Compact embankment material within the 15 foot area adjacent to the piles/shafts or casing to the required density with compaction equipment weighing less than 1,000 pounds. When installing piles/shafts prior to the completion of the surrounding fills, do not cap them until placing the fills as near to final grade as possible, leaving only the necessary working room for construction of the caps.

When shown in the Plans, provide permanent casings installed prior to placement of the fill, for all drilled shafts through mechanically stabilized fills (for example, behind proprietary retaining walls) for shafts installed after fill placement. Install temporary casings through the completed conventional fill when permanent casings are not required.

Provide permanent casings, if required, before the fill is placed extending a sufficient distance into the existing ground to provide stability to the casings during construction of the abutment fill.

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455-1.3 Cofferdams: Construct cofferdams as detailed in the Plans. When cofferdams are not detailed in the Plans, employ a qualified Specialty Engineer to design cofferdams, and to sign and seal the plans and specification requirements. Submit the designs to the Engineer for their records before beginning construction.

Provide a qualified diver and a safety diver to inspect the conditions of the foundation enclosure or cofferdam when the Contract Documents require a seal for construction. Equip these divers with suitable voice communications, and have them inspect the foundation enclosure and cofferdam periphery including each sheeting indentation and around each piling or drilled shaft to ensure that no layers of mud or other undesirable materials were left above the bottom of seal elevation during the excavation process. Also have the divers check to make sure the surfaces of the piles or drilled shafts are sufficiently clean to allow bond of the concrete down to the minimum bottom of seal elevation. Ensure that there are no mounds of stone, shell, or unapproved backfill material left after placement and grading. Assist the Engineer as required to ensure that the seal is placed as specified and evaluate the adequacy of the foundation soils or rock. Correct any deficiencies found by the divers. Upon completion of inspection by the divers, the Department may also elect to inspect the work before authorizing the Contractor to proceed with subsequent construction operations. Submit a written report by the divers to the Engineer indicating the results of their underwater inspection before requesting authorization to place the seal concrete.

455-1.4 Vibrations on Freshly Placed Concrete (Drilled Shafts and Piers): Ensure that freshly placed concrete is not subjected to peak particle velocities greater than 1.5 inches per second from vibration sources located within 30 feet (from the nearest outside edge of freshly placed concrete to the vibration source) until that concrete has attained its final set as defined by ASTM C403 except as required to remove temporary casings before the drilled shaft elapsed time has expired.

455-2 Static Compression Load Tests.

455-2.1 General: Employ a professional testing laboratory, or Specialty Engineer with prior load test experience on at least three projects, to conduct the load test in compliance with these Specifications, to record all data, and to submit reports of the test results to the Engineer except when the Contract Documents show that the Department will supply a Geotechnical Engineer to provide these services.

Perform the load test by applying a load up to the load required in the Contract Documents or to the failure load, whichever occurs first.

Do not apply test loads to piles sooner than 48 hours (or the time interval shown in the Plans) after driving of the test pile or reaction piles, whichever occurs last.

Do not begin static load testing of drilled shafts until the concrete has attained a compressive strength of 3,400 psi. The Contractor may use high early strength concrete to obtain this strength at an earlier time to prevent testing delays.

Load test piles/shafts in the order directed by the Engineer. Unless shown otherwise in the Contract Documents, provide all equipment, materials, labor, and technical personnel required to conduct the load tests, including determination of anchor reaction member depths. In this case, provide a loading apparatus designed to accommodate the maximum load plus an adequate safety factor.

While performing the load test, provide safety equipment, and employ safety procedures consistent with the latest approved practices for this work. Include with these safety

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procedures, adequate support for the load test plates and jack to prevent them from falling in the event of a release of load due to hydraulic failure, test pile/shaft failure, or any other cause.

Include in the bid the cost of transporting load test equipment and instrumentation supplied by the Department from their storage location to the job site and back. Handle these items with care. The Contractor is responsible for the safe return of these items. After completion of the static load tests, return all Department furnished equipment in satisfactory operating condition. Repair all damage to the test equipment furnished by the Department to the satisfaction of the Engineer. Clean all areas of rust on structural steel items, and recoat those areas in accordance with Section 560. Return all load test equipment supplied by the Department within 30 days after completing the load tests.

The Contractor is responsible for the equipment from the time it leaves its storage area until the time it is returned. During this time, insure the equipment against loss or damage for the replacement cost thereof (the greater of $150,000 or the amount shown in the Plans) or for the full insurable value if replacement cost insurance is not available.

Notify the Engineer at the preconstruction conference, or no later than 30 days before beginning test pile installation, of the proposed testing schedule so that items supplied by the Department may be reserved. Notify the Department at least ten working days before pick-up or return of the equipment. During pick-up, the Department will complete a checklist of all equipment placed in the Contractor's possession. The Department will later use this checklist to verify that the Contractor has returned all equipment. Provide personnel and equipment to load or unload the equipment at the Department's storage location. Provide lifting tongs or nylon slings to handle Department owned test girders. Do not perform cutting, welding, or drilling on Department owned girders, jacks, load cells, or other equipment.

455-2.2 Loading Apparatus: Provide an apparatus for applying the vertical loads as described in one of the following:

1. As shown and described in the Contract Documents.

2. As supplied by the Contractor, one of the following devices designed to accommodate a load at least 20% higher than the test load shown in the Plans or described herein for test loads:

a. Load Applied by Hydraulic Jack Acting Against Weighted Box or Platform: Construct a test box or test platform, resting on a suitable support, over the pile, and load it with material with a total weight greater than the anticipated maximum test load. Locate supports for the weighted box or platform at least 6 feet or three pile/shaft diameters, whichever is greater, measured from the edge of the pile or shaft to the edge of the supports. Insert a hydraulic jack with pressure gauge between the test pile or shaft and the underside of the reaction beam, and apply the load to the pile or shaft by operating the jack between the reaction beam and the top of the pile or shaft.

b. Load Applied to the Test Pile or Shaft by Hydraulic Jack Acting Against Anchored Reaction Member: Construct reaction member anchorages in accordance with article 6.3 of ASTM D1143. Attach a girder(s) of sufficient strength to act as a reaction beam to the upper ends of the anchor piles or shafts. Insert a hydraulic jack with pressure gauges between the head of the test pile/shaft and the underside of the reaction beam, and apply the test load to the pile/shaft by operating the jack between the reaction beam and the pile/shaft head.

If using drilled shafts with bells as reaction member anchorages, locate the top of the bell of any reaction shaft anchorage at least three shaft diameters below the bottom of the test shaft.

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c. Combination Devices: The Contractor may use a combination of devices (a) and (b), as described above, to apply the test load to the pile or shaft.

d. Other systems proposed by the Contractor and approved by the Engineer: When necessary, provide horizontal supports for loading the pile/shaft, and space them so that the ratio of the unsupported length to the minimum radius of gyration of the pile does not exceed 120 for steel piles, and the unsupported length to the least cross-section dimension does not exceed 20 for concrete piles or drilled shafts. Ensure that horizontal supports provide full support without restraining the vertical movement of the pile in any way.

When required by the Contract Documents, apply a horizontal load to the shaft either separately or in conjunction with the vertical load. Apply the load to the test shaft by hydraulic jacks, jacking against Contractor provided reaction devices. After receiving the Engineer's approval of the proposed method of load application, apply the horizontal load in increments, and relieve it in decrements as required by the Contract Documents.

455-2.2.1 Modified Quick Test:

1. Loading Procedure: Apply vertical loads concentric with the longitudinal axis of the tested pile/shaft to accurately determine and control the load acting on the pile/shaft at any time. Place the load on the pile/shaft continuously, in increments equal to approximately 5% of the maximum test load specified until approaching the failure load, as indicated by the measuring apparatus and/or instruments. Then, apply increments of approximately 2.5% until the pile/shaft "plunges" or attains the limiting load. The Engineer may elect to stop the loading increments when he determines the Contractor has met the failure criteria or when a settlement equal to 10% of the pile/shaft width or diameter is reached. Apply each load increment immediately after taking and verifying the complete set of readings from all gauges and instruments. Apply each increment of load within the minimum length of time practical, and immediately take the readings. Complete the addition of a load increment and the completion of the readings within 5 to 15 minutes. The Engineer may elect to hold the maximum applied load up to one hour.

Remove the load in decrements of about 10% of the maximum test load. Remove each decrement of load within the minimum length of time practical, and immediately take the readings. Complete the removal of a load decrement and the taking of the readings within 5 to 15 minutes. The Engineer may also require up to two reloading cycles with five loading increments and three unloading decrements. Record the final recovery of the pile/shaft until movement is essentially complete for a period up to one hour after the last unload interval.

2. Failure Criteria and Nominal Resistance: Use the criteria described herein to establish the failure load. The failure load is defined as the load that causes a pile/shaft top deflection equal to the calculated elastic compression plus 0.15 inches plus 1/120 of the pile/shaft minimum width or the diameter in inches for piles/shafts 24 inches or less in width, and equal to the calculated elastic compression plus 1/30 of the pile/shaft minimum width or diameter for piles/shafts greater than 24 inches in width. Consider the nominal resistance of any pile/shaft so tested as either the maximum applied load or the failure load, whichever is smaller.

455-2.3 Measuring Apparatus: Provide an apparatus for measuring movement of the test piles/shafts that consists of all of the following devices:

1. Wire Line and Scale: Stretch a wire as directed by the Engineer between two supports located at a distance at least:

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a. 10 feet from the center of the test pile but not less than 3.5 times the pile diameter or width.

b. 12 feet from the centerline of the shaft to be tested but not less than three shaft diameters.

Locate the wire supports as far as practical from reaction beam anchorages. At over-water test sites, the Contractor may attach the wire line as directed by the Engineer to the sides of the service platform. Mount the wire with a pulley on one support and a weight at the end of the wire to provide constant tension on the wire. Ensure that the wire passes across the face of a scale mounted on a mirror attached to the test pile/shaft so that readings can be made directly from the scale. Use the scale readings as a check on an average of the dial readings. When measuring both horizontal and vertical movement, mount separate wires to indicate each movement, horizontal or vertical. Measure horizontal movements from two reference wires set normal to each other in a horizontal.

2. Wooden Reference Beams and Dial Gauges: Attach wooden reference beams as detailed in the Plans or approved by the Engineer to independent supports. For piles, install the greater of 3.5 times the pile diameter or width or 10 feet from the centerline of the test pile. For drilled shafts, install at the greater of three shaft diameters or 12 feet from the centerline of the shaft to be tested. Locate the reference beam supports as far as practical from reaction beam anchorages. For over-water test sites, the Contractor may attach the reference beams as directed by the Engineer between two diagonal platform supports. Attach dial gauges, with their stems resting either on the top of the pile/shaft or on lugs or similar reference points on the pile/shaft, to the fixed beams to record the movement of the pile/shaft head. Ensure that the area on the pile/shaft or lug on which the stem bears is a smooth surface which will not cause irregularities in the dial readings.

Provide a minimum of four dial gauges, each with 0.001 inch divisions and with 2 inch minimum travel, placed at 90 degree intervals for measuring vertical or horizontal movement.

3. Survey Level: As a check on the dial gauges, determine the elevation of a point near the top of the test pile/shaft (on plan datum) by survey level at each load and unload interval during the load test. Unless approved otherwise by the Engineer, level survey precision is 0.001 foot. Alternately, the surveyor may read an engineer's 50 scale attached near the pile/shaft head. Determine the first elevation before applying the first load increment; make intermediate readings immediately before a load increment or an unload decrement, and after the final unload decrement that completely removes the load. Make a final reading at the time of the last recovery reading or as directed by the Engineer.

For over-water test sites, when shown in the Plans or directed by the Engineer, the Contractor shall drive an H pile through a 36 inch casing to provide a stable support for the level and to protect it against wave action interfering with level measurements. Provide a suitable movable jig for the surveyor to stand. Use a jig that has a minimum of three legs, has a work platform providing at least 4 feet width of work area around the casing, and is approved by the Engineer before use. The described work platform may be supported by the protective casing when approved by the Engineer.

455-2.4 Load Test Instrumentation:

1. General: The intent of the load test instrumentation is to measure the test load on top of the pile/shaft and, when provided in the Contract Documents, its distribution between side friction and end bearing to provide evaluation of the preliminary design calculations and

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settlement estimates and to provide information for final pile/shaft length design. Ensure that the instrumentation is as described in the Contract Documents.

When requested by the Engineer, provide assistance during installation of any instrumentation supplied by the Department. Supply 110 V, 60 Hz, 30 A of AC electric power in accordance with the National Electric Code (NEC) to each test pile/shaft site during the installation of the instrumentation, during the load testing, and during any instrumented redrives ordered by the Engineer.

Place all of the internal instrumentation on the rebar cage before installation in the test shaft. Construct the rebar cage at least two days before it is required for construction of the test shaft. Provide assistance during installation of instrumentation supplied by the Department, including help to string, place, and tie the instrumentation and any assistance needed in moving or repositioning the cage to facilitate installation. Place the rebar cage in one segment complete with its instrumentation. The Engineer may require multiple lift points and/or a suitable "stiffleg" (length of H pile or other suitable section) to get the cage in a vertical position without causing damage to the instrumentation. Successfully demonstrate the lifting and handling procedures before the installing instrumentation.

2. Hydraulic Jack and Load Cell: Provide hydraulic jack(s) of adequate size to deliver the required test load to the pile/shaft unless shown otherwise in the Plans. Before load testing begins, submit a certificate from a reputable testing laboratory showing a calibration of gauge readings for all stages of jack loading and unloading for jacks provided. Ensure that the jack has been calibrated within the preceding six months unless approved otherwise. Recalibrate the jack after completing load testing if so directed by the Engineer. Ensure that the accuracy of the gauge is within 5% of the true load.

Provide an adequate load cell approved by the Engineer that has been calibrated within the preceding six months. Provide an approved electrical readout device for the load cell. Submit a certificate from an independent testing laboratory showing a calibration of readings for all stages of loading and unloading for load cells furnished by the Contractor and obtain the approval of the Engineer before beginning load testing. Ensure that the accuracy of the load cell is within 1% of the true load.

3. Telltales: When shown in the Contract Documents, furnish and install telltales that consist of an unstressed steel rod placed, greased for reducing friction and corrosion, with appropriate clearance inside a constant-diameter pipe that rests on a flat plate attached to the end of the pipe at the point of interest shown in the Contract Documents. Construct telltales in accordance with the Contract Documents. Install dial gauges reading to 0.001 inch with 1 inch minimum travel as directed by the Engineer to measure the movement of the telltale with respect to the top of the pile/shaft.

4. Embedded Strain Gauges: When shown in the Contract Documents, furnish and install strain gauges in the test shaft to measure the distribution of the load. Ensure that the type, number, and location of the strain gauges are as shown in the Plans or as directed by the Engineer. Use strain gauges that are waterproof and have suitable shielded cable that is unspliced within the shaft.

455-2.5 Support Facilities: Furnish adequate facilities for making load and settlement readings 24 hours per day. Provide such facilities for the instrumented area, and include lighting and shelter from rain, wind, and direct sunlight.

455-2.6 Load Test Personnel Furnished by the Contractor: Provide a certified welder, together with necessary cutting and welding equipment, to assist with the load test setup and to

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make any necessary adjustments during the load test. Provide personnel to operate the jack, generators, and lighting equipment, and also provide one person with transportation to assist as required during load test setup and conducting of the load tests. Provide qualified personnel, as determined by a Specialty Engineer or testing lab, required to read the dial gauges, take level measurements, and conduct the load test, except when the Contract Documents show that the Department will provide these personnel.

455-2.7 Cooperation by the Contractor: Cooperate with the Department, and ensure that the Department has access to all facilities necessary for observation of the conduct and the results of the test.

455-2.8 Required Reports: Include in the report of the load test the following information:

1. A tabulation of the time of, and the amount of, the load and settlement readings, and the load and recovery readings taken during the loading and unloading of the pile/shaft.
2. A graphic representation of the test results, during loading and unloading of pile/shaft top movement as measured by the average of the dial gauge readings, from wireline readings and from level readings.
3. A graphic representation of the test results, when using telltales, showing pile/shaft compression and pile/shaft tip movement.
4. The estimated failure and safe loads according to the criteria described herein.
5. Remarks concerning any unusual occurrences during the loading of the pile/shaft.
6. The names of those making the required observations of the results of the load test, the weather conditions prevailing during the load test, and the effect of weather conditions on the load test.
7. All supporting data including jack and load cell calibrations and certificates and other equipment requiring calibration.
8. When the Contract Document requires internal instrumentation of the pile/shaft, furnish all of the data taken during the load test together with instrument calibration certifications. In addition, submit a report showing an analysis of the results of axial load and lateral load tests in which soil resistance along and against the pile/shaft is reported as a function of deflection.

Submit the necessary reports prepared by the Specialty Engineer responsible for collection and interpretation of the data, except when the Contract Documents show that the Department will provide a Geotechnical Engineer.

455-2.9 Disposition of Loading Material: Remove all equipment and materials, which remains the Contractor’s property, from the site. Clean up and restore the site to the satisfaction of the Engineer.

455-2.10 Disposition of Tested Piles/Shafts: After completing testing, cut off the tested piles/shafts, which are not to be incorporated into the final structure, and any reaction piles/shafts at an elevation 24 inches below the finished graded surface or as shown in the Plans. Take ownership of the cut-offs and provide areas for their disposal.

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B. PILING

455-3 Description.

Furnish and install concrete, steel, or timber piling including driving, jetting, preformed pile holes, cutting off, splicing, dynamic load testing, and static load testing of piling. Prior to driving, clearly mark the piles to facilitate inspection. Provide individual straight-line marks at 1-ft intervals legibly numbered at least every 5 ft. Use markers or lumber crayons or paint marks that can be easily observed by the inspector. Ensure marks are spaced uniformly and perpendicular to the face of the pile. Face pile so that the pile markings are readable by the pile inspector. When set checks or practical refusal checks are required, provide inch marks as directed by the Engineer.

In the event a pile is broken or otherwise damaged by the Contractor to the extent that the damage is irreparable due to mishandling or incorrect installation, in the opinion of the Engineer, the Contractor shall extract and replace the pile at no additional expense to the Department. In the event that a pile is mislocated by the Contractor, the Contractor shall extract and replace the pile, at no expense to the Department, except when a design change proposed by the Contractor is approved by the Department as provided in 455-5.16.5. In the event a pile is broken or otherwise damaged by no fault of the Contractor, the pile extraction and replacement will be paid for as Unforeseeable Work.

455-4 Classification.

The Department classifies piling as follows:

1. Treated timber piling.
2. Prestressed concrete piling.
3. Steel piling.
4. Test piling.
5. Sheet piling.
    a. Concrete sheet piling.
    b. Steel sheet piling.
6. Polymeric Piles (see Section 471 for requirements).

455-5 General Requirements.

455-5.1 Predrilling of Pile Holes: Predrilled pile holes are either starter holes to the depth described in this Subarticle or holes drilled through embankment/fill material down to the natural ground surface. When using low displacement steel piling such as structural shapes, drive them through the compacted fill without the necessity of drilling holes through the fill except when the requirements for predrilling are shown in the Plans. When using concrete or other high displacement piles, drill pile holes through fill, new or existing, to at least the elevation of the natural ground surface. Use a drill with a diameter not greater than the largest dimension of the pile. Accurately drill the pile holes with the hole centered over the Plan location of the piling. Maintain the location and vertical alignment within the tolerances allowed for the piling.

For predrilled holes required through rock or other hard materials shown in the Plans that may damage the pile during installation, predrill hole diameters approximately 2 inches larger than the largest dimension across the pile cross-section. Fill the annular space around the piles as described in 455-5.10.1 with clean sand.

In the setting of permanent and test piling, the Contractor may initially predrill holes to a depth up to 20% of the test pile length, unless approved otherwise by the Engineer or

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required by the Plans. Predrill holes for production piles in the same manner as the test piles. With prior written authorization from the Engineer, the Contractor may predrill holes to greater depths to minimize the effects of vibrations on existing structures adjacent to the work and/or for other reasons the Contractor proposes.

455-5.2 Underwater Driving: Underwater driving is defined as any driving through water which is above the pile head at the time of driving.

When conducting underwater driving, provide a diver equipped with voice communications to aid in placing the hammer back on the pile for required cushion changes or for subsequent redriving, to attach or recover instrumentation the Engineer is using, to inspect the condition of the pile, or for other assistance as required.

Select one of the following methods for underwater driving:

1. Accomplish underwater driving using conventional driving equipment and piling longer than authorized so that the piling will extend above the water surface during final driving. When choosing this option, furnish a pile hammer that satisfies the requirements of this Section for use with the longer pile.

2. Accomplish underwater driving using an underwater hammer that meets the requirements of this Section and is approved by the Engineer. When choosing this option, provide at least one pile longer than authorized at each pile group, extending above the water surface at final driving. At each group location, drive the longer pile first. The Engineer will evaluate the adequacy of the underwater driving system. The Engineer may use the pile tip elevation of the longer pile that the Contractor has driven and the Engineer has accepted, to evaluate the acceptability of the piles driven with the underwater hammer.

3. Accomplish underwater driving using conventional driving equipment with a suitable approved pile follower. When choosing this option, provide at least one pile longer than required at each pile group, extending above the water surface at final driving. At each group location, drive the full length pile first without using the follower. The Engineer will evaluate the adequacy of the follower used for underwater driving. The Engineer may choose to perform a dynamic load test on the first pile the Contractor drives with the follower in each group. The Engineer may use the pile tip elevation of the longer pile, that the Contractor has driven and the Engineer has accepted, to evaluate the acceptability of the piles driven with the follower.

Prior to use, submit details of the follower for the Engineer's evaluation and approval along with the information required in 455-10. Include the weight, cross-section details, stiffness, type of materials, and dimensions of the follower.

455-5.3 Pile Hammers: All equipment is subject to satisfactory field performance during and without dynamic testing. Use a variable energy hammer to drive concrete piles. Hammers will be rated based on the theoretical energy of the ram at impact. Supply driving equipment which provides the required resistance at a blow count ranging from 3 blows per inch (36 blows per foot) to 10 blows per inch (120 blows per foot) at the end of initial drive, unless approved otherwise by the Engineer after satisfactory field trial. Ensure the hammer is capable of driving to a resistance equal to at least 2.0 times the factored design load plus the scour and down drag resistance shown in the Contract Documents, without overstressing the piling in compression or tension and without reaching or exceeding 20 blows per inch. When the Engineer determines the stroke height or bounce chamber pressure readings do not adequately determine the energy of the hammer, provide and maintain a device to measure the velocity of the ram at impact. Determine the actual hammer energy in the field so that it is consistent with the hammer energy used for

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each bearing capacity determination. When requested, submit to the Engineer all technical specifications and operating instructions related to hammer equipment.

455-5.3.1 Air: Variable energy air hammers shall be capable of providing at least two ram stroke lengths. The short ram stroke length shall be approximately half of the full stroke for hammers with strokes up to 4 feet and no more than 2 feet for hammers with maximum strokes lengths over 4 feet. Operate and maintain air hammers within the manufacturer's specified ranges. Use a plant and equipment for air hammers with sufficient capacity to maintain, under working conditions, the hammer, volume and pressure specified by the manufacturer. Equip the plant and equipment with accurate pressure gauges which are easily accessible to the Engineer. The Engineer will not accept final bearing on piles the Contractor drives with air hammers unless the Contractor operates the hammers within 10% of the manufacturer's rated speed in blows per minute, unless otherwise authorized by the Engineer. Provide and maintain in working order for the Engineer's use an approved device to automatically determine and display the blows per minute of the hammer.

455-5.3.2 Diesel: Variable energy diesel hammers shall have at least three fuel settings that will produce reduced strokes. Operate and maintain diesel hammers within the manufacturer's specified ranges. Determine the rated energy of diesel hammers using measured ram stroke length multiplied by the weight of the ram for open end hammers and by methods recommended by the manufacturer for closed end hammers.

Equip closed-end (double acting) diesel hammers with a bounce chamber pressure gauge, in good working order, mounted near ground level so the Engineer can easily read it. Also, submit to the Engineer a chart, calibrated to actual hammer performance within 30 days prior to initial use, equating bounce chamber pressure to either equivalent energy or stroke for the closed-end diesel hammer to be used.

455-5.3.3 Hydraulic: Variable energy hydraulic hammers shall have at least three hydraulic control settings that provide for predictable energy or equivalent ram stroke. The shortest stroke shall be a maximum of 2 feet for the driving of concrete piles. The remaining strokes shall include full stroke and approximately halfway between minimum and maximum stroke.

Supply hammer instrumentation with electronic read out, and control unit that allows the Engineer to monitor, and the operator to read and adjust the hammer energy or equivalent ram stroke. When pressure measuring equipment is required to determine hammer energy, calibrate the pressure measuring equipment before use.

455-5.3.4 Vibratory: Vibratory hammers of sufficient capacity (force and amplitude) may be used to drive steel sheet piles and, with approval of the Engineer, to drive steel bearing piles a sufficient distance to get the impact hammer on the pile (to stick the pile). The Engineer will determine the allowable depth of driving using the vibratory hammer based on site conditions. However, in all cases, use a power impact hammer for the last 15 feet or more of the final driving of steel bearing piles for bearing determinations after all piles in the bent/pier have been driven with a vibratory hammer. Do not use vibratory hammers to install concrete piles, or to install support or reaction piles for a load test.

455-5.3.5 Pile Inspection Device: Provide a pile inspection device that displays and stores electronically for every hammer blow along with a timestamp: stroke for open-ended diesel hammers and blows per foot and blows per minute for all hammers. The device must auto-generate the Department's Pile Driving Record form and export the non-editable electronic data

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in a format compatible with the Pile Driving Record form. Use this device during the inspection of test piles and production piles.

455-5.4 Cushions and Pile Helmet:

455-5.4.1 Capblock: Provide a capblock (also called the hammer cushion) as recommended by the hammer manufacturer. Use commercially manufactured capblocks constructed of durable manmade materials with uniform known properties. Do not use wood chips, wood blocks, rope, or other material which permit excessive loss of hammer energy. Do not use capblocks constructed of asbestos materials. Obtain the Engineer's approval for all proposed capblock materials and proposed thickness for use. Maintain capblocks in good condition, and replace them when charred, melted, or otherwise significantly deteriorated. The Engineer will inspect the capblock before driving begins and at appropriate intervals determined by the Engineer based on field trial. Replace or repair any capblock which loses more than 25% of its original thickness, in accordance with the manufacturer's instructions, before permitting further driving.

455-5.4.2 Pile Cushion: Provide a pile cushion that is adequate to protect the pile from being overstressed in compression and tension during driving. Use a pile cushion sized so that it will fully fill the lateral dimensions of the pile helmet minus one inch but does not cover any void or hole extending through the top of the pile. Determine the thickness based upon the hammer-pile-soil system. For driving concrete piles, use a pile cushion made from pine plywood or oak lumber. Alternative materials may be used with the approval of the Engineer. Do not use materials previously soaked, saturated or treated with oil. Maintain pile cushions in good condition and replace them when charred, splintered, excessively compressed, or otherwise deteriorated to the point it will not protect the pile against overstressing in tension or compression. Protect cushions from the weather, and keep them dry. Do not soak the cushions in any liquid. Provide a new cushion for each pile unless approved otherwise by the Engineer after satisfactory field trial during dynamic testing.

During dynamic load tests, replace the pile cushion when any of the pile stress measurements exceed the maximum allowed pile stress determined by 455-5.12.2. When driving a pile without dynamic testing, replace the pile cushion when the cushion is either compressed more than one-half the original thickness, begins to burn, or as directed by the Engineer after field performance.

Reuse pile cushions in good condition to perform all set-checks and redrives. Use the same cushion to perform the set-check or redrive as was used during the initial driving, unless this cushion is unacceptable due to deterioration, in which case use a similar cushion.

455-5.4.3 Pile Helmet: Provide a pile helmet suitable for the type and size of piling being driven. Use a pile helmet deep enough to adequately contain the required thickness of pile cushion and to assist in maintaining pile-hammer alignment. Use a pile helmet that fits loosely over the pile head and is at least 1 inch larger than the pile dimensions. Use a pile helmet designed so that it will not restrain the pile from rotating.

455-5.5 Leads: Provide pile leads constructed in a manner which offers freedom of movement to the hammer and that have the strength and rigidity to hold the hammer and pile in the correct position and alignment during driving. When using followers, use leads that are long enough and suitable to maintain position and alignment of the hammer, follower, and pile throughout driving.

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455-5.6 Followers: When using followers, perform dynamic load testing as per 455-5.14. Obtain the Engineer's approval for the type of follower, when used, and the method of connection to the leads and pile. Use followers constructed of steel with an adequate cross-section to withstand driving stresses. When driving concrete piles, ensure that the cross-sectional area of the follower is at least 18% of the cross-sectional area of the pile. When driving steel piles, ensure that the cross-sectional area of the follower is greater than or equal to the cross-sectional area of the pile. Provide a pile helmet at the lower end of the follower sized according to the requirements of 455-5.4.3. Use followers constructed that maintain the alignment of the pile, follower, and hammer and still allow the pile to be driven within the allowable tolerances. Use followers designed with guides adapted to the leads that maintain the hammer, follower, and the piles in alignment.

Use information from dynamic load tests described in 455-5.14 to evaluate the adequacy of the follower and to determine pile capacity.

455-5.7 Templates and Ground Elevations: Provide a fixed template, adequate to maintain the pile in proper position and alignment during driving with swinging leads or with semi-fixed leads. The Engineer may allow the use of templates attached to a barge if the Contractor demonstrates satisfactory that the pile alignment, and the elevation and horizontal position of the template can be maintained during all pile driving operations. Where practical, place the template so that the pile can be driven to cut-off elevation before removing the template. Ensure that templates do not restrict the vertical movement of the pile.

Supply a stable reference close to the pile, which is satisfactory in the opinion of the Engineer, for determination of the pile penetration. At the time of driving piles, furnish the Engineer with elevations of the original ground and template at each pile or pile group location. Note the highest and lowest elevation at each required location and the ground elevation at all piles.

455-5.8 Water Jets: Use jet pumps, supply lines, and jet pipes that provide adequate pressure and volume of water to freely erode the soil. Do not perform jetting without prior approval by the Engineer or unless allowed by the Plans.

Do not perform jetting in the embankment or for end bents. Where conditions warrant, with approval by the Engineer, perform jetting on the holes first, place the pile therein, then drive the pile to secure the last few feet of penetration. Only use one jet for prejetting (jetting before setting the pile). Use at-least two jets when jetting and driving. Position the jet(s) slightly behind the advancing pile tip (approximately 3 feet or as approved by the Engineer). Use at-least two jets when jetting and driving. When using water jets in the driving, determine the pile bearing only from the results of driving after withdrawing the jets, except where using jets to continuously eliminate soil resistance through the scour zone, ensure that they remain in place as directed by the Engineer and operating during pile bearing determination. Where practical, perform jetting on all piles in a pile group before driving begins. When large pile groups or pile spacing and batter make this impractical, or when the Plans specify a jet-drive sequence, set check a sufficient number of previously driven piles in a pile group to confirm their capacity after completing all jetting.

455-5.9 Penetration Requirements: Measure the penetration of piles from the elevation of the natural ground, the existing surface, the deepest scour elevation shown in the Pile Data Table, or the bottom of excavation, whichever is lowest. The Engineer will accept the bearing of a pile only if the Contractor achieves the required bearing when the tip of the pile is at or below

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the specified minimum tip elevation and below the bottom of the preformed or predrilled pile hole.

Do not drive piles beyond practical refusal. To meet the requirements in this Subarticle, provide penetration aids, such as jetting or preformed pile holes, when piles cannot be driven to the required penetration without reaching practical refusal.

If the Contractor encounters unforeseeable, isolated obstructions that the Contractor cannot practically penetrate by driving, jetting, or preformed pile holes, and the Contractor must remove the pile to obtain the required pile penetration, the Department will pay the costs for such removal as Unforeseeable Work.

455-5.10 Preformed Pile Holes:

455-5.10.1 Description: Preformed pile holes serve as a penetration aid when all other pile installation methods fail to achieve the minimum tip elevation shown in the Plans or, when authorized by the Engineer, to minimize the effects of vibrations on adjacent structures. The Engineer may require preformed holes for any type of pile. Drive all piles installed in preformed pile holes to determine that the bearing requirements have been met. The bottom of the preformed hole is considered the lowest elevation the preforming operation matched the largest dimension of the pile.

For preformed holes which are required through material that caves during driving to the extent that the preformed hole does not serve its intended purpose, case the hole from the surface through caving material in accordance with the Contract Documents. After installing the pile to the bottom of the casing, remove the casings unless shown otherwise in the Plans. Determine bearing of the pile after removing the casing unless shown otherwise in the Plans. Fill all voids between the pile and soil remaining after driving through preformed holes with clean sand after the pile has achieved the required minimum tip elevation, unless grouting of preformed pile holes is shown in the Plans. If pile driving is interrupted during sand placement, drive the pile at least 20 additional blows after filling all of the voids between the pile and soil with sand at no additional cost to the Department.

455-5.10.2 Provisions for Use of Preformed Pile Holes: The Department will anticipate the necessity for preformed pile holes and include directions in the Plans. The Department considers, but does not limit to, the following conditions as reasons for preformed pile holes:

1. Inability to drive piles to the required penetration with driving and jetting equipment.
2. To penetrate a hard layer or layers of rock or strong stratum that the Engineer considers not sufficiently thick to support the structure.
3. To obtain greater penetration into dense (strong) material and into dense material containing holes, cavities or unstable soft layers.
4. To obtain penetration into a stratum in which it is desired to found the structure.
5. To minimize the effects of vibrations or heave on adjacent existing structures.
6. To minimize the effects of ground heave on adjacent piles.

455-5.10.3 Conditions Under Which Payment Will Be Made: The Department will make payment for preformed pile holes shown in the Plans, required by the Engineer or where the Contractor demonstrates that such work is necessary to achieve the required penetration without overstressing the pile.

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455-5.10.4 Construction Methods: Construct preformed pile holes by drilling, or driving and withdrawing a suitable punch or chisel guided by a template or using drilling equipment with fixed leads at the locations of the piles. Construct a hole that is equal to or slightly greater than the largest pile dimension for the entire length of the hole and of sufficient depth to obtain the required penetration. Do not exceed the minimum dimensions necessary to achieve the required penetration of the pile. When the Plans call for grouting the preformed pile holes, provide a pile hole dimension 2 to 4 inches larger than the largest pile dimension. Construct the holes at the Plan position of the pile and the tolerances in location, and ensure the hole is straight and that the batter is the same as specified for the pile. Loose material may remain in the preformed pile hole if the conditions in 455-5.10.1 are satisfied.

455-5.10.5 Grouting of Pile Holes: Clean and grout preformed pile holes for bearing piles, when the Plans require grouting after driving. Use grout that meets the requirements of 455-40 to 455-42 and has a minimum compressive strength of 3,000 psi at 28 days or as specified in the Plans. Prepare cylinders and perform QC testing in accordance with 455-43. LOT size and verification will be in accordance with 455-43. Pump the grout through three or more grout pipes initially placed at the bottom of the preformed hole. Raise the grout pipes when necessary to prevent clogging and to complete the grouting operations. Maintain the grout pipes below the surface of the previously placed grout. Continue grouting until the grout reaches the ground surface all around the pile. Provide divers to monitor grouting operations when the water depth is such that it is impractical to monitor from the ground surface. In the event that the Engineer determines the Contractor must grout and the required grouting is not shown in the Plans, the Department will pay for the grouting work as Unforeseeable Work.

455-5.11 Bearing Requirements:

455-5.11.1 General: Drive piles to provide the bearing required for carrying the loads shown in the Plans. For all types of bearing piles, consider the driving resistance as determined by the methods described herein sufficient for carrying the specified loads as the minimum bearing which is accepted for any type of piles. Determine pile bearing using the method described herein or as shown in the Plans.

For foundations requiring 100% dynamic testing of production piles, ensure each pile has achieved minimum penetration requirements in 455-5.9 and the required bearing for minimum 6 inches of consecutive driving, or when the minimum penetration is achieved, driving has reached practical refusal in firm material and the bearing capacity is obtained in all the refusal blows.

For foundations not requiring 100% dynamic testing of production piles, ensure each pile has achieved the minimum penetration requirements in 455-5.9, the blow count is generally the same or increasing and the minimum required bearing capacity obtained for 24 inches of consecutive driving with less than 1/4 inch rebound per blow, or achieved the minimum penetration requirements in 455-5.9 and driving has reached practical refusal in accordance with 455-5.11.3

With concurrence of the Engineer, the Dynamic Testing Engineer (DTE) may modify the scour resistance shown in the Plans if the dynamic load test is used to determine the actual soil resistance through the scour zone.

455-5.11.2 Bearing Criteria: For foundations requiring 100% dynamic testing, the DTE will determine the bearing of all piles using the data received from dynamic load testing equipment utilizing internally or externally mounted sensors according to the methods described in 455-5.12.1.

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For foundations not requiring 100% dynamic testing, the DTE shall forward a signed and sealed driving criteria letter indicating the minimum blow counts at each hammer stroke expected during driving to safely install the pile based on the test pile data and analyses to the Engineer at least one working day before driving the piles. The letter will contain an itemized list of the blow count criteria for acceptance of the piles, maximum strokes, criteria to replace cushions and any other conditions and limitations deemed appropriate for the safe installation of the piles. Drive all piles to the blow count criteria established by the DTE using the methods described herein and presented in the driving criteria letter.

If the pile is driven to approximately 12 inches above cut-off without reaching the required resistance, interrupt driving to perform an instrumented set-check.

455-5.11.3 Practical Refusal: Practical refusal is defined as 20 blows per inch or less than one inch penetration, with the hammer operating at the highest setting determined by the DTE for driving piles without damage and less than 1/4 inch rebound per blow. Stop driving as soon as the pile has reached practical refusal.

455-5.11.4 Set-checks and Pile Redrive:

1. Set-checks: Set-checks consist of redriving the pile after a certain period of time, typically within the same day. Perform set-checks as required and at the waiting periods shown in the Contract Documents. Provide an engineer's level or other suitable equipment for elevation determinations to determine accurate pile penetration during the set-checks. A pile may be accepted when a set-check shows that it has achieved the minimum required pile bearing and has met all other requirements of this Section.

2. Pile Redrive: Pile redrive consists of redriving the pile after the following working day from initial driving to determine time effects, to reestablish pile capacity due to pile heave, or for other reasons.

3. Uninstrumented Set-Checks and Uninstrumented Pile Redrive: Piles may be accepted based on uninstrumented set-checks or uninstrumented pile redrives only when the piles are redriven for at least 24 inches. In these cases, the piles may be considered to have sufficient bearing resistance when the specified blow count criteria is achieved in accordance with 455-5.11.1 and 455-5.11.2. Unless practical refusal is obtained as defined in 455-5.11.3, set-checks or redrives for piles redriven less than 24 inches must be instrumented for pile acceptance.

4. Instrumented Set-Checks and Instrumented Pile Redrive: Use dynamic load tests using at least 6 hammer blows to determine whether the pile bearing is sufficient. The pile may be considered to have sufficient bearing resistance when dynamic measurements demonstrate the static pile resistance exceeds the required pile resistance for at least one hammer blow and the average static pile resistance during the next five hammer blows exceeds 95% of the required pile resistance. If the pile is advanced farther, the static pile resistance during all subsequent blows must exceed 90% of the required pile resistance.

455-5.11.5 Pile Heave: Pile heave is the upward movement of a pile from its originally driven elevation. Drive the piles in an approved sequence to minimize the effects of heave and lateral displacement of the ground. Monitor piles previously driven in a pile group for possible heave during the driving of the remaining piles. Take elevation measurements to determine the magnitude of the movement of piles and the ground surface resulting from the driving process. Redrive all piles that have heaved 1/4 inches or more .

455-5.11.6 Piles with Insufficient Bearing: When the bearing capacity of any pile is less than the required bearing capacity, the Contractor may splice the pile and continue

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driving or may extract the pile and drive a pile of greater length, or, if so ordered by the Engineer, drive additional piles.

455-5.11.7 Optional Soil Set-up approach: Production piles that are driven to less than the Nominal Bearing Resistance (NBR) may be accepted based on the anticipated soil setup without set checks on all piles, only if the following criteria are met:

1. Pile tip penetration satisfies the minimum penetration requirements in 455-5.9.

2. End of Initial Drive (EOID) resistance exceeds 1.10 times the Factored Design Load for the pile bent/pier, as determined by the dynamic testing or blow count criteria.

3. The Resistance Factor for computing NBR is taken from the following table:

Table 455-1
Resistance Factors for Pile Installation Using Soil Setup (all structures)

Loading	Design Method	Construction QC Method	Resistance Factor, φ	
			Blow Count Criteria[4]	100% Dynamic Testing[5]
Compression	Davisson Capacity	EDC[1], or PDA/GPC[2]	0.55	0.60
		Static Load Testing[3]	0.65	0.70
		Statnamic Load Testing[3]	0.60	0.65
Uplift	Skin Friction	EDC[1], or PDA/GPC[2]	0.45	0.50
		Static Load Testing[3]	0.55	0.55

1. Using the analysis methods published by Tran et al (2012).
2. Dynamic Load Testing and Signal Matching Analysis.
3. Used to confirm the results of Dynamic Load Testing and Signal Matching Analysis.
4. Initial drive of production piles using Blow Count Criteria.
5. Initial drive of all piles accepted by results of Dynamic Testing of all blows.

4. At least one test pile is driven at each bent/pier with a successful set check at the anticipated production pile tip elevations and one of the following sets of dynamic load testing conditions are met at each bent/pier.

a. The bearing of at least 10% of piles in the bent/pier (round up to the next whole number) is confirmed by instrumented set-check, and all test piles and instrumented set-checks demonstrate the pile resistance exceeds the NBR within seven days after EOID

b. The bearing of at least 20% of piles in the bent/pier (round up to the next whole number) is confirmed by instrumented set-check, and all test piles and instrumented set-checks demonstrate the pile resistance exceeds the NBR within 21 days after EOID.

5. All uninstrumented piles are driven deeper and to a greater EOID resistance than the EOID resistance of all instrumented production piles in the same bent/pier.

455-5.12 Methods to Determine Pile Capacity:

455-5.12.1 General: Dynamic load tests using an externally mounted instrument system and signal matching analyses or embedded gauges will be used to determine pile capacity for all structures or projects unless otherwise shown on the Plans. Notify the Engineer two working days prior to placement of piles within the template and at least one working day prior to driving piles. Do not drive piles without the presence of the Engineer.

455-5.12.2 Wave Equation:

1. Use Wave Equation Analysis for Piles (WEAP) programs to evaluate the suitability of the proposed driving system (including the hammer, follower, capblock and pile

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cushions) as well as to estimate the driving resistance, in blows per 12 inches or blows per inch, to achieve the pile bearing requirements and to evaluate pile driving stresses.

Use Wave Equation Analyses to show the hammer meets the requirements described in 455-5.3 and maximum allowed pile stresses are not exceeded.

2. Required Equipment for Driving: Hammer approval is based on satisfactory field performance including dynamic load test results. In the event piles require different hammer sizes, the Contractor may elect to drive with more than one size hammer or with a variable energy hammer, provided the hammer is properly sized and cushioned, will not damage the pile, and will develop the required resistance.

3. Maximum Allowed Pile Stresses:

a. General: The maximum allowed driving stresses for concrete, steel, and timber piles are given below. In the event dynamic load tests show that the hammer will overstress the pile, modify the driving system or method of operation as required to prevent overstressing the pile. In such cases provide additional cushioning, reduce the stroke, or make other appropriate agreed upon changes.

b. Prestressed Concrete Piles: Use the following equations to determine the maximum allowed pile stresses:

$$s_{apc} = 0.7 f'_c - 0.75 f_{cpe} \qquad (1)$$

$$s_{apt} = 6.5(f'_c)^{0.5} + 1.05 f_{cpe} \qquad \text{(2a) for piles less than 50 feet long}$$

$$s_{apt} = 3.25(f'_c)^{0.5} + 1.05 f_{cpe} \qquad \text{(2b) for piles 50 feet long and greater}$$

$$s_{apt} = 500 \qquad \text{(2c) within 20 feet of a mechanical splice}$$

where:

s_{apc}= maximum allowed pile compressive stress, psi
s_{apt}= maximum allowed pile tensile stress, psi
f'_c= specified minimum compressive strength of concrete, psi
f_{cpe}= effective prestress (after all losses) at the time of driving, psi, taken as 0.8 times the initial prestress force divided by the minimum net concrete cross-sectional area of the pile (f_{cpe}= 0 for dowel spliced piles).

c. Steel Piles: Ensure the maximum pile compression and tensile stresses measured during driving are no greater than 0.9 times the yield strength (0.9 f_y) of the steel.

d. Timber Piles: Ensure the maximum pile compression and tensile stresses measured during driving are no greater than 3.6 ksi for Southern Pine and Pacific Coast Douglas Fir and 0.9 of the ultimate parallel to the grain strength for piles of other wood.

455-5.12.3 Temporary Piles: Submit for the Engineers review, an analysis signed and sealed by a Specialty Engineer which establishes the pile lengths for temporary piles required for structures which affect public safety. Submit for the Engineers approval, a Wave Equation analysis signed and sealed by a Specialty Engineer which establishes the driving criteria for temporary piles at least five working days prior to driving temporary production piles. The required driving resistance is equal to the sum of the factored design load plus the scour and

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down drag resistances shown in the Plans, divided by the appropriate resistance factor or the nominal bearing resistance shown in the Plans, whichever is higher.

The maximum resistance factor is 0.45 when only wave equation analysis is performed. However, a larger resistance factor may be applicable when additional testing is provided by the Specialty Engineer in accordance with Section 3.5.6 of Volume 1 of the FDOT Structures Manual. If the Contractor elects to perform 100% dynamic load testing submit a certification package prepared by the Specialty Engineer. The certification package shall include a signed and sealed letter by the Specialty Engineer that certifies the piles meet the load requirements and have no integrity deficiencies. The package shall also include the dynamic load test records, all signal matching analysis performed to determine pile capacities and a summary table that indicates the final capacity of every pile.

455-5.12.4 Dynamic Load Tests: Dynamic load testing consists of estimating pile capacity by the analysis of electronic data collected from blows of the hammer during driving of an instrumented pile in accordance with 455-5.14.

455-5.12.5 Static Load Tests: Static load testing consists of applying a static load to the pile to determine its capacity. Use the Modified Quick Test Procedure in accordance with 455-2.2.1.

455-5.12.6 Fender Pile Installation: For piles used in fender systems, regardless of type or size of pile, either drive them full length or jet the piles to within 2 feet of cutoff and drive to cutoff elevation to seat the pile. The Engineer will not require a specific driving resistance unless noted in the Plans. Use methods and equipment for installation that do not damage the piles. If the method or equipment used causes damage to the pile, modify the methods or equipment at no expense to the Department.

455-5.12.7 Structures Without Test Piles: For structures without 100% dynamic testing or test piles, the DTE will dynamically test the first pile(s) in each bent or pier at locations shown in the Plans to determine the blow count criteria for the remaining piles. The DTE shall forward the driving criteria letter to the Engineer in accordance with 455-5.11.2, except that the letter may be submitted as soon as the driving criteria is determined if piles are driven the same day. The DTE will dynamically test or perform an instrumented set-check on at least 5% of the piles at each bent or pier (rounded up to the next whole number).

455-5.13 Test Piles:

455-5.13.1 General: All test piles will have dynamic load tests. Drive piles of the same cross-section and type as the permanent piles shown in the Plans, in order to determine any or all of the following:

1. installation criteria for the piles.
2. nature of the soil.
3. lengths of permanent piles required for the work.
4. driving resistance characteristics of the various soil strata.
5. amount of work necessary to obtain minimum required pile penetration.
6. ability of the driving system to do the work.
7. need for point protection.

Because test piles are exploratory in nature, drive them harder (within the limits of practical refusal), deeper, and to a greater bearing resistance than required for the permanent piling. Except for test piles which are to be statically or Statnamically load tested, drive test piles their full length or to practical refusal. Splice test piles which have been driven

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their full length without achieving the required bearing, and proceed with further driving unless otherwise directed by the Engineer.

As a minimum, unless otherwise directed by the Engineer, do not cease driving of test piles until obtaining the required bearing capacity continuously, where the blow count is increasing, for 10 feet unless reaching practical refusal first. Drive test piles which are to be statically or Statnamically load tested as anticipated for the production piles.

When test piles attain practical refusal prior to attaining minimum penetration, perform all work necessary to attain minimum penetration and the required bearing. Where practical, use water jets to break the pile loose for further driving. Where jetting is impractical, extract the pile and install a preformed pile hole through which driving will continue. The Department will consider the work of extracting the pile to be Unforeseeable Work.

When driving test piles other than low displacement steel test piles, have preforming equipment available at the site and water jets as specified in 455-5.8 when jetting is allowed, ready for use, before the test pile driving begins.

The Engineer may elect to interrupt pile driving up to four times on each test pile, two times for up to two hours and two additional times during the next working day of initial driving to determine time effects during the driving of test piles.

455-5.13.2 Location of Test Piles: Drive all test piles in the position of permanent piles at the locations shown in the Plans. Ensure that all test piles designated to be statically load tested are plumb. In the event that all the piles are battered at a static load test site, the Engineer will designate an out-of-position location for driving a plumb pile for the static load test.

455-5.13.3 Equipment for Driving: Use the same hammer and equipment for driving test piles as for driving the permanent piles. Also use the same equipment to redrive piles.

455-5.14 Dynamic Load Tests: The DTE will take dynamic measurements during the driving of piles designated in the Plans or authorized by the Engineer. For concrete piles, install instruments prior to driving and assist the Engineer in monitoring all blows delivered to the pile. For steel production piles, the Engineer may accept instrumented set-checks or redrives. The Engineer will perform dynamic load tests to evaluate any or all of the following:

1. Suitability of the Contractor’s driving equipment, including hammer, capblock, pile cushion, and any proposed follower.
2. Pile capacity.
3. Pile stresses.
4. Energy transfer to pile.
5. Distribution of soil resistance.
6. Soil variables including quake and damping.
7. Hammer-pile-soil system for Wave Equation analyses.
8. Pile installation problems.
9. Pile integrity
10. Other.

Either supply and install embedded gauges in the piles in accordance with Standard Plans, Index 455-003 or attach instruments (strain transducers to measure force and accelerometers to measure acceleration) with bolts to the pile for dynamic testing.

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Make each follower and pile to be dynamically tested with externally attached instruments available to drill holes for attaching instrumentation and for wave speed measurements. Support the pile with timber blocks placed at appropriate intervals. Ensure that the pile is in a horizontal position and does not contact adjacent piles. Provide a sufficient clear distance at the sides of the pile for drilling the holes. The Engineer will furnish the equipment, materials, and labor necessary for drilling holes and taking the wave speed measurements. If the Engineer directs dynamic load testing, instrumented set-checks or instrumented redrives, provide the Engineer safe access to the top of the piles for drilling the attachment holes. After placing the leads provide the Engineer safe access to the piles to attach the instruments and for removal of the instruments after completing the pile driving.

The Engineer will monitor the stresses in the piles with the dynamic test equipment during driving to ensure the Contractor does not exceed the maximum allowed stresses. If necessary, add additional cushioning, replace the cushions, or reduce the hammer stroke to maintain stresses below the maximum allowable. If dynamic test equipment measurements indicate non-axial driving, immediately realign the driving system. If the cushion is compressed to the point that a change in alignment of the hammer will not correct the problem, add cushioning or change the cushion as directed by the Engineer.

Drive the pile to the required penetration and resistance or as directed by the Engineer.

When directed by the Engineer, perform instrumented set-checks or redrives. Do not use a cold diesel hammer for a set-check or redrive unless in the opinion of the Engineer it is impractical to do otherwise. Warm up the hammer by driving another pile or applying at least 20 blows to a previously driven pile or to timber mats placed on the ground.

455-5.15 Pile Lengths:

455-5.15.1 Test Pile Length: Provide the length of test piles shown in the Plans or as directed by the Engineer.

455-5.15.2 Production Pile Length:

455-5.15.2.1 Structures with Test Piles: When test pile lengths are shown in the Plans, the production pile bid quantity is based on information available during design and estimated pile lengths. Production pile lengths shall be recommended by the DTE for the Engineer's approval based on all information available before the driving of the permanent piles, including, but not limited to, information gained from the driving of test piles, dynamic load testing, static load testing, supplemental soil testing, etc. When authorized by the Department, soil freeze information obtained during set checks and pile redrives may be used to determine authorized pile lengths for sites with extreme soil conditions.

After completion of the test pile program, production pile lengths shall be recommended in a letter signed and sealed by the DTE. Submit the letter and load test reports to the Engineer including the following electronic files (Windows 10 compatible): dynamic testing data, signal matching data and results, and Wave Equation data and results.

455-5.15.2.2 Structures without Test Piles: Authorized lengths are provided as Production Pile Order Lengths in the Pile Data Table in the Structure Plans. Use these lengths for furnishing the permanent piling for the structure.

455-5.15.3 Authorized Pile Lengths: The authorized pile lengths are the lengths determined by the Engineer after reviewing the pile lengths recommended by the DTE. The Contractor may elect to provide piling with lengths longer than authorized to suit his method of installation or schedule. When the Contractor elects to provide longer than authorized pile

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lengths, the Department will pay for the furnished length as either the originally authorized length or the length between cut-off elevation and the final accepted pile tip elevation, whichever is the longer length.

The Engineer will provide an itemized list of authorized pile lengths within three working days after receipt of all test reports and the DTE's recommended pile lengths. Use these lengths for furnishing the permanent piling for the structure. If the Contractor is willing to start the pile driving operations in zones consisting of at least four test piles designated by the Engineer, and if the Contractor so requests in writing at the beginning of the test pile program, the Department will provide pile lengths for these designated phases within three working days after receiving all test reports and the DTE's recommended pile lengths for those designated zones.

On multiple phase projects, the Engineer will not provide pile lengths on subsequent phases until completing the piling on initial phases.

455-5.16 Allowable Driving Tolerances:

455-5.16.1 General: Meet the tolerances described in this Subarticle for the piles that are free standing without lateral restraint (after the template is removed). After the piles are driven, do not move the piles laterally to force them to be within the specified tolerances, except to move battered piles to overcome the dead load deflections caused by the pile's weight. When this is necessary, submit calculations signed and sealed by a Specialty Engineer that verify the amount of dead load deflection prior to moving any piles.

455-5.16.2 Position: Ensure that the final position of the pile head at cut-off elevation is no more than 3 inches, or 1/6 of the diameter of the pile, whichever is less, laterally in the X or Y coordinate from the Plan position indicated in the Plans.

455-5.16.3 Axial Alignment: Ensure that the axial alignment of the driven piles does not deviate by more than 1/4 inches per foot from the vertical or batter line indicated in the Plans.

455-5.16.4 Elevation: Ensure that the final elevation of the pile head is no more than 1-1/2 inches above, or more than 4 inches below, the elevation shown in the Plans, however in no case shall the pile be embedded less than 8 inches into the cap or footing.

For fender piles, cut off piles at the elevation shown in the Plans to a tolerance of plus 0 inches to minus 2 inches using sawing or other means as approved by the Engineer to provide a smooth level cut.

455-5.16.5 Deviation from Above Tolerances: When the Contractor has failed to meet the above tolerances for position of axial alignment, the Contractor may propose a redesign to incorporate out of tolerance piles into pile caps or footings, at no expense to the Department. Ensure the Contractor's Engineer of Record performs any redesign and signs and seals the redesign drawings and computations. Do not begin any proposed construction until the redesign has been reviewed for acceptability and approved by the Engineer. Utilize Standard Plans for treatment of piles driven more than 4 inches below cutoff elevation.

455-5.17 Disposition of Pile Cut-offs, Test Piles, and Load Test Materials:

455-5.17.1 Pile Cut-offs:

Upon completion of all work under the Contract in connection with piling, unless shown otherwise in the Plan, take ownership of any unused cut-off lengths remaining, and remove them from the right-of-way. Provide areas for their disposal.

455-5.17.2 Test Piles: Where so directed by the Plans or the Engineer, cut off, or build-up as necessary, test piles, and leave them in place as permanent piles. Extract and replace

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test piles driven in permanent position and found not suitable for use due to actions of the Contractor at no expense to the Department. Pull, or cut off, at an elevation 2 feet below the ground surface or bottom of proposed excavation, test piles driven out of permanent position, and dispose of the removed portion of the test pile.

When test piles are required to be driven in permanent pile positions, the Contractor may elect to drive the test pile out of position, with the approval of the Engineer, provided that a replacement pile is furnished and driven by the Contractor at no expense to the Department in the position that was to be occupied by the test pile. Under this option, the Department will pay for the test pile in the same manner as if it were in permanent position.

Unless otherwise directed in the Plans or by the Engineer, retain ownership of test piles that are pulled or cut off and provide areas for their disposal.

455-5.18 Recording: Provide pile inspectors in accordance with 105-8.13. The qualified pile inspector shall inspect and record all the pile installation activities, including but not limited to handling, jetting, predrilling, preforming and driving on the Department's Pile Driving Record form. Steel piles and dynamically tested concrete piles in accordance with 455-5.14 will not require inspection during handling. Keep a pile driving log for each pile installed whether it is, or is not, instrumented. Within one working day after completing the installation of each pile, submit the Pile Driving Record and dynamic testing records to the Engineer.

455-5.19 Foundation Certification Packages: Submit certification packages of pile foundations to the Engineer prior to Pile Verification Testing. A separate Foundation Certification Package must be submitted for each foundation unit. A foundation unit is defined as all the piles within one bent or pile footing for a specific bridge for each phase of construction. Each Foundation Certification Package shall contain an original certification letter signed and sealed by the DTE certifying the piles have the required minimum tip elevation, axial capacity including compression and uplift, pile integrity, and that the inspection of the pile installation was performed under the supervision of the DTE. The package shall also include all pile driving logs, dynamic testing records, all supplemental dynamic testing raw data and analyses for the foundation unit, and the signed and sealed evaluation performed to address out of tolerance piles in accordance with 455-5.16.5. The certification shall not be contingent on any future repair or testing, or any approval by the Engineer.

455-5.20 Verification: One working day, excluding weekends and Department observed holidays, after receipt of the Foundation Certification Package, the Engineer will determine whether a pile in that foundation unit will be selected for verification testing. Based on its review of the certification package, the Engineer may or may not choose a pile for verification testing in any or all foundation units. For the pile selected by the Engineer for verification testing, the Engineer will provide the dynamic load test equipment and personnel for the Pile Verification Testing. Provide the driving equipment and pile driving crew for the Pile Verification Testing and provide support as needed to prepare the piles for testing. The Engineer will provide the results of the verification testing and identify additional needs for verification testing within one working day of testing.

If the capacity or integrity of any pile is found to be deficient, the Engineer will reject the entire certification package for the foundation unit, and the Contractor shall:

1. Correct the deficiency;
2. Correct the process that led to the deficiency;

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3. Demonstrate to the Engineer that the remainder of the piles in the foundation unit are acceptable, including additional dynamic load tests to verify pile capacity and integrity, and;

4. Recertify the foundation unit.

One working day, excluding weekends and Department observed holidays, after receipt of the recertification, the Engineer shall then determine whether additional verification testing is required in that foundation unit. If the capacity or integrity of a verification pile is found to be deficient, additional cycles of deficiency correction and verification testing shall be completed until no more pile capacity or integrity deficiencies are detected. Piles shall not be cut-off nor bent/pier caps placed prior to successful completion of the Pile Verification Testing Program for that foundation unit. In case of disagreement of dynamic testing results, the Engineer's results will be final and will be used for acceptance.

On land foundation units or water foundation units when the pile cutoff is at least six feet above mean high water, the Contractor may cut-off piles prior to a complete submittal of the Certification Package or to a successful completion of the Pile Verification Testing Program at its own risk. If any piles in a foundation unit are cut-off prior to the submittal of a certification package or completion of the Pile Verification Testing Program and the Engineer determines that verification testing is required, the Contractor shall perform, at no expense to the Department, any work and labor required to expose any pile selected for verification to allow the installation of the instruments in dry conditions and to provide references and access to the Engineer for such testing. Piles experiencing damage during the verification testing or requiring build-up after the verification shall be repaired by the Contractor at no expense to the Department. No pile bent/cap shall be poured prior to successful completion of the Pile Verification Testing Program for that foundation unit or notification by the Engineer that no verification will be required.

455-6 Timber Piling.

455-6.1 Description: Drive timber piles of the kind and dimensions specified in the Plans at the locations and to the elevations shown in the Plans, or as directed by the Engineer.

455-6.2 Materials: Meet the timber piling requirements of Section 953. Treat the piles according to the applicable provisions of Section 955. Treat all cuts and drilled holes in accordance with 470-3.

455-6.3 Preparation for Driving:

455-6.3.1 Caps: Protect the heads of timber piles during driving, using a cap of approved type, that will distribute the hammer blow over the entire cross-section of the pile. When necessary cut the head of the pile square before beginning pile driving.

455-6.3.2 Collars: Provide collars or bands to protect piles against splitting and brooming at no expense to the Department.

455-6.3.3 Shoes: Provide piles shod with metal shoes, of a design satisfactory to the Engineer. Shape pile tips to receive the shoe and install according to the manufacturer's directions.

455-6.4 Storage and Handling: Store and handle piles in the manner necessary to avoid damage to the piling. Take special care to avoid breaking the surface of treated piles. Do not use cant dogs, hooks, or pike poles when handling and storing the piling.

455-6.5 Cutting Off: Saw off the tops of all timber piles at the elevation indicated in the Plans. Saw off piles which support timber caps to the exact plane of the superimposed structure so that they exactly fit. Withdraw and replace broken, split, or misplaced piles.

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455-6.6 Build-ups: The Engineer will not permit splices or build-ups for timber piles. Extract piles driven below Plan elevation and drive a longer pile.

455-6.7 Pile Heads:

455-6.7.1 Piles with Timber Caps: On piles wider than the timber caps, dress off the part of the pile head projecting beyond the sides of the cap to a slope of 45 degrees. Coat the cut surface with the required preservative and then place a sheet of copper, with a weight of 10 ounces per square foot or greater, meeting the requirements of ASTM B370. Provide a cover measuring at least 4 inches more in each dimension greater than the diameter of the pile. Bend the cover down over the pile and fasten the edges with large head copper nails or three wraps of No. 12 copper wire.

455-6.7.2 Fender and Bulkhead Piles: Paint the heads of fender piles and of bulkhead piles with preservative and then cover with copper as provided above for piles supporting timber caps.

455-7 Prestressed Concrete Piling.

455-7.1 Description: Provide prestressed concrete piles that are manufactured, cured, and driven in accordance with the Contract Documents. When the required lengths are less than or equal to the maximum length as shown in the Standard Plans, provide piles full length without splices. When the pile length exceeds the maximum length according to Standard Plans, and splicing is required, the piles may be spliced and splices will be paid for in accordance with 455-11.8.

When splices are desired for convenience of the Contractor, provide mechanical splices at no additional cost. Include the cost of these splices in the cost of the pile.

455-7.2 Manufacture: Fabricate piles in accordance with Section 450. When embedded gauges will be used for dynamic load testing, supply and install in square prestressed concrete piles in accordance with Standard Plans Index 455-003. Ensure the embedded gauges are installed by personnel approved by the manufacturer.

455-7.3 Storage and Handling:

455-7.3.1 Time of Driving Piles: Drive prestressed concrete piles at any time after the concrete has been cured in accordance with Section 450, and the concrete compressive strength is equal to or greater than the specified 28 day compressive strength.

455-7.3.2 Storage: Support piles on adequate dunnage both in the prestress yard and at the job site in accordance with the locations shown in the Standard Plans to minimize undue bending stresses or creating a sweep or camber in the pile.

455-7.3.3 Handling: Handle and store piles in the manner necessary to eliminate the danger of fracture by impact or of undue bending stresses in handling or transporting the piles from the forms and into the leads. In general, lift concrete piles by means of a suitable bridge or slings attached to the pile at the locations shown in the Standard Plans. Construct slings used to handle piles of a fabric material or braided wire rope constructed of six or more wire ropes which will not mar the corners or the surface finish of the piles. Do not use chains to handle piles. During transport, support concrete piles at the lifting locations shown in the Standard Plans or fully support them throughout 80% or more of their length. In handling piles for use in salty or brackish water, exercise special care to avoid damaging the surface and corners of the pile. If an alternate transportation support arrangement is desired, submit calculations, signed and sealed by the Specialty Engineer, for approval by the Engineer prior to transporting the pile. Calculations must show that the pile can be transported without exceeding the bending moments calculated using the support locations shown in the Plans.

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455-7.4 Cracked Piles: The Engineer will reject any pile that becomes cracked in handling to the point that a transverse or longitudinal crack extends through the pile, shows failure of the concrete as indicated by spalling of concrete on the main body of the pile adjacent to the crack, which in the opinion of the Engineer will not withstand driving stresses, or becomes damaged during installation. The Engineer will not reject any pile for the occasional minor surface hairline cracking caused by shrinkage.

Do not drive piling with irreparable damage, which is defined as any cracks that extend through the pile cross-sectional area that are, or will be, below ground or water level at the end of driving. Remove and replace broken piles or piles cracked to the extent described above at no expense to the Department. The Engineer will accept cracks less than 0.005 inches which do not extend through the pile. Using approved methods, cut off and splice or build-up to cut-off elevation piles with cracks greater than 0.005 inches at the pile head or above ground or water level, and piles with cracks above ground or water level which extend through the cross-sectional area of the pile. The Engineer may require correction of pile damage or pile cracks by cutting down the concrete to the plane of sound concrete below the crack and rebuilding it to cut-off elevation, or the Engineer may reject the pile. Extract and replace rejected piles that cannot be repaired, at no expense to the Department.

Take appropriate steps to prevent the occurrence of cracking, whether due to handling, transporting, or driving.

455-7.5 Preparation for Transportation: Cut strands flush with the surface of the concrete using an abrasive cutting blade before transporting the piles from the casting yard.

Cut and patch the metal lifting devices in accordance with 450-9.2.1.

455-7.6 Method of Driving: Unless otherwise directed, drive piles by a hammer or by means of a combination of water jets and hammer when jetting is allowed. When using jets in combination with a hammer, withdraw the jets and drive the pile by the hammer alone to secure final penetration and to rigidly fix the tip end of the pile. Keep jets in place if they are being used to continuously eliminate the soil resistance in the scour zone.

455-7.7 Extensions and Build-ups used to Increase Production Lengths:

455-7.7.1 General: Where splices, extensions and build-ups for concrete piles are necessary, construct them in accordance with the Standard Plans.

These requirements are not applicable to specially designed piling. Make splices for special pile designs as shown in the Plans.

455-7.7.2 Extensions to be Driven or those 21 feet or Longer: Construct extensions to be driven or extensions 21 feet or longer in length in accordance with the details shown in the Standard Plans and in a manner including the requirements, sequences, and procedures outlined below:

1. Cast a splice section in accordance with Section 450 with the dowel steel in the correct position and alignment as shown in the Standard Plans.
2. Drill dowel holes using an approved steel template that will position and align the drill bit during drilling. Drill holes a minimum of 2 inches deeper than the length of the dowel to be inserted.
3. Clean the drilled dowel holes by inserting a high pressure air hose to the bottom of the hole and blowing the hole clean from the bottom upward. Eliminate any oil, dust, water, and other deleterious materials from the holes and the concrete surfaces to be joined.
4. Place forms around joints between the pile sections.

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5. Mix the adhesive components in accordance with the manufacturer's directions. Do not mix sand or any other filler material with the epoxy components unless it is prepackaged by the manufacturer for this specific purpose. Use adhesives meeting the requirements of Section 926 for Type AB epoxy compounds.

6. After ensuring that all concrete surfaces are dry, fill the dowel holes with the adhesive material.

7. Insert the dowels of the spliced section into the adhesive filled holes of the bottom section and position the spliced section so that the axes of the two sections are in concentric alignment and the ends of the abutting sections are spaced 1/2 inches apart. The Contractor may use small steel spacers of the required thickness provided they have 3 inches or more of cover after completing the splice. Fill the space between the abutting sections completely with the adhesive.

8. Secure the spliced sections in alignment until the adhesive is cured in accordance with the manufacturer's directions for the time appropriate with the prevailing ambient temperatures. Utilize alignment braces to maintain the proper pile alignment during the epoxy cure time.

9. After curing is completed, remove alignment braces and forms and clean and dress the spliced area to match the pile dimensions.

When dowel splices need to be driven, perform a dynamic load test during the driving of each dowel spliced pile to monitor and control the stresses and verify the splicing integrity. Provide the Engineer two working days advance notification prior to driving spliced piles.

455-7.7.3 Precast Reinforced Non-Drivable Build-ups less than 21 feet: Construct precast reinforced non-drivable build-ups less than 21 feet in accordance with the requirements of this Subarticle, Section 346, and Section 400. Provide the same material for the form surfaces for precast build-ups as was used to form the prestressed piles. Use concrete of the same mix as used in the prestressed pile and dimension the cross-section the same as piling being built up. Install build-ups as specified in 455-7.7.2(2) through 455-7.7.2(9). Apply to the build-ups the same surface treatment or sealant applied to the prestressed piles.

455-7.8 Pre-Planned Splices: Construct splices in accordance with the dowel splice method contained in the Standard Plans or using proprietary splices which are listed on the Department's Approved Product List (APL). Splice test piles in the same manner as the production piles. Include in the pile installation plan, the chosen method of splicing and the approximate locations of the splice. Generally, place the splice at approximately the midpoint between the estimated pile tip and the ground surface, considering scour if applicable. Stagger the splice location between adjacent piles by a minimum of 10 feet. Obtain the Engineer's approval prior to constructing any pile sections.

When dowel splices need to be driven, comply with the requirements of 455-7.7.2.

Mechanical pile splices must be capable of developing the following capacities in the pile section unless shown otherwise in the Plans and capable of being installed without damage to the pile or splice:

1. Compressive strength = (Pile Cross sectional area) x (28 day concrete strength)

2. Tensile Strength = (Pile Cross sectional area) x 900 psi

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Table 455-2	
Pile Size (inches)	Bending Strength (kip-feet)
18	245
24	600
30	950

455-7.9 Pile Cut-offs: After the completion of driving, cut piles off which extend above the cut-off elevation with an abrasive saw. Make the cut the depth necessary to cleanly cut through the prestressed strands.

455-8 Steel Piling.

455-8.1 Description: Furnish, splice, drive, and cut off structural steel shapes to form bearing piles. Include in this work the preparation of a smooth and square pile top meeting the requirements of ASTM A252 or API 5L prior to driving, installation of structural steel bracing by bolting or welding, construction of splices and the filling of pipe piles with the materials specified in 455-8.9.

455-8.2 Material: For the material in steel piles, and splices, meet the requirements of Section 962.

455-8.3 Pile Splices: Order and use the full authorized pile length where practicable. Do not splice to obtain authorized lengths less than 50 feet except when shown in the Plans. Locate all field splices in the authorized pile length in portions of the pile expected to be at least 15 feet below the final ground surface after driving. When it is not practicable to provide authorized pile lengths longer than 50 feet in a single length, use no more than one field splice per additional 50 feet of authorized pile length. Shop splices may be used to join single lengths of pile which are at least 20 feet in length. One shorter segment of pile may be used to achieve the authorized pile length when needed.

Where the pile length authorized is not sufficient to obtain the required bearing value or penetration, provide an additional length of pile as directed by the Engineer and splice it to the original length.

Make all splices in accordance with details shown in the Plans and in compliance with the general requirements of AWS D1.1 or American Petroleum Institute Specification 5L (API 5L).

455-8.4 Welding: Make all welded connections to steel piles by electric arc welding, in accordance with details shown in the Plans and in compliance with the general requirements of AWS D1.5. Electroslag welding is not permitted. Welds will be inspected by visual methods.

455-8.5 Pile Heads and Tips: Cut off all piles at the elevation shown in the Plans. If using a cutting torch, make the surface as smooth as practical.

Where foundation material is so dense that the Contractor cannot drive the pile to the required penetration and firmly seat it without danger of crumpling the tip, reinforce the tips with approved cast steel point protectors, as shown in the Plans or required by the Engineer. Construct point protectors in one piece of cast steel meeting the requirements of ASTM A27, Grade 65-35 heat treated to provide full bearing for the piles. Attach points by welding according to the recommendations of the manufacturer.

455-8.6 Pile Bent Bracing Members: Where piles are not driven into position in exact alignment as shown in the Plans, furnish and place all fills and shims required to square and line up faces of flanges for cross bracing at no additional expense to the Department.

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455-8.7 Coating: Coat exposed parts of steel piling, wedging, bracing, and splices as shown in the Plans.

455-8.8 Storage and Handling: While handling or transporting the piles from the point of origin and into the leads, store and handle in the manner necessary to avoid damage due to bending stresses. In general, lift steel piles by means of a suitable bridge or a sling attached to the pile at appropriate points to prevent damage. Lift the pile from the horizontal position in a manner that will prevent damage due to bending of the flanges and/or web.

455-8.9 Filling Pipe Piles: Ensure closed-end pipe piles are watertight. When required by the Plans, fill pipe piles with the specified materials. Place concrete in open ended pipes containing water using methods in accordance with 455-15.9 with modified tremie and pump line sizes. Concrete may be placed directly into pipes which are dry. Construct and place reinforcement cages in accordance with 455-16 except the minimum number of spacers per level is three. Reinforcement cages may be installed before concrete placement or after concrete placement is completed if proper alignment and position is obtainable.

455-9 Sheet Piling.

455-9.1 Description: Leave permanent piling in place as part of the finished work and remove temporary piling after each construction phase unless otherwise authorized by the Engineer.

455-9.2 Materials: Meet the following requirements:

Concrete	Section 346
Bar Reinforcement	Section 931
Prestressing Reinforcement	Section 933
Steel Sheet Piles*	Section 962

*For temporary steel sheet piles meet the requirements specified in the Plans.

455-9.3 Steel Sheet Piling: Drive steel sheet piling and cut off true to line and grade. Install steel sheet piling with a suitable hammer. Remove and replace any section damaged during handling and installation at no additional expense to the Department.

455-9.3.1 Method of Installation: Where rock or strong material is encountered such that the sheet piles cannot be set to grade by driving, remove the strong material by other acceptable means, such as excavation and backfilling, drilling or by punching. When the Plans do not indicate the existence of rock or strong material, work of removing, drilling or punching the strong material or rock will be paid for as Unforeseeable Work.

455-9.4 Concrete Sheet Piling:

455-9.4.1 Description: Ensure that concrete sheet piling is of prestressed concrete construction and manufactured, cured, and installed in accordance with the requirements of the Contract Documents.

455-9.4.2 Manufacture of Piles: Ensure that the piles are fabricated in accordance with Section 450.

455-9.4.3 Method of Installation: Jet concrete sheet piling to grade where practical. Provide water at the nozzles of sufficient volume and pressure to freely erode material adjacent to the piles. Where encountering rock or strong material, such that the sheet piles cannot be set to grade by jetting, remove the strong materials by other acceptable means, such as excavation and backfilling, drilling or by punching with a suitable punch. When the Plans do not indicate the existence of rock or strong material and the piles cannot be set by jetting, the Department will pay for the work of removing, drilling or punching the strong material or rock as Unforeseeable Work.

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455-9.4.4 Grouting and Caulking: Concrete sheet piles are generally detailed to have tongues and grooves on their lower ends, and double grooves on their upper ends. Where so detailed, after installation, clean the grooves of all sand, mud, or debris, and fully grout the grooves. Use approved plastic bags (sheaths) which will meet the shape and length of the groove to be grouted to contain the plastic grout within the double grooves. Provide grout composed of one part cement and two parts sand. Use clean A-3 sand or sand meeting the requirements of Section 902 in this grout. In lieu of sand-cement grout, the Contractor may use concrete meeting the requirements of Section 347, using small gravel or crushed stone coarse aggregate. Deposit the grout through a grout pipe placed within a watertight plastic sheath (bag) extending the full depth of the double grooves and which, when filled, completely fills the slot formed by the double grooves.

455-9.5 Storage and Handling: Handle and store all sheet piles in a manner to prevent damage. Handle long sheet piles with fabric slings or braided wire rope constructed of six or more wire ropes placed at appropriate lift points to prevent damage due to excessive bending.

455-10 Pile Installation Plan (PIP).

455-10.1 General: Submit the completed Pile Driving Installation Plan Form (Form No. 700-020-01) with the following information at the preconstruction conference or no later than 30 days before driving the first pile.

1. The names of the CTQP qualified inspectors assigned to inspect the pile installation. If the Dynamic Testing Engineer is also a CTQP qualified pile driving inspector and is able to perform both operations, then an additional pile driving inspector is not required when driving piles using embedded sensors.
2. The quality control processes to ensure the required capacity is achieved in all piles. Include in the PIP the steps and analyses that would be performed when driving conditions change (such as unanticipated tip elevations, hammer modifications, presence of temporary piles and structures, preforming, changes, etc.).
3. The name and contact information for the single representative of the Contractor, independent of field operations personnel, to resolve to the Engineer's satisfaction conflicts in the driving procedures or interpretations of the driving criteria. This person shall be available within two hours notice, and shall have the authority to refer issues to higher levels (corporate, if needed).
4. A letter from the DTE certifying concurrence with the PIP.

Notify the Engineer of any test pile driving and production pile driving at least one week prior to beginning the installation operations of any pile.

455-10.2 Acceptance of Equipment and Procedures: The Engineer will evaluate the PIP for conformance with the Contract Documents. Within five working days, excluding weekends and Department observed holidays, after receipt of the plan, the Engineer will notify the Contractor of any comments and additional information required and/or changes that may be necessary to satisfy the Contract Documents. Submit changes and respond to the Engineer's comments and allow at least two working days, excluding weekends and Department observed holidays, for the Engineer to review the revised PIP.

All equipment and procedures are subject to satisfactory field performance. Make required changes to correct unsatisfactory field performance. The Engineer will give final acceptance after the Contractor makes necessary modifications. Do not make any changes in the driving system after acceptance without a revised PIP with concurrence of the DTE and acceptance by the Engineer. A hammer repaired on site or removed from the site and returned is

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considered to have its performance altered (efficiency increased or decreased), which is considered a change in the driving system. Perform a dynamic load test in accordance with 455-5.14 on the first pile driven with this hammer to confirm the driving criteria is still appropriate at no additional compensation.

Acceptance of the PIP by the Engineer does not relieve the Contractor of the responsibility to perform the work in accordance with the Contract Documents. The Engineer's acceptance is not a guarantee that the chosen methods and equipment are capable of obtaining the required results; this responsibility lies with the Contractor.

455-11 Method of Measurement (All Piling).

455-11.1 General:

No adjustments in the length, in feet, of piling will be made if cut-offs are required after the pile has been driven to satisfactory bearing.

455-11.2 Prestressed Concrete Piling:

455-11.2.1 Length: The length of precast concrete piles will be considered as the overall length from head to tip. Final pay length will be based on the casting length as authorized in accordance with 455-5.15.3 subject to provisions of 455-11.2.3, 455-11.2.4, 455-11.8, 455-11.9, 455-11.12, and 455-11.13.

455-11.2.2 Monitoring of Unplanned Epoxy-Bonded Dowel Splice During Driving: If a pile is driven below cut-off and satisfactory bearing is not obtained, and additional driving is required after construction of a satisfactory splice, splicing and additional driving will be paid as Unforeseeable Work.

455-11.2.3 Extracting Piles: In the event that a pile is driven below cut-off without obtaining the required bearing, and the Engineer elects to have the pile extracted and a longer pile substituted, the pile extraction will be paid for as Unforeseeable Work. In the event a pile is damaged or mislocated, and the damage or mislocation is determined to be the Department's responsibility, and the Engineer elects to have the pile extracted, the pile extraction will be paid for as Unforeseeable Work. If a replacement pile is required, compensation will be made under the item for piling, for both the original pile and replacement pile.

The Contractor may substitute a longer pile in lieu of splicing and building-up a pile. In this event, the Contractor will be paid for the original authorized length of the pile, plus any additional length furnished by the Contractor up to the authorized length of the build-up, as piling. The Contractor will be paid 50% of the Contract unit price for piling as full compensation for extracting the original pile.

455-11.2.4 Underwater Driving: When the Contractor selects one of the optional underwater driving methods, payment will be made by selecting the applicable method from the following:

1. Using a pile longer than the authorized length: Measurement for piling will be made only for the authorized length at that location unless the length of pile from cut-off elevation to the final tip elevation is greater than the authorized length, in which case payment for piling will be made from cut-off elevation to final tip elevation. No payment will be made for pile splice, when this option is selected, unless the pile is physically spliced and the splice is driven below cut-off elevation to achieve bearing.

2. Using an underwater hammer or a pile follower: Measurement will be in accordance with 455-11.2.1.

455-11.3 Steel Piling:

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455-11.3.1 Length: The length of steel piles will be considered as the overall length from head to tip. Final pay length will subject to provisions of 455-11.8, 455-11.9, 455-11.10, 455-11.12, and 455-11.13.

455-11.3.2 Point Protectors: The quantity to be paid for will be each for the total of point protectors authorized, furnished, and properly installed.

455-11.4 Test Piles: The quantity to be paid for of test piles of various types, will be the length, in feet, of test piling furnished, driven and accepted, according to the authorized length list, and any extensions thereof as approved by the Engineer.

Test piles left in place as permanent piles will be paid for only as test piling. Any extensions necessary to continue driving the pile for test purposes, as authorized by the Engineer, will be paid for as test piles. Other extensions of piles, additional length paid for splicing and build-ups will be included in the quantities of regular piling and will not be paid for as test piling.

455-11.5 Dynamic Load Tests: Payment will be based on the number of and type of dynamic load tests shown in the Plans, required by the Engineer, or required in 455-5.12.7, completed and accepted in accordance with the Contract Documents. No separate payment will be made for dynamic load tests used to evaluate changes in the Contractor's driving equipment. Include all costs associated with dynamically testing production piles with epoxy-bonded dowel splices under Pay Item No. 455-17.

Payment for internal gauges, when shown in the Plans, will be the number of piles with internal gauges successfully installed and used for dynamic testing.

455-11.6 Steel Sheet Piling: The quantity to be paid for will be the plan quantity area, in square feet, measured from top of pile elevation to the bottom of pile elevation and beginning and end wall limits as shown in the Plans with no allowance for variable depth surface profiles. Approved alternate support structures would be paid for as plan quantity computed for sheet pile. No separate payment will be made for sheet piling used in cofferdams and to incorporate the Contractor's specific means and methods, and not ordered by the Engineer.

455-11.7 Concrete Sheet Piling: The quantity to be paid for will be the plan quantity area, in square feet, with no area reduction for chamfered bottom ends or top recesses, measured from top of pile elevation to the bottom of pile elevation and beginning and end wall limits as shown in the Plans.

When the Engineer approves, the Contractor may furnish the concrete sheet piling in widths wider than shown in the Plans; then the number of piles shall be the actual number of units completed times the width used divided by the width in the Plans.

455-11.8 Pile Splices: The quantity to be paid for will be the number of authorized drivable splices and build-ups greater than 5 feet in length in concrete piling, and test piling, which are made for the purpose of obtaining authorized pile lengths longer than shown as the maximum length in the Standard Plans, for obtaining greater lengths than originally authorized by the Engineer, to incorporate test piling in the finished structure, for further driving of test piling, or for splices shown in the Plans.

The quantity to be paid for will be the number of authorized splices in steel piling and test piling, for the purpose of obtaining lengths longer than the lengths originally authorized by the Engineer.

455-11.9 Set-Checks and Redrives:

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455-11.9.1 Set Checks/Test Piles: There will be no separate payment for the initial four set-checks performed the day of and the working day following initial driving. Each additional set-check ordered by the Engineer will be paid as a redrive.

455-11.9.2 Set Checks/Production Piles: There will be no separate payment for the initial set-check performed the day of initial driving. Each additional set-check ordered by the Engineer will be paid as a redrive.

455-11.9.3 Redrives: The quantity of redrives to be paid for, when shown in the Plans, will be the number of redrives, each, authorized by the Engineer. Redrives required by the Engineer, when not shown in the Plans, will be paid for as Unforeseeable Work.

455-11.10 Pile Extraction: Piles authorized to be extracted by the Engineer and successfully extracted as provided in 455-11.2.3 will be paid for as described in 455-11.2.3. No payment for extraction will be made for piles shown in the Plans to be extracted or piling damaged or mislocated by the Contractor that are ordered to be extracted by the Engineer.

455-11.11 Static Load Tests: The quantity to be paid for will be the number of static load tests of the designated tonnages, each, as shown in the Plans or authorized by the Engineer, actually applied to piles, completed and accepted in accordance with the Plans and these Specifications.

455-11.12 Preformed Pile Holes: The quantity to be paid for will be the length of completed preformed pile holes from existing surface or the bottom of any required excavation, whichever is lower, to the bottom of preformed hole shown in the Plans acceptably provided, for the installation of the bearing piles, regardless of the type of pile (test pile or production pile) installed therein. Only those holes authorized to be paid for, as provided in 455-5.10.3, will be included in the measurement for payment. The Engineer will authorize payment for preformed pile holes only when the pile has been placed in proper position and has achieved the required penetration. When preformed pile holes are not shown in the Plans, the work will be considered Unforeseeable Work.

455-11.13 Grouted Preformed Pile Holes: The quantity to be paid will be the length of grouted preformed pile holes from the bottom of preformed hole acceptably provided to the required top of grouting, regardless of the type of pile (test pile or production pile) installed therein. Only those holes required to be grouted, will be included in the measurement for payment.

455-11.14 Casing for Preformed Pile Holes: The quantity to be paid will be the cased length of preformed pile holes authorized by the Engineer or shown in the Plans, regardless of the type of pile (test pile or production pile) installed therein. When casing for preformed pile holes is not shown in the Plans, the work will be considered Unforeseeable Work.

455-11.15 Preformed Pile Holes For Sheet Piles: The quantity to be paid for will be the area, in square feet, completed and accepted, bounded by the existing ground surface or the bottom of any required excavation, whichever is lower, to the preform elevation and beginning and end limits of required preforming.

455-11.16 Pile Inspection: The quantity to be paid will be the number of piles and test piles inspected, driven, and accepted by a dedicated, qualified inspector.

455-11.17 Verification Test: The quantity to be paid will be the number of piles tested and accepted.

455-12 Basis of Payment (All Piling).

455-12.1 Treated Timber Piling: Price and payment will be full compensation for all labor, equipment, and materials required for furnishing, pile marking and installing all materials,

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including collars, metal shoes, copper cover sheets, preservatives and tar, and for wrapping pile clusters with wire cable, where so shown in the Plans.

455-12.2 Prestressed Concrete Piling: Price and payment will be full compensation for all labor, equipment, and materials required for furnishing, pile marking and installing all concrete piling, predrilling pile holes described in 455-5.1, and furnishing the material for and wrapping pile clusters with wire cable where so shown in the Plans.

455-12.3 Steel Piling: Price and payment will be full compensation for all labor, equipment, and materials required for furnishing, marking and installing steel piling, including welding and painting as specified and the cost of predrilling pile holes described in 455-5.1. The cost of any concrete fill and reinforcing steel in pipe piles will be included in the price for steel piling.

Bracing and other metal parts attached to or forming a part of piling or bracing and not otherwise classified, will be measured and paid for as provided in Section 460.

455-12.4 Test Piles: Price and payment will be full compensation for all incidentals necessary to complete all the work of this item except splices, build-ups, pile extractions and preformed pile holes authorized by the Engineer and paid for under other pay items or payment methods.

455-12.5 Dynamic Load Tests:

455-12.5.1 Dynamic Load Tests/Test Piles: All test piles will require dynamic load tests. Include all costs associated with engaging a specialty engineer and perform the dynamic load tests in the pay items for test piles.

455-12.5.2 Dynamic Load Tests/Production Piles: Payment will be full compensation for all costs associated with engaging a specialty engineer and perform the dynamic load tests.

455-12.5.3 Dynamic Load Tests/Internal Gauges: Payment will be full compensation for all costs associated with supplying and installing internal gauges for dynamic testing.

455-12.6 Steel Sheet Piling:

455-12.6.1 Permanent Sheet Piling: Price and payment will be full compensation for all labor, equipment, and materials required for furnishing and installing steel sheet piling and coating but will not include furnishing and placing anchors when an anchored wall system is designed and detailed in the Plans. In such cases, furnishing and installing anchors will be paid separately.

455-12.6.2 Temporary Sheet Piling: For critical temporary steel sheet pile walls, walls which are necessary to maintain the safety of the traveling public or structural integrity of nearby structures, roadways and utilities during construction, that are detailed in the Plans, price and payment will be full compensation for all labor, equipment, and materials required for furnishing and installing steel sheet piling including preformed holes when shown in the Plans, and including wales, anchor bars, dead men, soil anchors, proof tests, performance tests, creep tests, and other incidental items when an anchored wall system is required. Removal of the sheet piling, anchors, and incidentals will be included in the cost per square foot for steel sheet piling (critical temporary). When the temporary steel sheet pile walls are not detailed in the Plans, the cost of furnishing and installation shall be incidental to cost of other related items and no separate payment shall be made. If the wall is not shown in the Plans, but deemed to be critical as determined by the Engineer, then a design shall be furnished by the Department and paid for separately under steel sheet piling (critical temporary).

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455-12.7 Concrete Sheet Piling: Price and payment will be full compensation for all labor, equipment, and materials required for furnishing and installing concrete sheet piling, including reinforcing steel, grouting, filter fabric, and installation.

455-12.8 Preformed Pile Holes: Payment will be full compensation for all labor, equipment, and materials required to perform this work.

455-12.8.1 Grouted Preformed Pile Holes: Payment will be full compensation for all labor, equipment, and materials required to perform this work.

455-12.8.2 Casing for Preformed Pile Holes: Payment will be full compensation for all labor, equipment, and materials required to perform this work.

455-12.9 Point Protectors: Price and payment will be full compensation for all labor, equipment, and materials required for furnishing and installing point protectors.

455-12.10 Static Load Tests: Price and payment will be full compensation for all labor, equipment, and incidentals required to perform this work, including instrumentation, data collection and professional services to prepare the report.

455-12.11 Pile Cut-Off: Anticipate all piles will require cutting-off, and include all costs associated with pile cut-off in the pay items for piling.

455-12.12 Pile Redrives: Payment will be full compensation for all labor, equipment, and materials required to perform this work.

455-12.13 Pile Inspection: Price and payment will be full compensation for all labor, equipment, and incidentals required to perform this work, including providing the pile inspection device, data collection and submitting the records.

455-12.14 Verification Tests: Payment will be full compensation for all costs associated with assisting the Engineer in performing the dynamic load tests to verify the resistance and integrity of the tested pile.

455-12.15 Payment Items: Payment will be made under:

Item No. 455- 2-	Treated Timber Piling - per foot.
Item No. 455- 14-	Concrete Sheet Piling - per square foot.
Item No. 455- 15-	Preformed Pile Holes
Item No. 455- 17-	Pre-planned Pile Splices - each.
Item No. 455- 20-	Pile Inspection - each.
Item No. 455- 34-	Prestressed Concrete Piling - per foot.
Item No. 455- 35-	Steel Piling - per foot.
Item No. 455- 36-	Concrete Cylinder Piling - per foot.
Item No. 455-115-	Pile Redrive - each.
Item No. 455-119-	Test Loads - each.
Item No. 455-120-	Point Protection - each.
Item No. 455-133-	Sheet Piling - per square foot.
Item No. 455-137-	Dynamic Load Tests - each.
Item No. 455-143-	Test Piles (Prestressed Concrete) - per foot.
Item No. 455-144-	Test Piles (Steel) - per foot.
Item No. 455-145-	Test Piles (Concrete Cylinder) - per foot.

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C. DRILLED SHAFTS

455-13 Description.

Construct drilled shaft foundations consisting of reinforced concrete drilled shafts.

455-14 Materials.

455-14.1 Concrete: Use concrete meeting the requirements of Section 346, unless otherwise shown in the Plans.

455-14.2 Reinforcing Steel: Meet the reinforcing steel requirements of Section 415.

455-14.3 Polymer Slurry: Use a product listed on the Department's Approved Product List (APL) meeting the requirements of 932-5.

455-15 Construction Methods and Equipment.

455-15.1 General Requirements:

455-15.1.1 Templates: When drilling from a barge, provide a fixed template, adequate to maintain shaft position and alignment during all excavation and concreting operations. Do not use floating templates (attached to a barge). When the Contractor fails to properly maintain shaft position and alignment without use of a template when drilling on land, the Engineer will require a fixed template, adequate to maintain shaft position and alignment during all excavation and concreting operations.

455-15.1.2 Drilled Shaft Installation Plan (DSIP): At the preconstruction conference submit a DSIP for review by the Engineer. Final approval will be subject to satisfactory performance. Include in this plan the following details:

1. Name and experience record of drilled shaft superintendent or foreman in responsible charge of drilled shaft operations. Ensure the drilled shaft superintendent or foreman in responsible charge of the drilled shaft operations has a minimum of one year of experience of installing drilled shafts of the size and depth shown in the Plans and a minimum of three years' experience in the construction of drilled shafts using the following methods:
   a. Wet Method (mineral and polymer slurry),
   b. Casings up to the length shown in the Plans,
   c. Shaft drilling operations on water under conditions as shown in the Plans.
2. List and size of proposed equipment, including cranes, drills, augers, bailing buckets, final cleaning equipment, desanding equipment, slurry pumps, core sampling equipment, tremies or concrete pumps, casings, and equipment to install and remove casing.
3. Details of sequence of construction operations and sequence of shaft construction in bents or shaft groups.
4. Details of shaft excavation methods, including casing installation procedures.
5. Details of slurry, including proposed methods to mix, circulate, desand, test methods, and proposed CTQP certified technician that will perform and document the fluid tests.
6. Details of proposed methods to clean the shaft excavation.

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7. Details of shaft reinforcement, including methods to ensure centering/required cover, cage integrity during placement, placement procedures, cage support, and tie downs.

8. Details of concrete placement, including elapsed concrete placement times and proposed operational procedures for concrete tremie or pump, including initial placement, raising during placement, and overfilling of the shaft concrete. Include provisions to ensure proper final shaft cutoff elevation.

9. Details of casing removal when removal is required, including minimum concrete head in casing during removal.

10. Required submittals, including shop drawing and concrete design mixes.

11. Details of any required load tests, including equipment and procedures, and recent calibrations for any jacks or load cells.

12. Proposed Cross-Hole Sonic Logging (CSL) and Thermal Integrity Testing for Drilled (TITDS) Specialty Engineer to supervise field testing and report the test results.

13. Methods and equipment proposed to prevent displacement of casing and/or shafts during placement and compaction of fill.

14. Provide the make and model of the shaft inspection device, if applicable.

15. Details of environmental control procedures used to prevent loss of slurry or concrete into waterways or other protected areas.

16. Proposed schedule for test shaft installation, load tests and production shaft installation.

17. For drilled shafts constructed using polymer slurry, identify the polymer slurry, the pH and proposed viscosity ranges and a description of the mixing method to be used. Submit the contact information for the manufacturer's representative available for immediate contact during shaft construction and the representative's schedule of availability.

18. When settlement and vibration monitoring of adjacent structures are required as per 108-2, submit a proposed monitoring plan identifying the proposed equipment, the structures and the specific points that will be monitored.

19. Procedure for grouting non-destructive testing access tubes.

20. Other information shown in the Plans or requested by the Engineer.

The Engineer will evaluate the DSIP for conformance with the Contract Documents. Within 20 days after receipt of the plan, the Engineer will notify the Contractor of any additional information required and/or changes that may be necessary to meet the above requirements and satisfy the Contract Documents. The Engineer will reject any part of the plan that does not meet specifications, plans or has the potential to affect the integrity of adjacent structures or negatively affect the environmental conditions. Submit changes agreed upon for reevaluation. The Engineer will notify the Contractor within seven days after receipt of proposed changes of their acceptance or rejection. All equipment and procedures are subject to trial and satisfactory performance in the field.

Acceptance by the Engineer does not relieve the Contractor of the responsibility to perform the work in accordance with the Contract Documents. The installation plan is for the Contractor to explain the approach to the work and allow the Engineer an

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opportunity to comment on the equipment and procedures chosen before field operations begin. The Engineers acceptance is not a guarantee that the chosen methods and equipment are capable of obtaining the required results, this responsibility lies with the Contractor.

455-15.1.3 General Methods & Equipment: Perform the excavations required for the shafts, through whatever materials encountered, to the dimensions and elevations shown in the Contract Documents, using methods and equipment suitable for the intended purpose and the materials encountered. Provide drilling tools with a diameter not smaller than one inch of the shaft diameter required in the Plans. Provide equipment capable of constructing shafts supporting bridges to a depth equal to the deepest shaft shown in the Plans plus 15 foot or plus three times the shaft diameter, whichever is greater, except when the Plans require equipment capable of constructing shafts to a deeper depth. Provide equipment capable of constructing shafts supporting non-bridge structures, including sign, signal, lighting and ITS structures, to a depth equal to the deepest shaft shown in the Plans plus 5 feet.

Construct drilled shafts according to the Contract Documents using generally either the dry method, wet method, casing method, or permanent casing method as necessary to produce sound, durable concrete foundation shafts free of defects. Use the permanent casing method only when required by the Plans or authorized by the Engineer. When the Plans describe a particular method of construction, use this method except when permitted otherwise by the Engineer, after field trial. When the Plans do not describe a particular method, propose a method on the basis of its suitability to the site conditions and submit it for approval by the Engineer.

Set a suitable temporary removable surface casing from at least 1 foot above the ground surface to at least 1-1/2 shaft diameters below the ground surface to prevent caving of the surface soils and to aid in maintaining shaft position and alignment. Do not use a temporary casing larger than 12 inches of the shaft diameter. Fill the oversized temporary casing with drilled shaft concrete at no additional expense to the Department. Withdraw the surface casing after concrete placement. The Engineer may require predrilling with slurry and/or overreaming to the outside diameter of the casing to install the surface casing at some sites.

For drilled shafts installed to support sign, signal, lighting and ITS structures, provide temporary surface casings from at least 1 foot above the ground surface to at least 5 feet below the ground surface. For sign, signal, lighting and ITS structure foundations located within permanent sidewalks or within 5 feet of curb sections, provide temporary surface casings from no lower than the top of sidewalk to at least 5 feet below the ground surface.

For drilled shafts installed to support sign, signal, lighting and ITS structures, do not attempt to excavate the shaft using plain water or natural slurry. Do not attempt to excavate the shaft using dry construction method unless specifically indicated in the Plans or approved by the Engineer.

455-15.2 Dry Construction Method: Use the dry construction method only at sites where the ground water table and soil conditions, generally stiff to hard clays or rock above the water table, make it feasible to construct the shaft in a relatively dry excavation and where the sides and bottom of the shaft are stable and may be visually inspected by the Engineer prior to placing the concrete.

In applying the dry construction method, drill the shaft excavation, remove accumulated seepage water and loose material from the excavation and place the shaft concrete in a relatively dry excavation.

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Use the dry construction method only when shaft excavations, as demonstrated in a test hole, have 12 inches or less of seepage water accumulated over a four hour period, the sides and bottom remain stable without detrimental caving, sloughing, or swelling for a four hour period, and the loose material and water can be satisfactorily removed prior to inspection and prior to placing concrete. Use the wet construction method or the temporary casing construction method for shafts that do not meet the requirements for the dry construction method.

455-15.3 Wet Construction Method: Use the wet construction method at all sites where it is impractical to provide a dry excavation for placement of the shaft concrete.

The wet construction method consists of keeping the shaft excavation filled with fluid (mineral slurry, polymer slurry, natural slurry or water), desanding and cleaning the slurry and final cleaning of the excavation by means of a bailing bucket, air lift, submersible pump or other approved devices and placing the shaft concrete (with a tremie or concrete pump extending to the shaft bottom) which displaces the water or slurry during concreting of the shaft excavation.

Where drilled shafts are located in open water areas, construct the shafts by the wet method using exterior casings extending from above the water elevation into the ground to protect the shaft concrete from water action during placement and curing of the concrete. Install the exterior casing in a manner that will produce a positive seal at the bottom of the casing so that there is no intrusion or extrusion of water or other materials into or from the shaft excavation.

455-15.4 Temporary Casing Construction Method: Use the temporary casing method at all sites where it is inappropriate to use the dry or wet construction methods without the use of temporary casings other than surface casings. In this method, the casing is advanced prior to excavation and withdrawn after concrete placement. When a formation is reached that is nearly impervious, seal in the nearly impervious formation. Proceed with drilling as with the wet method to the projected depth. Proceed with the placement of the concrete as with the dry method. In the event seepage conditions prevent use of the dry method, complete the excavation and concrete placement using wet methods.

Where drilling through materials having a tendency to cave, advance the excavation by drilling in a mineral or polymer slurry. In the event that a caving layer or layers are encountered that cannot be controlled by slurry, install temporary removable casing through such caving layer or layers. The Engineer may require overreaming to the outside diameter of the casing. Take whatever steps are required to prevent caving during shaft excavation including installation of deeper casings. If electing to remove a casing and replace it with a longer casing through caving soils, backfill the excavation. The Contractor may use soil previously excavated or soil from the site to backfill the excavation. The Contractor may use other approved methods which will control the size of the excavation and protect the integrity of the foundation soils to excavate through caving layers.

Before withdrawing the casing, ensure that the level of fresh concrete is at such a level that the fluid trapped behind the casing is displaced upward. As the casing is withdrawn, maintain the level of concrete within the casing so that fluid trapped behind the casing is displaced upward out of the shaft excavation without mixing with or displacing the shaft concrete.

The Contractor may use the casing method, when approved by the Engineer, to construct shafts through weak caving soils that do not contribute significant shaft shear resistance. In this case, place a temporary casing through the weak caving soils before beginning excavation. Conduct excavation using the dry construction method where appropriate for site

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conditions and the wet construction method where the dry construction method is not appropriate. Withdraw the temporary casing during the concreting operations unless the Engineer approves otherwise.

455-15.5 Permanent Casing Construction Method: Use the permanent casing method when required by the Plans. In this method, place a casing to the prescribed depth before beginning excavation. If the Contractor cannot attain full penetration, the Engineer may direct the Contractor to excavate through the casing and advance the casing until reaching the desired penetration. In some cases, the Engineer may require the Contractor to overream to the outside diameter of the casing before placing the casing.

Construct the shaft in accordance with 455-15.4 except for cutting the casing off at the prescribed elevation upon reaching the proper construction sequence and leaving the remainder of the casing in place.

455-15.5.1 Temporary Extension of Permanent Casing: When the wet method does not provide enough support to excavate and clean the drilled shaft extension below the permanent casing tip elevations shown in the Plans, the permanent casing may be temporarily extended to an elevation deeper than the tip elevation at no additional expense to the Department. The rock socket length must be extended as specified in 455-15.7 and the casing raised to the original casing tip elevation shown in the Plans after the concrete placement. Include details of this procedure in the DSIP for the Engineer's review and approval.

455-15.5.2 Temporary Casing to Stabilize Excavation below the Permanent Casing: To stabilize the excavation below the permanent casing tip elevation, a temporary casing inside an oversized permanent casing may be used at no additional expense to the Department. The permanent casing must have an inside diameter no more than 6 inches larger than the drilled shaft diameter specified in the Plans.

The following requirements apply:

1. Excavate and clean the materials from inside the permanent casing. Ensure all materials are removed from the inside wall of the permanent casing.

2. Install the temporary casing prior to excavating below the permanent casing tip elevation. The temporary casing must have a minimum internal diameter equal to the shaft diameter required in the Plans.

3. If the temporary casing is advanced deeper than the minimum top of rock socket elevation as shown in the Plans, or the top of rock elevation if deeper, extend the rock socket length in accordance with 455-15.7.

4. Place concrete in accordance with 455-15.9.3 through the temporary casing. Do not allow concrete to fall or overflow into the annular space between the temporary and permanent casing.

5. After placement of the concrete, remove the temporary casing in accordance with 455-15.4, 455-15.7 and 455-17. During withdrawal of the temporary casing, maintain adequate concrete head in both the temporary and permanent casings to avoid breaching, caving, or contamination of the concrete.

Include details of this procedure in the DSIP for the Engineer's review and approval.

455-15.6 Excavations: When pilot holes and/or load tests are performed, the Engineer will use the pilot hole and/or load test results to determine the authorized tip elevations and/or the authorized installation criteria of the drilled shafts. Drilled shaft construction shall not begin until pilot hole and/or load test reports are approved by the Engineer. Shaft tip elevations based

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on pilot hole results and/or load tests may vary from the tip elevations presented in the Plans. Extend drilled shaft excavations deeper by extra depth excavation when the Engineer determines the material encountered while drilling the shaft excavation is unsuitable and/or is not the same as anticipated in the design of the drilled shaft. In the absence of suitable strength tests or load tests to evaluate materials excavated, construct the shafts no higher than the tip elevations shown in the Plans.

455-15.6.1 Pilot Hole: When pilot holes are shown in the Plans core a pilot hole, prior to shaft excavation, in accordance with ASTM D2113 Standard Practice for Rock Core Drilling and Sampling of Rock for Site Excavation and the Department's Soils & Foundations Handbook using a double or triple wall core barrel through part or all of the shaft, to a depth of 3 times the diameter of the drilled shaft below the tip elevation shown in the Plans, as directed by the Engineer. The Engineer may require the Contractor to cut any core to a total depth below the bottom of the drilled shaft excavation of up to 5 times the diameter of the drilled shaft.

455-15.6.2 Cores: Take cores when shown in the Plans or directed by the Engineer to determine the character of the material directly below the shaft excavation. Provide equipment to retrieve the core from a depth of 5 times the diameter of the drilled shaft below the bottom of the drilled shaft excavation in accordance with ASTM D2113 Standard Practice for Rock Core Drilling and Sampling of Rock for Site Excavation. Cut the cores with an approved core barrel to a minimum depth of 3 times the diameter of the drilled shaft below the bottom of the drilled shaft excavation after completing the shaft excavation, as directed by the Engineer. The Engineer may require the Contractor to cut any core to a total depth below the bottom of the drilled shaft excavation of up to 5 times the diameter of the drilled shaft.

For cores or pilot holes, use only a double or triple wall core barrel designed:

1. to cut a core sample from 4 inches to 6 inches in diameter, at least 5 feet in length, and,

2. so that the sample of material cored can be removed from the shaft excavation and the core barrel in an undisturbed state.

The Engineer will inspect the cores and determine the depth of required excavation. When considered necessary by the Engineer, take additional cores. Place the core samples in suitable containers, identified by shaft location, elevation from and to, and job number, and deliver to the Department within 48 hours after cutting. When called for in the Plans, substitute Standard Penetration Tests (SPT) for coring. In such cases, supply these tests at no additional cost per foot to the Department above that bid for core (shaft excavation).

Provide areas for the disposal of unsuitable materials and excess materials as defined in 120-5 that are removed from shaft excavations, and dispose of them in a manner meeting all environmental requirements.

Furnish the additional drilled shaft concrete over the theoretical amount required to complete filling any excavations for shafts which are larger than required by the Plans or authorized by the Engineer, at no expense to the Department.

455-15.7 Casings: Ensure that casings are metal, of ample strength to withstand handling and driving stresses and the pressure of concrete and of the surrounding earth materials, and that they are smooth and water tight. Ensure that the inside diameter of casing is not less than the specified size of shaft except as provided below. The Department will not allow extra compensation for concrete required to fill an oversize casing or oversize excavation.

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The Engineer will allow the Contractor to supply casing with an outside diameter equal to the specified shaft diameter (O.D. casing) provided additional shaft length is supplied at the shaft tip. Determine the additional length of shaft required by the following relationship:

$$Additional\ Length = \frac{(D_1 - D_2)\,L}{D_2}$$

where:

D_1= casing inside diameter specified = shaft diameter specified
D_2= casing inside diameter provided ($D_2 = D_1$ minus twice the wall thickness).
L= authorized shaft length below ground for temporary casing methods or below casing for permanent casing methods.

Bear all costs relating to this additional length including but not limited to the cost of extra excavation, extra concrete, and extra reinforcing steel.

Install and remove casing by rotating, exerting downward pressure, or with a vibratory hammer, unless otherwise shown in the Contract Documents. Remove all casings from shaft excavations except those used for the Permanent Casing Method. Ensure that the portion of casings installed under the Permanent Casing Method of construction below the shaft cut-off elevation remains in position as a permanent part of the drilled shaft. The Contractor may leave casings if in the opinion of the Engineer the casings will not adversely affect the shaft capacity in place. When casings that are to be removed become bound in the shaft excavation and cannot be practically removed, drill the shaft excavation deeper as directed by the Engineer to compensate for loss of capacity due to the presence of the casing. The Department will not compensate for the casing remaining. The Department will pay for the additional length of shaft under Pay Item No. 455-88.

If temporary casing is advanced deeper than the minimum top of rock socket elevation shown in the Plans or actual top of rock elevation if deeper, withdraw the casing from the rock socket and overream the shaft. If the temporary casing cannot be withdrawn from the rock socket before final cleaning, extend the length of rock socket below the authorized tip elevation one-half of the distance between the minimum top of rock socket elevation or actual elevation if deeper, and the temporary casing tip elevation.

Form drilled shafts extending through a body of water with permanent casings. When the shaft extends above ground or a body of water, the Contractor may form the exposed portion with removable casing, unless otherwise specified in the Plans. Remove the portion of metal casings between an elevation 2 feet below the lowest water elevation, or 2 feet below ground, whichever is higher and the top of shaft elevation after the concrete is cured. Remove casings to expose the concrete as required above in a manner which will not damage the drilled shaft concrete. Dismantle removable casings in accordance with the provisions of 455-17.5.

When practical, do not start casing removal until completing all concrete placement in the shaft. Extract casing at a slow, uniform rate with the pull in line with the axis of the shaft. Withdraw temporary casings while the concrete remains fluid.

When conditions warrant, the Contractor may pull the casing in partial stages. Maintain a sufficient head of concrete above the bottom of the casing to overcome the hydrostatic pressure of water outside the casing. At all times maintain the elevation of the

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concrete in the casing high enough to displace the drilling slurry between the outside of the casing and the edge of the hole while removing the casing.

The Contractor may use special casing systems in open water areas, when approved, which are designed to permit removal after the concrete has hardened. Design special casings so that no damage occurs to the drilled shaft concrete during their removal.

Expandable or split casings that are removable are not permitted for use below water.

455-15.8 Slurry and Fluid in Excavation:

455-15.8.1 General: Thoroughly premix the slurry in a mixing tank with clean fresh water prior to introduction into the shaft excavation. Introduce slurry before the excavation advances below the bottom of the casing. Ensure that the percentage of polymer or mineral admixture used to make the suspension is such as to maintain the stability of the shaft excavation. Provide adequate water and/or slurry tanks to perform the work in accordance with this Section. The Engineer will not allow excavated pits on projects requiring slurry tanks without the written permission of the Engineer. Take the steps necessary to prevent the slurry from “setting up” in the shaft; including, but not limited, to agitation, circulation, and adjusting the composition and properties of the slurry. Provide suitable offsite disposal areas and dispose of all waste slurry in a manner meeting all requirements pertaining to pollution.

For shafts to support sign, signal, lighting, and ITS structures, polymer slurry may be mixed in the casing portion, in accordance with the APL approved instructions if the following conditions are met:

1. Contractor tests and verifies the polymer slurry meets the property requirements of 455-15.8.3, before continuing the excavation below the casing.
2. Polymer mix continues to be added as required below the bottom of the casing, to maintain the slurry properties during the excavation within compliance of 455-15.8.3.
3. Slurry sampling and testing is performed at intervals not exceeding one hour, in the middle of the excavation depth at the time of testing to verify the properties are maintained within compliance throughout the excavation.
4. If failing to demonstrate the properties are maintained within compliance of 455-15.8.3, discontinue this mixing method and use a slurry pre-mixed in a tank.

Provide a CTQP qualified drilled shaft inspector to perform control tests using suitable apparatus on the slurry mixture to determine the slurry and fluid properties as specified in 455-15.8.2 to 455-15.8.4.

Measure the viscosity of the freshly mixed slurry regularly as a check on the quality of the slurry being formed using an approved measuring device.

Perform tests from the fluid in the excavation to determine density, viscosity, and pH value to establish a consistent working pattern, taking into account the mixing process and blending of freshly mixed slurry and previously used slurry. Repeat tests to determine density, viscosity, and pH value at intervals not exceeding 2 hours during the first 8 hours slurry is in use and every 4 hours thereafter, including overnight, until concrete placement. Perform density, viscosity, and pH tests again when the excavation reaches the midpoint. When the contractor operations require the shaft excavation to be interrupted and performed in multiple shifts, the continuous testing may be waived if the excavation at the time of suspension of the operations is not deeper than the bottom of the casing provided.

For shafts to support sign, signal, lighting, and ITS structures up to 6 feet in diameter and up to 40 feet in depth, when the contractor operations require the shaft to be

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constructed in multiple shifts, the continuous testing may be waived if the excavation at the time of operations suspension is not deeper than the bottom of the casing provided, or if all the conditions below are met:

1. The shaft location is not within a distance equal to the shaft depth, or five shaft diameters, whichever is greater, from an edge of an adjacent lane, utility structure, or any structure.

2. Slurry testing is performed at the time of suspending operations and at a time not exceeding 12 hours after that or at the time the operations resume whichever comes first. Testing shall be performed at intervals not exceeding 2 hours for the first 8 hours after resuming operations and every 4 hours thereafter.

3. Slurry testing shall be performed on at least two samples each time, one sample approximately three feet from the bottom and one sample from the middle of the excavation depth at the time the operations were suspended. The results must indicate the polymer slurry meets the viscosity requirements of 455-15.8.3. If this requirement is not met, do not continue without testing for more than 4 hours including the time periods between shifts.

4. The contractor performs soundings of the fluid level, at intervals of 15 minutes or longer, that demonstrate the fluid level is stable over two consecutive soundings.

5. If when resuming operations, slurry does not meet density, pH, or both, adjust the slurry to meet all property requirements of 455-15.8.3. Re-test slurry to verify properties meet the requirements, before resuming operations. Continue testing the slurry every 4 hours after resuming operations until completion of the excavation.

The Department may perform comparison tests as determined necessary during the mineral and polymer slurry operations.

If, at any time in the opinion of the Engineer, the wet construction method fails to stabilize the excavation, discontinue this method of construction, backfill the excavation and submit modifications in procedure or alternate means of construction for approval.

455-15.8.2 Mineral Slurry: When mineral slurry is used in an excavation, use only processed attapulgite or bentonite clays with up to 2% (by dry weight) of added polymer. Use mineral slurry having a mineral grain size such that it will remain in suspension and having viscosity and gel characteristics to transport excavated material to a screening system. Use a percentage and specific gravity of the material to make a suspension able to maintain the stability of the excavation and to allow proper placement of concrete. Ensure that the material used to make the slurry is not detrimental to concrete or surrounding ground strata. During construction, maintain the level of the slurry at a height sufficient to prevent caving of the hole. In the event of a sudden significant loss of slurry such that the slurry level cannot be maintained by adding slurry to the hole, backfill the excavation and delay the construction of that foundation until an alternate construction procedure has been approved.

Perform the following tests on the mineral slurry supplied to and in the shaft excavation and ensure that the results are within the ranges stated in the table below:

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Table 455-3		
Item to be measured	Range of Results at 68ºF fluid temperature	Test Method
Density	64 to 73 lb/ft^3 (in freshwater environment) 66 to 75 lb/ft^3 (in saltwater environment)	Mud density balance: FM 8-RP13B-1
Viscosity	30 to 40 seconds	Marsh Cone Method: FM 8-RP13B-2
pH	8 to 11	Electric pH meter or pH indicator paper strips: FM 8-RP13B-4
Sand Content	4% or less	FM 8-RP13B-3

The Contractor may adjust the limits in the above table when field conditions warrant as successfully demonstrated in a test hole or with other methods approved by the Engineer. The Engineer must approve all changes in writing before the Contractor can continue to use them.

During construction, maintain the level of mineral slurry in the shaft excavation within the excavation and at a level not less than 4 feet above the highest expected piezometric water elevation along the depth of a shaft.

455-15.8.3 Polymer Slurry: A representative of the manufacturer must be on-site or available for immediate contact to assist and guide the construction of the first three drilled shafts at no additional cost to the Department. This representative must also be available for on-site assistance or immediate contact if problems are encountered during the construction of the remaining drilled shafts as determined by the Engineer. Use polymer slurry only if the soils below the casing are not classified as organic, and the pH of the fluid in the hole can be maintained in accordance with the manufacturer's recommendations.

Perform the following tests on the polymer slurry supplied to and in the shaft excavation and ensure that the results are maintained within the ranges stated in the table below:

Table 455-4 Mixed Polymer Slurry Properties		
Item to be measured	Range of Results at 68ºF fluid temperature	Test Method
Density	62 to 65 lb/ft^3 (in freshwater environment) 64 to 67 lb/ft^3 (in saltwater environment)	Mud density balance: FM 8-RP13B-1
Viscosity for bridges and main structure foundations	50 seconds to upper limit defined by the APL	Marsh Cone Method: FM 8-RP13B-2
Viscosity for miscellaneous structure foundations	50 seconds to upper limit recommended by the manufacturer based on soil type	Marsh Cone Method: FM 8-RP13B-2

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Table 455-4 Mixed Polymer Slurry Properties		
Item to be measured	Range of Results at 68ºF fluid temperature	Test Method
pH	Range published by the manufacturer for materials excavated	Electric pH meter or pH indicator paper strips: FM 8-RP13B-4
Sand Content	0.5% or less	FM 8-RP13B-3

If desired, sodium bicarbonate or soda ash may be added to the fluid in the hole to raise the pH. Premix polymer slurry in accordance with the manufacturer's published procedures. Do not mix the slurry in the excavation as a means to prepare slurry. When approved by the Engineer, adjustments to slurry properties can be made in the excavation.

During construction, maintain the level of the slurry at a height sufficient to prevent caving of the hole and which should not be lower than 4 feet above the highest expected piezometric water elevation along the depth of the shaft.

Ensure the method of disposal meets the requirements of local authorities.

455-15.8.4 Fluid in Excavation at Time of Concrete Placement: When any fluid is present in any drilled shaft excavation, including shafts to support sign, signal, lighting and ITS structures, the applicable test methods and reporting requirements described in 455-15.8.1, 455-15.8.2 and 455-15.8.3 apply to tests of fluid in the shaft prior to placing the concrete.

When mineral slurries are used, ensure the properties at the time of concrete placement are within the acceptable ranges indicated in 455-15.8.2. When polymer slurries are used ensure the properties of the polymer slurry are within the following acceptable ranges at the time of concrete placement:

Table 455-5 Polymer Slurry Properties at Time of Concrete Placement		
Item to be measured	Range of Results at 68ºF fluid temperature	Test Method
Density	62 to 65 lb/ft^3 (in freshwater environment) 64 to 67 lb/ft^3 (in saltwater environment)	Mud density balance: FM 8-RP13B-1
Viscosity	50 seconds to upper limit defined by the APL	Marsh Cone Method: FM 8-RP13B-2
pH	Range published by the manufacturer for materials excavated	Electric pH meter or pH indicator paper strips: FM 8-RP13B-4
Sand Content	0.5% or less	FM 8-RP13B-3

Test samples of the fluid in the shaft from within 1 inch of the base of the shaft and from the middle of the shaft height for shafts up to 60 feet in depth. Test samples of the fluid in the shaft from within 1 inch of the base of the shaft and at intervals not exceeding 30 feet up the shaft for shafts deeper than 60 feet. Use a sampling tool designed to sample over a depth range of 12 inches or less. Take whatever action is necessary prior to placing the concrete to

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bring the fluid within the specification and reporting requirements, outlined in the tables in 455-15.8.2 and 455-15.8.3, except as follows:

The Engineer will not require tests for pH or viscosity, nor require the fluid to meet the minimum density specified in 455-15.8.2 and 455-15.8.3 when neither polymer nor mineral slurry has been introduced into the shaft excavation.

455-15.9 Tremies and Pumps:

455-15.9.1 General: The requirements of the applicable provisions of Section 400 will apply when using a tremie or a pump to place drilled shaft concrete.

455-15.9.2 Dry Excavations: Ensure that the tremie for depositing concrete in a dry drilled shaft excavation consists of a tube of solid construction, a tube constructed of sections which can be added and removed, or a tube of other approved design. The Contractor may pass concrete through a hopper at the top of the tube or through side openings as the tremie is retrieved during concrete placement. Support the tremie so that the free fall of the concrete is less than 5 feet at all times. If the free falling concrete causes the shaft excavation to cave or slough, control the movement of concrete by reducing the height of free fall of the concrete and/or reducing the rate of flow of concrete into the excavation.

455-15.9.3 Wet Excavations: Construct the tremie or pump line used to deposit concrete beneath the surface of water so that it is water-tight and will readily discharge concrete. Construct the discharge end of the tremie or pump line to prevent water intrusion and permit the free flow of concrete during placement operations. Ensure that the tremie or pump line has sufficient length and weight to rest on the shaft bottom before starting concrete placement.

During placement operations, ensure that the discharge end of the tremie or pump line is within 6 inches of the bottom of the shaft excavation until at least 10 feet of concrete has been placed. Ensure the discharge end of the tremie or pump line is continuously embedded at least 10 feet into the concrete after 10 feet of concrete has been placed and until the casing is overpoured sufficiently to eliminate all contaminated concrete. Ensure that the free fall of concrete into the hopper is less than 5 feet at all times. Support the tremie so that it can be raised to increase the discharge of concrete and lowered to reduce the discharge of concrete. Do not rapidly raise or lower the tremie to increase the discharge of the concrete. Maintain a continuous flow of concrete and a positive pressure differential of the concrete in the tremie or pump line at all times to prevent water or slurry intrusion into the shaft concrete.

455-15.10 Excavation and Drilling Equipment:

455-15.10.1 General: All shaft excavation is unclassified shaft excavation. The Engineer will require drilled shaft sidewall overreaming when inspections show it to be necessary. These terms are defined in 455-15.10.2, 455-15.10.3, and 455-15.10.4, respectively.

Use excavation and drilling equipment having adequate capacity, including power, torque, and crowd (downthrust), and excavation and overreaming tools of adequate design, size, and strength to perform the work shown in the Plans or described herein. When the material encountered cannot be drilled using conventional earth augers and/or underreaming tools, provide special drilling equipment, including but not limited to rock augers, core barrels, rock tools, air tools, blasting materials, and other equipment as necessary to continue the shaft excavation to the size and depth required. In the event blasting is necessary, obtain all necessary permits. The Contractor is responsible for the effects of blasting on already completed work and adjacent structures. The Engineer must approve all blasting.

455-15.10.2 Unclassified Shaft Excavation: Unclassified shaft excavation is defined as all processes required to excavate a drilled shaft of the dimensions shown in the

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Contract Documents to the depth indicated in the Plans plus 15 feet or plus 3 shaft diameters, whichever is deeper, completed and accepted. Include in the work all shaft excavation, whether the material encountered is soil, rock, weathered rock, stone, natural or man-made obstructions, or materials of other descriptions.

455-15.10.3 Unclassified Extra Depth Excavation: Unclassified extra depth excavation is defined as all processes required to excavate a drilled shaft of plan dimensions which is deeper than the limits defined as unclassified shaft excavation.

455-15.10.4 Drilled Shaft Sidewall Overreaming: Drilled shaft sidewall overreaming is defined as the unclassified excavation required to roughen its surface or to enlarge the drilled shaft diameter due to softening of the sidewalls or to remove excessive buildup of slurry cake when slurry is used. Increase the shaft radius a minimum of 1/2 inch and a maximum of 3 inches by overreaming. The Contractor may accomplish overreaming with a grooving tool, overreaming bucket, or other approved equipment.

Meet the limit for depth of sidewall overreaming into the shaft sidewall material and the elevation limits between which sidewall overreaming is required.

455-15.11 Inspection of Excavations:

455-15.11.1 Dimensions and Alignment: Provide equipment for checking the dimensions and alignment of each permanent shaft excavation. Determine the dimensions and alignment of the shaft excavation under the observation and direction of the Department. Generally, check the alignment and dimensions by any of the following methods as necessary:

1. Check the dimensions and alignment of dry shaft excavations using reference stakes and a plumb bob.

2. Check the dimensions and alignment of casing when inserted in the excavation.

3. Insert any casing, rod or pipe assembly, or other device used to check dimensions and alignment into the excavation to full depth.

455-15.11.2 Depth: Generally, reference the depth of the shaft during drilling to appropriate marks on the Kelly bar or other suitable methods. Measure final shaft depths with a suitable weighted tape or other approved methods after final cleaning.

455-15.11.3 Shaft Inspection Device (SID): When shown in the Plans, furnish all power and equipment necessary for the Engineer to inspect the bottom conditions of a drilled shaft excavation and to measure the thickness of bottom sediment or any other debris using a SID. Provide a means to position and lower the SID into the shaft excavation to enable the bell housing to rest vertically on the bottom of the excavation. Include all cost related to the inspection device in the cost of drilled shaft items.

Furnish a SID meeting the following requirements:

1. A remotely operated, high resolution, color video camera sealed inside a watertight bell housing.

2. Provides a clear view of the bottom inspection on a video monitor at the surface in real time.

3. Provides a permanent record of the entire inspection with voice annotation on a quality DVD with a resolution of not less than 720 x 480.

4. Provides a minimum field of vision of 110 square inches, with at least two graduated measuring devices to record the depth of sediment on the bottom of the shaft excavation to a minimum accuracy of 1/2 inch and a length greater than 1-1/2 inches.

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5. Provides sufficient lighting to illuminate the entire field of vision at the bottom of the shaft in order for the operator and inspector to clearly see the depth measurement scale on the video monitor and to produce a clear recording of the inspection.

6. Provides a regulated compressed air or gas system to precisely adjust the drilling fluid level within the bell housing and a pressurized water system to assist in determination of bottom sedimentation depth.

Obtain the Engineer's approval of the device in advance of the first inspection contingent on satisfactory field performance. Notify the Engineer for approval before a different device is used for any subsequent inspection.

455-15.11.4 Shaft Cleanliness Requirements: Adjust cleaning operations so a minimum of 50% of the bottom of each shaft will have less than 1/2 inches of sediment at the time of placement of the concrete. Ensure the maximum depth of sedimentary deposits or any other debris at any place on the bottom of the shaft excavation does not exceed 1-1/2 inches. The Engineer will determine shaft cleanliness by visual inspection for dry shafts, using divers or an inspection device or other methods the Engineer deems appropriate for wet shafts.

When using slurry, meet the requirements of 455-15.8 at the time of concrete placement.

455-15.11.4.1 Exceptions for Shafts for Sign, Signal, Lighting and ITS Structures: Ensure the depth of sedimentary deposits or other debris does not exceed 1 inch over the bottom of the shaft when installing drilled shafts to support sign, signal, lighting and ITS structures.

455-15.11.5 Time of Excavation: Overream the sidewalls of any unclassified excavation work using mineral slurry lasting more than 36 hours (measured from the beginning of excavation for all methods except the Temporary or Permanent Casing Method, which begins at the time excavation begins below the casing) before placement of the concrete. Ensure that the minimum depth of overreaming the shaft sidewall is 1/2 inch and the maximum depth is 3 inches. Provide any overreaming required at no expense to the Department when exceeding the 36 hour limit unless the time limit is exceeded to accomplish excavating deeper than the elevation shown in the Plans as ordered by the Engineer. The Department will pay the Contractor for authorized overreaming when excavating deeper than the elevation shown in the Plans as ordered by the Engineer exceeds the 36 hour time limit as Extra Work.

When using mineral slurry, adjust excavation operations so that the maximum time that slurry is in contact with the bottom 5 feet of the shaft (from time of drilling to concreting) does not exceed 12 hours. If exceeding the 12 hour time limit, overream the shaft socket or the full shaft when socket is not specified, at no additional expense to the Department prior to performing other operations in the shaft.

455-16 Reinforcing Steel Construction and Placement.

455-16.1 Cage Construction and Placement: Completely assemble and place as a unit the cage of reinforcing steel, consisting of longitudinal bars, ties, and cage stiffener bars, immediately after the Engineer inspects and accepts the shaft excavation and immediately prior to placing concrete. Tie all intersections of drilled shaft reinforcing steel with cross ties or "figure 8" ties. Use double strand ties, ties with larger tie wire, U-bolts, or similar when necessary. The Engineer will give final approval of the cage construction and placement subject to satisfactory performance in the field.

455-16.2 Splicing Cage: If the bottom of the constructed shaft elevation is lower than the bottom of the shaft elevation in the Plans, extend a minimum of one half of the longitudinal bars

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required in the upper portion of the shaft the additional length. Continue the tie bars for the extra depth, spaced on 2 foot centers, and extend the stiffener bars to the final depth. The Contractor may lap splice these bars or use unspliced bars of the proper length. Do not weld bars to the planned reinforcing steel unless shown in the Contract Documents.

For drilled shafts supporting sign, signal, lighting and ITS structures, if the shaft cleaning operations result in excavating below the required tip elevation, the reinforcing steel cage does not need to be extended. The reinforcing steel cage may be spliced to rest on the bottom of the excavation or suspended in place from the top.

455-16.3 Support, Alignment, and Tolerance: Tie and support the reinforcing steel in the shaft so that the reinforcing steel will remain within allowable tolerances as specified in 455-20 and Section 415.

Ensure concentric spacing for the entire length of the cage. As a minimum, use centering devices consisting of wheels or other approved noncorrosive spacing devices within 3 feet of the bottom, within 6 feet of the top, and intervals not exceeding 10 feet along the cage length. Do not use block or wire type spacers. Ensure no permanent metallic elements will be within the concrete cover space. Use a minimum of one spacer per 30 inches of circumference of cage with a minimum of four at each level. Provide spacers at the bottom of the drilled shaft reinforcing cage as required to maintain the proper position of the cage.

For shafts to support sign, signal, lighting and ITS structures, when a casing with an inside diameter (I.D.) larger than the required shaft diameter is used, provide, within the portion of the oversized casing, centering devices specially dimensioned or other means to ensure the shaft, the cage and the upright are concentric. Provide spacers within 3 feet of the bottom and at intervals not exceeding 10 feet along the reinforcement, with a minimum of two levels of spacers below the bottom of the casing.

Check the elevation of the top of the steel cage before and after placing the concrete. If the cage is not within the specified tolerances, correct, and submit a revised DSIP to the Engineer for approval. Do not construct additional shafts until receiving approval from the Engineer.

455-16.4 Nondestructive Integrity Testing Access Tubes: Install access tubes full length in all drilled shafts from the tip of shaft to a point high enough above top of shaft to allow thermal integrity testing for drilled shafts (TITDS) and cross-hole sonic logging (CSL) testing, but not less than 30 inches above the top of the drilled shaft, ground surface or water surface, whichever is higher. Equally space tubes around circumference of drilled shaft. Securely tie access tubes to the inside of the reinforcing cage and align tubes to be parallel to the vertical axis of the center of the cage. Access tubes from the top of the reinforcing cage to the tip of the shaft shall be NPS 1-1/2 Schedule 40 black iron or black steel (not galvanized) pipe. Access tubes above the top of the reinforcing cage may be the same black iron or black steel pipe or Schedule 40 PVC pipe. Ensure that the access tubes are free from loose rust, scale, dirt, paint, oil and other foreign material. Couple tubes as required with threaded couplers, such that inside of tube remains flush. Seal the bottom and top of the tubes with threaded caps. The tubes, joints and bottom caps shall be watertight. Seal the top of the tubes with lubricated, threaded caps sufficient to prevent the intrusion of foreign materials. Stiffen the cage sufficiently to prevent damage or misalignment of access tubes during the lifting and installation of the cage. Exercise care in removing the caps from the top of the tubes after installation so as not to apply excess torque, hammering or other stress which could break the bond between the tubes and the concrete.

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Provide the following number (rounded up to the next whole number of tubes) and configuration of access tubes in each drilled shaft based on the diameter of the shaft.

Table 455-6		
Shaft Diameter	Number of Tubes Required	Configuration around the inside of Circular Reinforcing Cage
36 to 48 inches	4	90 degrees apart
Greater than 48 inches	1 tube per foot of Shaft Diameter	360 degrees divided by the Number of Tubes

Insert simulated or mock probes in each access tube prior to concreting to ensure the serviceability of the tube. Fill access tubes with clean potable water and recap prior to concreting. Repair or replace any leaking, misaligned or unserviceable tubes as in a manner acceptable to the Engineer prior to concreting.

For method shafts for bridge foundations, in addition to the access tubes, provide embedded thermal wires equally spaced around the reinforcing cage.

For drilled shaft foundations requiring anchor bolts, verify access tubes will not interfere with anchor bolt installation before excavating the shaft. When access tube locations conflict with anchor bolt locations, move the access tube location plus or minus 2 inches along the inner circumference of the reinforcing cage. Notify the Engineer before excavating the shaft if the access tube locations cannot be moved out of conflict with anchor bolt locations.

For drilled shafts supporting sign, signal, lighting and ITS structures, if the shaft cleaning operations result in excavating below the required tip elevation, the access tubes do not need to be extended. If the reinforcing steel cage is suspended in place from the top rather than resting on the bottom of the excavation, clearly mark the top of shaft location on each tube.

When called for in the Contract Documents, provide embedded thermal wires and equipment to allow TITDS in accordance with ASTM D7949 Method B.

455-17 Concrete Placement.

455-17.1 General: Place concrete in accordance with the applicable portions of Sections 346 and 400, 455-15.2, 455-15.3, 455-15.4, 455-15.5, 455-15.8, 455-15.9, and the requirements herein.

Place concrete as soon as possible after completing all excavation, cleaning the shaft excavation, inspecting and finding it satisfactory, and immediately after placing reinforcing steel. Continuously place concrete in the shaft to the top of the casing. Continue placing concrete after the casing is full until good quality concrete is evident at the top of the casing. Place concrete through a tremie or concrete pump using approved methods. After the shaft is overpoured sufficiently to eliminate all contaminated concrete, additional concrete may be added to the shaft without the use of a tremie or pump in accordance with Section 400.

If the pressure head is lost during concrete placement for any reason, the Engineer may direct the Contractor to perform integrity testing at no expense to the Department.

Immediately after concreting, check the water levels in the CSL access tubes and refill as necessary. If tubes become unserviceable, core new holes in the drilled shaft as directed by the Engineer.

455-17.2 Placement Time Requirements: The elapsed time for placing drilled shaft concrete includes the concrete mixing and transit time, the concrete placement time, the time

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required to remove any temporary casing that causes or could cause the concrete to flow into the space previously occupied by the casing, and the time to insert any required column steel, bolts, weldments, etc. The elapsed time begins at the time the first truck load placed in the shaft is batched. Maintain a minimum slump of 5 inches throughout the elapsed time. Use materials to produce and maintain the required slump through the elapsed time that meets the class of concrete specified. Provide slump loss tests that demonstrate to the Engineer that the concrete will maintain a 5 inch or greater slump for the anticipated elapsed time before beginning drilled shaft construction.

455-17.3 Forms: When the top of shaft elevation is above ground or above water, form the portion of the shaft above ground and the portion of the shaft above water with a removable form or another approved method to the dimensions shown in the Plans except when the Permanent Casing Method is specified.

455-17.4 Riser Blocks: The Contractor may cast a riser block of equal diameter as the column and of a maximum height of 6 inches at the top of the completed shaft. When this option is chosen, extend any dowel steel above the top of shaft an additional 6 inches.

455-17.5 Curing: Cure the top surface in accordance with the applicable provisions of Section 400, and construct any construction joint area as shown in the Plans. Protect portions of drilled shafts exposed to a body of water from the action of water by leaving the forms in place for a minimum of seven days after casting the concrete. The Contractor may remove forms prior to seven days provided the concrete strength has reached 2,500 psi or greater as evidenced by cylinder breaks.

455-17.6 Non-Destructive Testing of Drilled Shaft Integrity:

455-17.6.1 Thermal Integrity Testing for Drilled Shafts (TITDS): Perform all TITDS in accordance with ASTM D7949-14, which details two alternative procedures:

Method A: uses a thermal probe lowered into access ducts installed in the deep foundation element during construction.

Method B: uses multiple embedded thermal sensors attached to the reinforcing cage installed in the deep foundation element during construction.

Test method shafts, load test shafts, and all drilled shafts in bridge bents or piers considered nonredundant in the Plans, using TITDS. For all other drilled shafts, perform TITDS only on drilled shafts selected by the Engineer. The minimum number of shafts tested is the number of shafts indicated in the Plans. The Engineer may increase the number of shafts tested as deemed necessary.

Engage a qualified Specialty Engineer to supervise the TITDS. The qualified TITDS Specialty Engineer must have a minimum of six months experience of TITDS, have a Florida Licensed Professional Engineer and supervise the collection and interpretation of data. The individual performing the TITDS in the field must work for the Specialty Engineer firm and have a minimum of six months' experience of TITDS. The Contractor shall provide all necessary assistance to the TITDS Specialty Engineer to satisfactorily perform the testing.

After acceptance of production shafts by the Engineer, remove all water from the access tubes or core holes and fill the tubes or core holes with a structural non-shrink grout meeting the requirements of Section 934 from the bottom via tremie tube. Place the grout utilizing enough pressure to fill the tubes or core holes completely.

If the Contractor determines at any time during the non-destructive testing and evaluation of the drilled shaft that the drilled shaft should be replaced, no further testing or evaluation of that shaft is required.

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455-17.6.1.1 Equipment: Furnish TITDS test equipment in accordance with ASTM D7949-14 as follows:

1. Provide thermal probes with four orthogonally oriented infrared sensors able to be used in 1-1/2 inch I.D. pipes.
2. Provide a computer based TITDS data acquisition system for display of signals during data acquisition.
3. Provide a depth encoder sensor to determine probe depths.
4. Provide an air compressor and power supply with sufficient pressure to air lift the water from the access tubes.

455-17.6.1.2 Procedure: For non-bridge structures, perform TITDS testing between the minimum and maximum times shown below after the batching time of the first truck load placed in the drilled shaft, unless otherwise directed by the Engineer.

Table 455-7

Shaft Diameter (inches)	Minimum time (hours)	Maximum time (hours)
36 - 48	24	54
49 - 60	24	72
61 - 72	24	72
73 - 84	24	90
85 - 120	24	108

The Contractor may propose modifications in the above table for site specific and special concrete mix conditions, as demonstrated from lab and field testing and instrumentation. The Engineer must approve all changes to the testing times prior to the Contractor using them.

For bridges, prior to production drilled shaft and load test drilled shaft installation, perform TITDS in accordance with ASTM D7949-14 Method B to determine the temperature variability and time to peak temperature for each project specific concrete mix. Obtain temperature measurements at least every 15 minutes during curing on the method shafts. Submit the TITDS results within three working days of performing the tests, in accordance with 455-17, including the proposed temperature peak time established from the TITDS. The Engineer will review the results of the test and concur with the proposed peak time or revise it. After the peak time is established for each mix, perform TITDS in accordance with ASTM D7949-14 Method A on production drilled shafts and load test shafts, within the following times after batching the first truck:

$$\text{Minimum time (hours)} = \text{Peak time (hours)} - 8$$

$$\text{Maximum time (hours)} = \text{Peak time (hours)} + 4D$$

Where:

D = Drilled shaft diameter in feet.

Peak time: Time after batching the first truck load that was placed in the drilled shaft, at which the maximum temperature is observed.

Furnish information regarding the shaft, tube lengths and depths, construction dates, and other pertinent shaft installation observations and details to the

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Department at the time of testing. Verify access tube lengths and their condition in the presence of the Department, at the end of concrete placement. If the access tubes do not provide access over the full length of the shaft, repair the existing tube(s) or core additional hole(s), as directed by the Engineer, at no additional cost to the Department.

Just prior to inserting the thermal probe, remove water from the access tubes. Store the removed water in an insulated container for later replacement. Allow the thermal probe to acclimate in accordance with the equipment manufacturer recommendations. Continuously record temperatures at depth intervals of 3.0 inches or less from the top to the bottom of each access tube. Repeat the test at each access tube until two sets of data from the same access tube provide similar results. Return the warm water to the access tubes immediately after the testing has been completed.

Immediately report any potential defects indicated by low temperature anomalies to the Engineer.

455-17.6.1.3 Required TITDS Reports: Submit the TITDS data and analysis results to the Engineer in a signed and sealed report, together with all electronic data, within three working days of testing. The report shall include as minimum the following items:

1. Graphs displaying all temperature measurements and average temperature versus depth.
2. Indication of unusual temperatures, including cooler local deviations from the average at any depth from the overall average over the entire length.
3. A graph displaying the average temperature and theoretical temperature versus depth.
4. Variations in temperature between access tubes which may indicate variations in cage alignment.
5. When ASTM D7949-14 method B is used, include a chart indicating the variability of temperature vs. time, for all wires and the average. Submit the peak time in hours for the average temperature of the wires.
6. The calculated radius of the shaft throughout the entire depth.
7. Calculated concrete cover throughout the entire depth.
8. Shaft Details, Probe Details, Environmental Details, Tube Run Selection and Shaft Adjustment Data that show the measurements, inputs, and adjustments to the data. Screen captures of these pages from the TIP Reporter software will be acceptable.
9. A conclusion stating whether the tested shaft is free from integrity defects, meets the minimum concrete cover and diameter requirements by the specifications and the cage is properly aligned. When anomalies are detected, include in the report a three-dimensional rendering of the shape of the shaft.

455-17.6.1.4 Evaluation of TITDS Test Results: The Engineer will evaluate the observations during drilled shaft construction and TITDS results to determine whether or not the drilled shaft construction is acceptable. Drilled shafts not meeting the minimum cover and diameter requirements, or having integrity defects, are not acceptable without an engineering analysis.

455-17.6.1.5 Coring and/or Repair of Drilled Shafts: If the Engineer determines a drilled shaft is unacceptable based on the TITDS tests and other testing, or observes problems during drilled shaft construction, core the shaft to allow further evaluation and repair, or replace the shaft as directed by the Engineer. If coring to allow further evaluation of the shaft and repair is chosen, one or more core samples shall be taken from each unacceptable shaft for

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full depth of the shaft or to the depth directed by the Engineer. The Engineer will determine the number, location, and diameter of the cores based on the results of the TITDS. Keep an accurate log of cores. Properly mark and place the cores in a crate showing the shaft depth at each interval of core recovery. Submit the coring log and transport the cores to the location designated by the Engineer. Perform strength testing by an AASHTO certified lab on portions of the cores as required by the Engineer. If the TITDS and coring indicate the shaft is defective, propose remedial measures for approval by the Engineer. Such improvement may consist of but is not limited to correcting defective portions of the shaft, providing straddle shafts to compensate for capacity loss, or providing a replacement shaft. Repair all detected defects and conduct post repair integrity testing using horizontal and offset CSL testing and 3-D tomographic imaging as described in 455-17.6.2. Engage a Specialty Engineer to perform gamma-gamma density logging calibrated to 1-1/2 inch black iron access tubes, prior to and after the repair is performed, to verify the integrity of the shaft outside the reinforcing cage in the same locations where the repair was required. When straddle shafts or replacement shafts are used to correct a deficient foundation, perform TITDS in accordance with 455-17.6.1 through 455-17.6.3 to verify integrity of these shafts. Submit all results to the Engineer within five days of test completion for approval. Perform all work described in this subarticle at no additional cost to the Department, and with no increase in Contract Time.

455-17.6.2 Cross Hole Sonic Logging (CSL) and Tomography: When required by the Engineer, perform CSL testing in accordance with ASTM D6760 within 25 days of completion of the shaft. Engage a qualified Specialty Engineer to perform the CSL testing. The qualified CSL Specialty Engineer must be a Professional Engineer in the State of Florida and have a minimum of six months' experience of CSL testing, supervising the collection of CSL data and interpretation of CSL results. The individual performing the CSL testing in the field must work for the Specialty Engineer firm and have a minimum of six months' experience of CSL testing. The Contractor shall provide all necessary access and assistance to the CSL Specialty Engineer to satisfactorily perform the testing.

When a shaft contains four tubes, test every possible tube combination. For shafts with five or more tubes, test all pairs of adjacent tubes around the perimeter, and one-half of the remaining number of tube combinations, as chosen by the Engineer. Pull the probes simultaneously, starting from the bottoms of the tubes, over an electronic depth measuring device. Perform the CSL tests with the source and receiver probes in the same horizontal plane. Continuously record CSL signals at depth intervals of 2-1/2 inches or less from the bottom of the tubes to the top of each shaft. Remove all slack from the cables prior to pulling to provide accurate depth measurements in the CSL records. When the measurements indicate a 30% or greater reduction in velocity between one or more pairs, take one or two concrete cores to allow further evaluation and repair, or replace the shaft as directed by the Engineer. Determine the location of the concrete cores by performing 3D tomographic analysis using the CSL measurements. The core depths shall be at least 5 feet deeper than the bottom of the anomaly determined by the 3D tomography analysis or full depth if the anomaly is within 5 feet of the bottom of the shaft. The Engineer may accept a drilled shaft without concrete cores if an Engineering Analysis Report (EAR) demonstrates that the anomaly does not affect the structural and the geotechnical axial capacity, the structural and geotechnical lateral stability, the settlement behavior of the shaft, and that the anomaly will not impact the durability of the foundation.

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When repairs are done, perform CSL measurements in all tube pair combinations with the source and receiver running at the same horizonal plane and at the vertical offsets of 45 degrees above and below. Perform all measurements including the offset measurements from the point where the higher probe is at least 5 feet below the lower limit of the repaired zone to the point where the lower probe is at least 5 feet above the upper limit of the repaired zone. Offset measurements must be as follows: plus 45 degrees (source below receiver) and minus 45 degrees (source above receiver). Use the measurements of these two offsets in combination with the horizontal measurements to perform the 3D tomography. Provide the CSL measurements, CSL logs and 3D tomographic analysis at no additional cost to the Department.

After acceptance of production shafts by the Engineer, fill the tubes or core holes with a structural non-shrink grout in accordance with 455-17.6.1.

If the Contractor determines at any time during the non-destructive testing and evaluation of the drilled shaft that the drilled shaft should be replaced, no further testing or evaluation of that shaft is required.

455-17.6.2.1 Required CSL Reports: Present the CSL data and analysis results to the Engineer in a signed and sealed report. Include CSL logs with analyses of first pulse arrival time (FAT) versus depth and pulse energy/amplitude versus depth. Present a CSL log for each tube pair tested with any defect zones identified on the logs and discussed in the test report as appropriate. When offset measurements are required, perform 3D tomographic analysis using all offset data, and include color coded 3D tomographic images in the report.

455-17.6.2.2 Evaluation of Cross Hole Sonic logging Testing: The Engineer will evaluate the observations during drilled shaft construction and the CSL test results to determine whether or not the drilled shaft construction is acceptable. Drilled shafts with velocity reduction exceeding 30% are not acceptable without an engineering analysis.

455-17.6.2.3 Coring and/or Repair of Drilled Shafts: If the Engineer determines a drilled shaft is unacceptable based on the CSL test and other testing, core the shaft to allow further evaluation and repair, or replace the shaft in accordance with 455-17.6.1.5.

If repairs are performed or additional shafts installed to correct a deficient foundation, conduct integrity testing and submit the results to the Engineer in accordance with 455-17.6.1.5.

455-18 Method Shafts.

The Engineer will use the construction of method shafts (test holes) to determine if the methods and equipment used by the Contractor are sufficient to produce a shaft excavation meeting the requirements of the Contract Documents. During method shaft excavations, the Engineer will evaluate the ability to control dimensions and alignment of excavations within tolerances; to seal the casing into impervious materials; to control the size of the excavation under caving conditions by the use of slurry or by other means; to properly clean the completed shaft excavation; to construct excavations in open water areas; to determine the elevation of ground water; to place reinforcing steel and concrete meeting the requirements of these Specifications within the prescribed time frame; and to execute any other necessary construction operation. Revise the methods and equipment as necessary at any time during the construction of the method shaft when unable to satisfactorily carry out any of the necessary operations described above or when unable to control the dimensions and alignment of the shaft excavation within tolerances.

Construct method shafts out of permanent position at the location shown in the Plans or as directed by the Engineer. Ensure the diameter and depth of the method shaft or holes are the

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same diameter and maximum depth as the production drilled shafts. Reinforce the method shaft unless otherwise directed in the Contract Documents. Fill the method shaft with concrete in the same manner production drilled shafts will be constructed. Backfill method shaft which are not filled with concrete with suitable soil in a manner satisfactory to the Engineer. Leave concreted method shaft in place, except remove the top of the shaft to a depth of 2 feet below the finished graded surface. Use the same procedure for shafts constructed in water. Restore the disturbed areas at the sites of method shaft drilled out of position as nearly as practical to their original condition. When the Contractor fails to demonstrate to the Engineer the adequacy of his methods or equipment, and alterations are required, make appropriate modifications and provide additional test holes at no expense to the Department. Include the cost of all method shaft in the cost of the drilled shafts. Make no changes in methods or equipment after initial approval without the consent of the Engineer.

A separate method shaft is not required for drilled shafts installed under sign, signal, lighting and ITS structures. The first production shaft will serve as a method shaft for determining acceptability of the installation method.

455-19 Test Bells.

Test bells are no longer used.

455-20 Construction Tolerances.

Meet the following construction tolerances for drilled shafts:

1. Ensure that the top of the drilled shaft is no more than 3 inches laterally in the X or Y coordinate from the position indicated in the Plans.

2. Ensure that the vertical alignment of the shaft excavation does not vary from the alignment shown in the Plans by more than 1/4 inches per foot of depth.

3. After placing all the concrete, ensure that the top of the reinforcing steel cage is no more than 6 inches above and no more than 3 inches below plan position.

4. Ensure that the reinforcing cage is concentric with the shaft within a tolerance of 1-1/2 inches. Ensure that the horizontal concrete cover is a minimum of 4-1/2 inches unless shown otherwise in the Plans.

5. Ensure that the minimum diameter of the drilled shaft is not smaller than the specified shaft diameter minus 1 inch. All casing diameters shown in the Plans refer to I.D. (inside diameter) dimensions. However, the Contractor may use casing with an outside diameter equal to the specified shaft diameter if the extra length described in 455-15.7 is provided. In this case, ensure that the I.D. of the casing is not smaller than the specified shaft diameter minus 1 inch. When approved, the Contractor may elect to provide a casing larger in diameter than shown in the Plans to facilitate meeting this requirement. When conditions are such that a series of telescoping casings are used, provide the casing sized to maintain the minimum shaft diameters listed above.

6. Except when abutting or encroaching within a sidewalk, ensure that the top elevation of the drilled shaft concrete has a tolerance of plus 1 inch and minus 3 inches from the top of shaft elevation shown in the Plans.

7. When abutting or encroaching within a sidewalk, ensure that the top elevation of the drilled shaft is flush with the sidewalk surface.

8. The dimensions of casings are subject to American Petroleum Institute tolerances applicable to regular steel pipe.

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9. Use excavation equipment and methods designed so that the completed shaft excavation will have a flat bottom. Ensure that the cutting edges of excavation equipment are normal to the vertical axis of the equipment within a tolerance of plus or minus 3/8 inches per foot of diameter.

455-21 Drilled Shaft Excavations Constructed out of Tolerance.

Do not construct drilled shaft excavations in such a manner that the concrete shaft cannot be completed within the required tolerances. The Contractor may make corrections to an unacceptable drilled shaft excavation by any combination of the following methods:

1. Overdrilling the shaft excavation to a larger diameter to permit accurate placement of the reinforcing steel cage with the required minimum concrete cover.
2. Increasing the number and/or size of the steel reinforcement bars.

When the tolerances are not met, the Contractor may propose a redesign to incorporate shafts installed out of tolerance into caps or footings. Incorporate shafts installed out of tolerance at no expense to the Department. Ensure the Contractor's Engineer of Record performs any redesign and signs and seals the redesign drawings and computations. Do not begin any proposed construction until the redesign has been reviewed and approved by the Engineer.

Backfill any out of tolerance shafts in an approved manner when directed by the Engineer until the redesign is complete and approved. Furnish additional materials and work necessary, including engineering analysis and redesign, to effect corrections of out of tolerance drilled shaft excavations at no expense to the Department.

455-22 Load Tests.

When the Plans include load testing, perform all load tests in accordance with 455-2 or as shown in the Contract Documents.

455-23 Method of Measurement.

455-23.1 Drilled Shafts: The quantity to be paid for will be the length, in feet, of the reinforced concrete drilled shaft of the diameter shown in the Plans, completed and accepted. The length will be determined as the difference between the top of shaft elevation as shown in the Plans and the final bottom of shaft elevation as authorized and accepted. When the Contractor elects to provide outside diameter (O.D.) sized casing rather than inside diameter (I.D.) sized casing as allowed in 455-15.7, the pay quantity measured as described above will be multiplied by a factor (F) determined as follows:

$$F = \frac{2D_2 - D_1}{D_2}$$

where:

F= factor to adjust pay quantities to compensate for smaller shafts.

D_1= casing inside diameter specified = shaft diameter specified.

D_2= casing inside diameter provided ($D_2 = D_1$ minus twice the wall thickness).

455-23.2 Drilled Shafts (Unreinforced): The quantity to be paid for will be the length, in feet, of unreinforced concrete drilled shaft of the diameters shown in the Plans, completed and accepted. The length will be determined as the difference between the top of shaft elevation as

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shown in the Plans and the final bottom of shaft elevation as authorized and accepted. When the Contractor elects to use O.D. casing, the quantity as determined above will be multiplied by the factor "F" determined as described in 455-23.1.

455-23.3 Unclassified Shaft Excavation: The quantity to be paid for will be the length, in feet, of unclassified shaft excavation of the diameter shown in the Plans, completed and accepted, measured along the centerline of the shaft from the ground surface elevation after any required excavation per 455-1.2 to the plan bottom of shaft elevation authorized and accepted plus up to 15 feet or 3 shaft diameters, whichever is deeper, of additional excavation as authorized by the Engineer. When drilled shafts are constructed through fills placed by the Contractor, the existing surface will be used to determine the quantity of unclassified shaft excavation. When the Contractor elects to use O.D. casing, the quantity as determined above will be multiplied by the factor "F" determined as described in 455-23.1.

455-23.4 Unclassified Extra Depth Excavation: When excavation is required by the Engineer to extend more than 15 feet or 3 shaft diameters, whichever is deeper, below the bottom of the shaft elevation shown in the Plans, the work will be considered as Unforeseeable Work.

455-23.5 Method Shafts: The cost of all method shafts will be included in the cost of drilled shafts.

455-23.6 Core (Shaft Excavation): The quantity to be paid for will be the length, in feet, measured from the bottom of shaft elevation to the bottom of the core-hole, for each authorized core drilled below the shaft excavation, completed and accepted. When the Engineer authorizes pilot holes extending through part or all of the shaft, prior to excavation, to some depth below the shaft bottom, the quantity paid as core (shaft excavation) will be the length in feet, measured from the top elevation to the bottom elevation authorized by the Engineer, completed and accepted. When SPT tests are substituted for coring or pilot holes as provided in 455-15.6, the quantity will be determined as described above in this Section.

455-23.7 Casings: The quantity to be paid for will be the length, in feet, of each size casing as directed and authorized to be used. The length will be measured along the casing from the top of the shaft elevation or the top of casing whichever is lower to the bottom of the casing at each shaft location where casing is authorized and used, except as described below when the top of casing elevation is shown in the Plans. Casing will be paid for only when the Permanent Casing Method is specified, when the Plans show a casing that becomes a permanent part of the shaft, or when the Engineer directs the Contractor to leave a casing in place which then becomes a permanent part of the shaft. No payment will be made for casings which become bound or fouled during shaft construction and cannot be practically removed. The Contractor shall include the cost of all temporary removable casings for methods of construction other than that of the Permanent Casing Method in the bid price for unclassified shaft excavation item.

When the Permanent Casing Method and the top of casing elevation are specified, the casing will be continuous from top to bottom. Authorization for temporary casing will not be given unless the Contractor demonstrates that he can maintain alignment of the temporary upper casing with the lower casing to be left in place during excavation and concreting operations. When artesian conditions are or may be encountered, the Contractor shall also demonstrate that he can maintain a positive water-tight seal between the two casings during excavation and concreting operations.

When the top of casing elevation is shown in the Contract Documents, payment will be from the elevation shown in the Plans or from the actual top of casing elevation, whichever is lower, to the bottom of the casing. When the Contractor elects to use an approved

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special temporary casing system in open water locations, the length to be paid for will be measured as a single casing as provided above.

455-23.8 Load Tests: The quantity to be paid for will be the number and type of load tests conducted.

455-23.9 Instrumentation and Data Collection: The quantity to be paid for will be at the lump sum price.

455-23.10 Thermal Integrity Testing for Drilled Shafts and Cross-Hole Sonic Logging: The quantity of the TITDS to be paid for will be the number of drilled shafts accepted based on TITDS tests. When TITDS is not performed in accordance with 455-17.6.1, perform CSL testing at no cost to the Department. No payment will be made for any integrity testing when such testing indicates the shaft cannot be accepted based on the integrity testing itself. No payment will be made for integrity testing performed to evaluate the integrity of post-repair work or for CSL testing not requested by the Engineer. When the Engineer requests CSL tests and the results indicate the shaft is acceptable, the testing will be paid as unforeseen work.

455-24 Basis of Payment.

455-24.1 Drilled Shafts: Price and payment will be full compensation for all drilled shafts, including the cost of concrete, reinforcing steel, nondestructive integrity testing access tubes, embedded thermal wires when required by the Contract Documents, and including all labor, materials, equipment, and incidentals necessary to complete the drilled shaft. The cost of the reinforcing steel, including lap lengths, to accommodate shaft lengths longer than shown in the Plans is included in the cost of drilled shafts. Costs associated with repairing defects found in the drilled shaft shall be included in the cost of the drilled shaft.

455-24.2 Drilled Shafts (Unreinforced): Price and payment will be full compensation for all drilled shafts (unreinforced), including the cost of concrete and all labor, equipment, materials, and incidentals necessary to complete the drilled shaft.

455-24.3 Unclassified Shaft Excavation: Price and payment will be full compensation for the shaft excavation (except for the additional costs included under the associated pay items for casing); removal from the site and disposal of excavated materials; restoring the site as required; cleaning and inspecting shaft excavations; using slurry as necessary; using drilling equipment; blasting procedures, special tools and special drilling equipment to excavate the shaft to the depth indicated in the Plans; and furnishing all other labor, materials, and equipment necessary to complete the work in an acceptable manner.

455-24.4 Method Shafts: No separate payment will be made for method shafts (test holes). All cost of method shafts will be included in the cost of drilled shafts.

455-24.5 Core (Shaft Excavation): Price and payment will be full compensation for drilling and classifying the cores/pilot hole, delivering them to the Department, furnishing drilled shaft concrete to fill the core/pilot hole, and all other expenses necessary to complete the work. When SPT tests are substituted for cores/pilot holes as provided in 455-15.6, they will be paid for at the price per foot for coring.

455-24.6 Casings: Price and payment will be full compensation for additional costs necessary for furnishing and placing the permanent casing in the shaft excavation above the costs attributable to the work paid for under associated pay items for unclassified shaft excavation.

455-24.7 Load Tests: Price and payment will include all labor, equipment, materials and incidentals required to perform this work, including instrumentation, data collection and professional services to prepare the report.

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455-24.8 Thermal Integrity Testing for Drilled Shafts and Cross-Hole Sonic Logging: Price and payment will include all costs related to the performance of the TITDS and CSL testing and incidentals to the thermal integrity and cross-hole sonic tests.

455-24.9 Payment Items: Payment will be made under:

Item No. 455- 88-	Drilled Shaft - per foot.
Item No. 455-107-	Casing - per foot.
Item No. 455-111-	Core (Shaft Excavation) - per foot.
Item No. 455-119-	Test Loads - each.
Item No. 455-122-	Unclassified Shaft Excavation - per foot.
Item No. 455-147-	Thermal Integrity Testing for Drilled Shafts - each

D. SPREAD FOOTINGS

455-25 Description.

Construct reinforced concrete spread footing foundations, including dewatering when necessary, excavating to the required limits, compacting the underlying soil as required, and constructing seals when required.

455-26 General Requirements.

Meet the following requirements for all spread footings:

1. Perform excavations, including the removal of all material, of whatever nature, necessary for the construction of spread footings. As used herein, the term “soil” shall constitute any material, whether soil, rock, or other materials.

2. Slope excavations as required, or support them with sheeting, and shore them if necessary, to provide a safe excavation that is adequate for construction purposes and that will adequately protect any existing adjacent structures.

3. Ensure that the foundation soils are firm, stable, and, in the opinion of the Engineer, meet or exceed the design bearing and compressibility requirements before constructing the footings or any required seals. The Department may elect to use any type of tests to evaluate the foundation soils that is appropriate in the opinion of the Engineer. Cooperate with the Engineer in the evaluation of the foundation soils, and assist the Engineer as necessary to provide access to the site.

4. The elevation of the bottom of footings or seals and/or the depth of over-excavation shown in the Plans is approximate and the Engineer may order, in writing, such changes as may be necessary to secure a satisfactory foundation.

5. Place all spread footing concrete in the dry.

455-27 Monitor Existing Structures.

Monitor existing structures in accordance with Section 108.

455-28 Dewatering.

The Contractor is responsible for the design, installation, and operation of an adequate dewatering system to dewater excavations for spread footings. Use a well point or well system. Submit a dewatering plan to the Engineer for his records before beginning construction.

Use well points or wells where the piezometric water level is above an elevation 3 feet below the bottom of the excavation. Maintain the water table 3 feet or more below the maximum depth of excavation. Provide continuous dewatering until completing construction of the footing and backfill the excavation at least 3 feet above the piezometric water table elevation. Continue

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dewatering until the Engineer considers conditions safe to discontinue dewatering. In the event of a dewatering failure, assist the Engineer as required in determining the effects of such a failure on the foundation soils, and take whatever corrective measures are required at no additional expense to the Department. When the Engineer approves the discontinuing of dewatering, decrease the rate of pumping, allowing the water level to rise slowly. Use a rate, in feet per hour, that the water table is allowed to rise equal to the total number of feet the water table was lowered, divided by ten hours or a rate of 1 foot per hour, whichever is less.

Install one piezometer well approximately every 15 feet of footing perimeter. Provide a minimum of two and a maximum of six piezometers at locations within 2 feet from the outside of the footing perimeter. Install piezometer wells to a depth at least 10 feet below the bottom of footing elevation or as directed by the Engineer. Measure water elevation in the piezometer wells prior to excavation and at 12-hour intervals between excavation and discontinuation of dewatering. Maintain the piezometers in working condition throughout the dewatering process, and repair or replace them when damaged at no expense to the Department.

455-29 Excavations:

If the excavation must be carried deeper than shown in the Plans to obtain a satisfactory foundation, the Engineer will revise the Plans in accordance with the following:

1. When the change in bottom elevation of the footing is 12 inches or less, the Engineer will keep the top of the footing at the elevation shown in the original Plans and will increase the thickness to obtain a satisfactory foundation.

2. When the change in elevation of the bottom of footing exceeds 12 inches, the Engineer will revise the Plans and lower the footing, thereby increasing the height of stem, to obtain a satisfactory foundation. Generally, the Engineer will also increase the thickness and width of footing over that shown in the original Plans.

455-29.1 Dry Excavations: Dry excavations are excavations that can be completed without the need to lower the piezometric water level. Perform dry excavations when the piezometric water level at the time of construction is and, in the opinion of the Engineer, will remain at least 3 feet below the bottom of the authorized excavation or over-excavation. Demonstrate to the Engineer that a stable excavation can be made without dewatering. Make adequate provisions to divert surface runoff and to collect and remove any water entering the excavation.

Excavate to the bottom of footing, to the over-excavation limits shown in the Plans, or as directed by the Engineer. Save any suitable materials for backfill. Provide areas for the disposal of all unsuitable materials, and dispose of them in a satisfactory method. Compact the foundation soils below the footing as shown in the Plans or described herein before constructing the footing.

455-29.2 Dewatered Excavations: Dewatered excavations are excavations made after first lowering the piezometric water level with wellpoints or wells. Perform dewatering as described in 455-28. Excavate in the dry after lowering of the water table.

When dewatering is required, the Contractor may excavate within 3 feet of the ground water table before dewatering begins if the dewatering system is operating and the Contractor has demonstrated that the water level has been lowered to and maintained at acceptable limits. Where large excavations require stage lowering of the water table (additional wellpoint systems installed at lower elevations), the Contractor may continue excavating as long as the water elevation is maintained at least 3 feet below the excavation.

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Ensure that surface runoff is diverted from the excavation. Compact the foundation soils as shown in the Plans or as described herein before constructing the footing.

455-29.3 Wet Excavations: Wet excavations are excavations made below the existing water table without prior dewatering. When the Plans show a cofferdam and seal, perform the excavation in the wet. Maintain the water level during excavation at or above the water level outside the cofferdam.

Place the seal directly upon the foundation soils or rock when using wet excavations. Do not compact foundation soils for wet excavations. Ensure that the foundation soils or rock are disturbed as little as practical. Remove all materials that are determined by the Engineer to be loose or disturbed before placing the seal concrete.

455-30 Fill or Backfill.

In all excavations, including over-excavations below the footing, use only fill or backfill materials considered Select in accordance with Standard Plans, Index 120-001. Ensure the material is free of rubble, debris, or rocks that would prevent uniform placement and compaction. Ensure the material below the top of the footing is free of Recycled Asphalt Pavement (RAP). Perform sampling and testing in accordance with 120-10.1.4, except replace FM 1-T99 with FM 1-T180.

455-31 Compaction and Density Requirements.

Compact the bottom of the excavation with suitable equipment. Compact the soil beneath footing excavation (whether dug to the bottom of footing or over-excavated) to a density not less than 95% of the maximum density as determined by FM 1-T180, for a minimum depth of 2 feet below the bottom of the excavation or to the depth shown in the Plans before backfilling begins. For every 500 feet of excavation or isolated compaction operation, perform two Quality Control (QC) density tests with a 12 inch depth of measurement: one QC density test with the gauge placed at an elevation of 1 foot below the bottom of the excavation and one QC density test with the gauge placed at the bottom of the excavation in accordance with FM 1-T310. Compact the backfill in footing excavations which have been over-excavated to a density not less than 95% of the maximum density as determined by FM 1-T180. Ensure that the maximum lift thickness after compaction does not exceed 6 inches. For every 500 feet of backfill or isolated compaction operation, perform at least one QC density test. The Engineer will conduct one density verification test per every 4 QC test, with a minimum of one density test below the bottom of the excavation and one density test in the backfill. Verification comparison criteria and resolution procedures will be in accordance with 120-10.4 except replace FM 1-T99 with FM 1-T180.

For compaction, use an approved heavy vibratory roller with a static drum weight of at least 4 tons. Compact each lift to the required density. Also, compact the final lift below the footing with a suitable sled vibratory compactor to remove any upper disturbance caused by the drum roller. When conditions require use of smaller compaction equipment, obtain the Engineer's approval for the equipment, and reduce the lift thickness to achieve the required density.

Perform backfilling to the existing surface or finished graded surface as required by the Plans in the immediate vicinity by approved mechanical compactors weighing less than 1,000 pounds. The Contractor may compact backfill located more than 15 feet away from the exterior periphery of the footing with heavier compactors. Do not place backfill on the footing until the Engineer has given permission and until the concrete is at least seven days old.

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When the plans indicate spread footing abutments on mechanically stabilized earth (MSE) walls, place and compact the backfill material underneath the footing in accordance with the requirements of 548-8.5. Meet the density requirements of 548-9.4.

455-32 Forming.

Form spread footings if it cannot be demonstrated that the natural soil or rock is strong enough to prevent caving during construction. For forms, meet the applicable requirements of 400-5. When forms are not required, meet the requirements of 400-5.4.4.

455-33 Materials.

455-33.1 Concrete: Meet the requirements of Section 346.

455-33.2 Reinforcing Steel: Meet the requirements of Section 415. For spread footing reinforcing steel, use Grade 60.

455-34 Reinforcing Steel Placement.

Place and fasten reinforcing steel for footings according to the applicable provisions of 415-5.

455-35 Concrete Placement.

455-35.1 Placement: Place all footing concrete in the dry and according to the applicable provisions of Section 400. Do not construct joints in footings.

455-35.2 Finish: After placing and consolidating the concrete, strike-off the top surface to the grades shown in the Contract Documents, leaving the surface smooth and free of undesirable cavities and other defects. Do not provide a special finish unless the footing will be visible after construction, in which case, meet the applicable provisions of Section 400.

455-35.3 Curing: Provide continuous-moisture-curing for footings. For cover materials, use clean sand, sawdust, or other materials meeting the approval of the Engineer. Continuously wet the cover materials for a period of 72 hours.

455-36 Method of Measurement.

455-36.1 Dewatering: No separate payment will be made for dewatering.

455-36.2 Excavation: No separate payment will be made for backfill or will separate payment be made for excavation above bottom of footing elevation. The cost of this work will be included in the Contract unit price for concrete (substructure). For footings with excavation (over-excavation) below the bottom of the footing elevation shown in the Plans, the cost of this excavation, backfilling, and compaction will be included in the Contract unit price for excavation for structures. The pay quantity will be the volume in cubic yards bounded by vertical planes 12 inches outside of the limits of the footing and parallel thereto and extending from the bottom of the footing elevation to the authorized bottom of over-excavation or within the pay limits shown in the Plans. If the elevation of a footing as shown in the Plans is changed to a higher or lower elevation, the Engineer will not consider such change as a material change to the original Contract Documents, a waiver of any condition of the Contract, or an invalidation of any of the provisions of the Contract.

455-36.3 Reinforcing Steel: The quantity to be paid for will be the total weight, in pounds, determined as described in Section 415.

455-36.4 Concrete: The quantity to be paid for will be the volume of the classes shown in the Plans, in cubic yards, determined as described in Section 400.

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455-37 Basis of Payment.

455-37.1 Dewatering: No separate payment will be made for dewatering of footing excavations, including installing, maintaining, and monitoring piezometer wells. Dewatering will be considered Unforeseeable Work when the Engineer determines that dewatering deeper than the requirements described in 455-28 is required.

455-37.2 Excavation: Price and payment will be full compensation for all work related to over-excavating below the bottom of footing elevation, backfill, and compaction as specified.

455-37.3 Reinforcing Steel: Price and payment will be full compensation for all work required to furnish and place the steel as shown in the Plans and as specified herein.

455-37.4 Concrete: Price and payment will be full compensation for all work required to construct footings and seals as shown in the Plans and described herein.

No separate payment will be made for sheeting and shoring required for excavation and footing construction except when a separate pay item for sheeting and shoring is included in the Plans. The cost of all work not specifically mentioned in the other footing items will be included in the price per cubic yard for substructure concrete.

455-37.5 Payment Items: Payment will be made under:

Item No. 125- 1-	Excavation for Structures - per cubic yard.
Item No. 400- 2-	Class II Concrete - per cubic yard.
Item No. 400- 3-	Class III Concrete - per cubic yard.
Item No. 400- 4-	Class IV Concrete - per cubic yard.
Item No. 415- 1-	Reinforcing Steel - per pound.

E. STRUCTURES (OTHER THAN BRIDGE) FOUNDATIONS-AUGER CAST PILES

455-38 Description.

Furnish and install auger cast piles (ACP), or augered cast-in-place (ACIP) piles, used for structural support, other than bridge foundations.

ACP piles are defined as a foundation made by rotating a hollow-stem auger into the ground to the required pile depth with sufficient crowd (downward thrust) to prevent mining of the soil. A fluid cement grout is injected through the auger shaft under continuous positive pressure as the auger is being withdrawn. A reinforcing steel cage, as specified, is inserted into the column of fluid grout following the completion of grout placement.

455-39 General Requirements.

455-39.1 Contractor's Operations: Submit an Auger Cast Pile Installation Plan in accordance with 455-47. Prior to the start of production piles, demonstrate to the satisfaction of the Engineer, the dependability of the equipment, techniques, and source of materials by construction of a demonstration pile.

455-39.2 Monitor Existing Structures: Monitor existing structures in accordance with Section 108.

455-40 Materials.

Meet the following material requirements:

Portland Cement and Blended Cement .....Section 921
Supplementary Cementitious Materials .....Section 929

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Fine Aggregate (Sand)*	Section 902
Admixtures	Section 924
Water	Section 923
Fluidifier**	ASTM C937
Reinforcing Steel	Section 415

* The Engineer will only permit Silica Sand except as provided in 902-5.2.3.
** The fluidifier shall not contain chlorides

455-41 Grout Mix Proportions.

Use a grout mix consisting of a mixture of cementitious materials, admixtures, sand and water. Proportion and mix to produce a grout capable of maintaining the solids in suspension without appreciable bleed water which may be pumped without difficulty and will fill open voids in the adjacent soils and rock. The grout mix may include a fluidifier, used in accordance with the manufacturer's technical representative. Proportion these materials to produce a hardened grout of the required strength.

455-42 Mixing and Pumping Cement Grout.

Meet the following requirements:

1. Only use pumping equipment approved by the Engineer in the preparation and handling of the grout. Before using the mixers, remove all oil or other rust inhibitors from the mixing drums, stirring mechanisms, and other portions of the equipment in contact with the grout.

2. Use a quantity of water and mixing time that will produce a homogenous grout having an efflux of not less than 21 seconds, when tested with a flow cone in accordance with ASTM D6449. Reject loads with efflux of less than 21 seconds. Notify the production facility to adjust the mix design. Calibrate the flow cone in accordance with ASTM D6449. Conduct the calibration initially before its first use and as directed by the Engineer, when there is a question of the flow cone's accuracy.

Technicians performing the efflux test must take the Auger Cast Pile course and pass the final examination to be qualified to test for any auger cast pile installations in the field. Assist the Engineer in verifying the technicians meet these requirements.

Conduct tests for efflux time at the beginning of each days grouting operation and as directed by the Engineer to ensure the specification requirements are met.

3. Mix the grout at least one minute. If agitated continuously, the grout may be held in the mixer or agitator for a period not exceeding 2.5 hours at grout temperatures below 70ºF; two hours for temperatures from 70°F to 100ºF. Do not place grout when its temperature exceeds 100ºF. If there is a lapse in the operation of grout injection, recirculate the grout through the pump, or through the mixer drum or agitator.

4. Use mixers capable of combining components into a thoroughly mixed and uniform mass, free from balls or lumps and capable of discharging the grout with a satisfactory degree of uniformity. The Engineer's approval of grout mixers and all other equipment will be contingent on proper performance during construction of the demonstration pile and subsequent production work.

5. Use a screen no larger than 3/4 inch mesh between the mixer and pump to remove large particles which might clog the injection system.

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6. Use a positive displacement piston type grout pump equipped with a pressure gauge, capable of developing displacing pressures at the pump not less than 350 psi. The pump must be appropriately sized to the pile diameter. Provide a grout pressure gauge in clear view of the equipment operator. Provide a second pressure gauge near the drill rig where it can be observed by the Engineer.

7. Accurately monitor the volume and pressure of the grout flow. Test and calibrate the equipment during construction of the demonstration pile to demonstrate flow volume measurement accuracy of plus or minus 3% over the range of grouting pressures anticipated during this work. Provide a pump stroke counter in good working condition on the grout pump. Perform a calibration test of the pumping equipment, prior to construction of the demonstration piles, to determine the average volume of grout for every pump stroke, in accordance with FM 5-612. When the Contractor's installation procedure includes priming the grout pump, grouting lines or auger conduit after drilling the hole, perform a priming demonstration to determine the minimum number of pump strokes required to deliver fresh grout throughout the entire system and flow from the grout injection hole at the bottom of the auger. Perform this grout priming demonstration prior to any calibration test.

The Engineer may require additional pump calibrations and priming demonstrations when the pump is repaired, a different pump is used, when the length of the grout lines or hollow auger lengths increase from previous piles for which priming demonstrations were performed and at any time the Engineer determines the grout pump performance may have changed.

455-43 Testing Cement Grout.

Prepare three 4 inches x 8 inches cylinders for each LOT in accordance with ASTM C31, except pour grout in a single lift into cylinders molds without rodding. Plastic properties in accordance with ASTM C31 are not required. A LOT is defined as the lesser of 50 cubic yards of cement grout placed or one day of pile placement. Prepare two additional QC "hold" cylinders on the LOT selected by the Engineer for Verification. Provide curing facilities for all QC and Verification test cylinders in accordance with ASTM C31. Test the cylinders at 28 days, in accordance with ASTM C39.

When one of the three QC cylinders from a LOT is lost, missing, damaged or destroyed, determination of compressive strength will be made by averaging the remaining two cylinders. If more than one QC cylinder from a LOT is lost, missing, damaged or destroyed, core the structure at no additional expense to the Department to determine the compressive strength. Acceptance of LOT may be based on verification data at the discretion of the Engineer. Obtain the approval of the Engineer to core, and of the core location prior to coring. Repair core holes after samples are taken with a product meeting the approval of the Engineer, at no additional cost to the Department.

For each QC cylinder that is lost, missing, damaged or destroyed, payment for that LOT will be reduced by $750.00 per 1,000 psi of the specified design strength [Example: For f'_c=5,500 psi, and the loss of two auger cast pile grout QC cylinders that have no verification data will require the element to be cored and a pay reduction will be assessed (5,500 psi / 1,000 psi) x $750 x 2 = $8,250]. This reduction will be in addition to any pay adjustment for low strength.

The Engineer will cast three verification cylinders and two "hold" cylinders from one of every four consecutive Lots, randomly selected. The Engineer will compare QC and Verification results in accordance with Section 346. If the results do not compare, the Engineer will initiate a Resolution Investigation in accordance with Section 346.

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Personnel making/curing grout cylinders shall be certified as ACI Concrete Field Testing Technician Grade I. Personnel performing tests on hardened properties of grout, such as strength determination of cylinders or beams, shall be certified as ACI Concrete Strength Testing Technician.

All low strength cement grout accepted by the Engineer will be subject to reduced payment as follows: $0.80 per cubic yard for each 10 psi of strength test value below the specified minimum strength. The Engineer will use the average compressive strength of the LOT tests for the computation of this pay reduction.

The Engineer will compute the volume of grout for which the reduction will be applied as 115% of the theoretical volume of the auger cast pile diameter required in the Contract Documents. Reduction in pay will be applied to the entire length of all piles containing low strength cement grout, in any quantity. The quantity of cement grout affected by the price reduction may exceed the quantity of cement grout contained in the LOT.

When separate payment for auger grouted piles is provided, the dollar reduction will be equated to an equivalent length of pile not to exceed the total pile length constructed utilizing the subject LOT based on the following formula:

PLR = RC/UC

Where: PLR = Equivalent Pile Length Reduction in feet
RC = Total Reduction in payment, dollars
UC = Unit Cost of pile, dollars /foot

When a cement grout acceptance strength test falls more than 500 psi below the specified minimum strength perform one of the following:

1. Remove and replace the piles affected fully or partially by the low strength LOT at no additional cost to the Department; or,

2. Submit a structural analysis performed by the Contractor's Engineer of Record. If the results of the analysis, approved by the Department, indicate adequate strength to serve the intended purpose with adequate durability, the grout may remain in place.

Otherwise, abandon and install additional piles to the foundation, or remove and replace the piles affected fully or partially by the low strength LOT of grout at no additional cost to the Department. When installing additional piles to resolve the strength deficiency, submit a foundation redesign to add piles into pile caps or footings, at no expense to the Department in accordance with 455-46.

455-44 Pile Installation.

Meet the following requirements:

1. Locate the piles as shown on the drawings.

2. Should soft, compressible muck, organics, clay or other unsuitable materials (non A-1, A-3, A-2-4 or limestone materials) be encountered, remove the unsuitable material to a maximum depth of 5 feet and a radial distance around the pile centerline of two pile diameters, unless otherwise indicated in the Plans. Backfill with clean granular backfill materials (A-1, A-3, A-2-4), placed and compacted in maximum 12 inch lifts to at least 95% of maximum dry density as determined by FM 1-T180. Complete this work to the Engineer's satisfaction prior to ACP construction. Should more than 5 feet depth or excessive quantities of unsuitable material be encountered, immediately advise the Engineer and proceed with the work as directed by the Engineer.

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3. Provide continuous auger flighting from the bottom of the pile to the top of ground at the time of drilling with no gaps or other breaks, except for connections. Ensure the auger flights are uniform in diameter throughout its length, and of the diameter specified for the piles less a maximum of 3%. Provide augers with a distance between flights of approximately half the diameter of the auger.

4. Use augers with the grout injection hole located at the bottom of the auger head below the bar containing the cutting teeth, and with pile auger leads containing a bottom guide.

5. Construct piles of the length and diameter shown on the Plans.

6. Clearly mark the auger leads to facilitate monitoring of the incremental drilling and grout placement. Provide individual foot marks with 5 foot increments highlighted and clearly visible. Provide a clear reference mark on the moving auger assembly to facilitate accurately monitoring the vertical movement of the auger.

7. Place piles by rotating a continuous flight hollow shaft auger into the ground at a continuous rate that prevents removal of excess soil. Stop advancement after reaching the predetermined depth.

8. Should auger penetration to the required depth prove difficult due to hard materials/refusal, the pile location may be predrilled, upon approval of the Engineer, through the obstruction using appropriate drilling equipment, to a diameter no larger than one-half the prescribed finish diameter of the ACP. Commence grouting immediately upon reaching the required tip elevation to minimize ground loss and soil relaxation. Should non-drillable material be encountered preventing placement to the depth required, immediately advise the Engineer and proceed with the work as directed by the Engineer. Refusal is defined as the depth where the penetration of the standard auger equipment is less than 12 inches per minute.

9. Plug the hole in the bottom of the auger prior to advancing into the ground.

10. Pump the grout with sufficient pressure as the auger is withdrawn to completely fill the auger hole, preventing hole collapse and to cause the lateral penetration of the grout into soft or porous zones of the surrounding soil or rock. Prior to commencing withdrawal of the auger, establish a head of at least 5 feet of grout by pumping a volume of grout equivalent to 5 feet of pile volume. Do not include the volume or strokes required to prime the grout pumping system in the volume required to build this initial head. Maintain this head of at least 5 feet of grout above the injection point around the perimeter of the auger to displace and remove any loose material from the hole. Maintain positive rotation of the auger at least until placement of the grout.

11. Once the grout head has been established, greatly reduce the speed of rotation of the auger and commence extraction at a rate consistent with the pump discharge. Maintain extraction at a steady rate to prevent a locked-in auger, necking of the pile, or a substantially reduced pile section. Ensure grout starts flowing out from the hole when the cutting head is at least 5 feet below the ground surface. Place a minimum volume of grout in the hole of at least 115% of the column of the auger hole from a depth of 5 feet to the tip. Place a minimum volume of grout in the hole of at least 100% of the column of the auger hole from the ground surface to a depth of 5 feet. Do not include any grout needed to create surplus grout head in the volume of grout placed into the hole. If the grout does not flow out from the hole when the cutting head is at least 5 feet below the ground surface, redrill the pile under the direction of the Engineer. If grouting is interrupted for any reason, reinsert the auger by drilling at least 5 feet below the tip of the auger when the interruption occurred, and then regrout.

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Use this method of placement at all times. Do not depend on the stability of the hole without the earth filled auger.

12. Assume responsibility for the grout volume placed. If less than 115% of the theoretical volume of grout is placed in any 5 foot increment (100% in the top 5 foot increment), reinstall the pile by advancing the auger 10 feet or to the bottom of the pile if that is less, followed by controlled removal and grout injection.

13. Furnish and install the reinforcing steel and anchoring bolts as shown in the Contract Documents. For ACP for miscellaneous structures and low clearance post options for noise walls, use wheels or other approved noncorrosive spacing devices within 3 feet of the bottom, within 3 feet of the top, and intervals not exceeding 10 feet along the pile to ensure concentric spacing for the entire length of the cage. Do not use block or wire type spacers. Use a minimum of one spacer per 30 inches of circumference or perimeter of cage with a minimum of three at each level. For noise wall ACP in which the full reinforcement is attached to the post, spacing devices within 3 ft of the top of the pile are not required.

14. Use reinforcement that is without kinks or nonspecified bends, free of mud, oil or other coatings that could adversely affect the bond. Make splices in reinforcement as shown on the Contract Documents, unless otherwise approved by the Engineer. Place the required steel reinforcement while the grout is still fluid, and immediately after finishing grouting and clearing it from any contaminating material. Install the steel cage into the grout by its own weight or manually. Do not use a mechanical equipment or tool to impact the steel cage or to force it into the grout. If the steel cage cannot be placed completely following this procedure, redrill and regrout the pile.

15. Leave any temporary supports of/for items placed into a grouted pile (reinforcement template, anchor bolt template, precast column supports, etc.) in place for a minimum of 12 hours after completion of the pile. Do not place wall panels or other loads, before piles are accepted and the grout has set a minimum of seven days or reached the 28 day strength.

455-45 Construction Tolerances.

Locate piles as shown in the Plans, or as otherwise directed by the Engineer. Locate pile centers to an accuracy of plus or minus 3 inches. Ensure that the top of pile elevation is within an accuracy of plus or minus 3 inches of the plan elevation. Ensure the tolerances in 534-5.1 can be met.

455-46 Unacceptable Piles.

Repair or replace unacceptable piles, as directed by the Engineer, at no cost to the Department. Unacceptable piles are defined as piles that fail for any reason, including but not limited to the following: piles placed out of position or to improper elevation; piles with reduced cross section, contaminated grout, lack of grout consolidation (honeycombed), or deficient grout strength; and piles with reinforcement, anchor devices or other components cast or placed into the fluid grout out of position. When the Engineer determines that a pile is unacceptable, the Contractor may propose a foundation redesign to add piles into pile caps or footings, at no expense to the Department. The Contractor’s Engineer of Record must perform any redesign, and sign and seal the redesign drawings and calculations. Do not begin any proposed construction until the redesign has been reviewed and approved by the Engineer.

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455-47 Auger Cast Pile Installation Plan (ACPIP).

At the preconstruction conference, but no later than 30 days before ACP construction begins, submit an ACPIP for approval by the Engineer. Provide the following detailed information on the plan:

1. Name and experience record of ACP superintendent or foreman in responsible charge of ACP operations. Place a person in responsible charge of day to day ACP operations who possesses satisfactory prior experience constructing auger cast piles similar to those described in the Contract Documents. The Engineer will give final approval subject to satisfactory performance in the field.
2. List and size of the proposed equipment, including cranes, augers, concrete pumps, mixing equipment etc.
3. Details of grout mixing procedures and proposed pump calibration procedures.
4. Details of pile installation methods.
5. Details of reinforcement placement and method of centering in pile, including details of all temporary supports for reinforcement, anchor bolts, precast columns, etc.
6. Details of how and by whom the grout volumes will be determined, monitored and documented.
7. Required submittals, including shop drawings and cement grout design mixes.
8. Proposed plan for monitoring settlements of adjacent structures, identifying the proposed equipment, the structures and the specific points that will be monitored.
9. Other information shown in the Plans or requested by the Engineer.

455-48 Inspection and Records.

The Engineer will monitor pile installation.

455-49 Method of Measurement.

455-49.1 Auger Cast Pile: The quantity to be paid for will be at the Contract unit price per foot between tip and required pile top elevations for all piles completed and accepted.

455-50 Basis of Payment.

455-50.1 Auger Cast Piles: Price and payment will be full compensation for all labor, materials, and incidentals for construction of ACP of the sizes and depths indicated on the Contract Documents or as otherwise directed by the Engineer. Price and payment will also include the removal and proper disposal off site of all spoil from the auger operation and all excess grout displaced from the auger hole, unless otherwise approved by the Engineer. Work to remove and replace unsuitable material when necessary as specified in 455-44 will be considered Unforeseeable Work.

455-50.2 Payment Items: Payment will be made under:

Item No. 455-112- Auger Grouted Piles - per foot.

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SECTION 458
BRIDGE DECK JOINTS

458-1 Description.

Furnish and install bridge deck joints of the types and at the locations shown in the Plans. This Section covers the following types of joints:

Poured Joint
Poured Joint with Backer Rod System
Strip Seal Joint System
Modular Joint

458-2 Materials.

458-2.1 General: Transport, store and prepare all joint materials and components for all joint types as per the manufacturer's recommendations.

458-2.2 Poured Joint: Furnish a Type D silicone sealant material meeting the requirements of Section 932 that is listed on the Approved Product List (APL).

458-2.3 Poured Joint with Backer Rod System: Furnish poured joint with backer rod systems consisting of Type D silicone sealant material, foam backer rods, sidewalk cover plates (as required) and all associated miscellaneous components.

The Type D silicone sealant material used in the system shall be listed on the APL and meet the requirements of Section 932.

458-2.4 Strip Seal Joint System: Furnish strip seal joint systems that are listed on the APL. Manufacturers seeking evaluation of their product for the APL shall submit an application in accordance with Section 6. Design documentation showing the expansion joint system shall include installation details and temporary or sacrificial support brackets, bolts, clamps, etc. that are compatible with decks constructed with or without block-outs. Furnish joint systems consisting of watertight steel edge rails, strip seal glands and all associated miscellaneous components.

458-2.4.1 Strip Seal Joint Systems with elastomeric glands: Product must meet the requirements of ASTM D5973 and Standard Plans, Index 458-100. Obtain the strip seal elastomeric glands from the edge rail manufacturer.

458-2.4.2 Strip Seal Joint Systems with silicone glands: Product must meet the requirements of Standard Plans, Index 458-100. Adhesives must be supplied by the same manufacturer as the glands and must meet ASTM C793 with no cracking, ozone chalking or degradation.

458-2.5 Modular Joint: Furnish modular joints meeting the requirements of this Section. Submit manufacturer certification that modular joint components meet the following material requirements in Table 458-1.

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Table 458-1 Component Material Requirements	
Solid Separation Beams, Steel Extrusions, Support Bars, Plate and Milled Steel Shapes	ASTM A588 or ASTM A572, Grade 50
Box Seals	ASTM D3542
Strip Seals	ASTM D5973
Seal Adhesive	ASTM D4070
Stud Shear Connectors and Threaded Studs	ASTM A108
Stainless Steel Sliding Plates	ASTM A240, Type 316
PTFE Sliding Surface	ASTM D4895
*Provide seals with hardness Type A durometer equal to 55 (plus or minus 5) by ASTM D2240.	

Supply test results from the manufacturer verifying the maximum coefficient of friction between mating surfaces. Testing must be performed by an independent testing laboratory according to the manufacturer's stated precompression values for the system to a minimum of two million cycles. Maximum allowed coefficient of friction is 0.10.

Bond PTFE (polytetrafluorethylene) using a heat cured, high temperature epoxy capable of withstanding temperatures of minus 40°F to plus 250°F.

For springs, bearing, and equidistance devices (i.e. control springs), use the same material composition and formulation, manufacturer, fabrication procedure and configuration as those used in the prequalification test. Components manufactured from polyurethane compounds are not permitted.

458-2.6 Sidewalk Cover Plates: Furnish slip resistant, random hatch matrix or suitable pattern, galvanized steel sidewalk cover plates fabricated from steel meeting the requirements of ASTM A36 or ASTM A709, Grade 36 or 50. Do not use diamond plate or surface applied slip resistant tapes, films, nonmetallic coatings or other similar materials. Fabricate cover plates in accordance with Standard Plans, Indexes 458-100 and 458-110. After shop fabrication, hot-dip galvanize cover plates in accordance with Section 962. Galvanized sidewalk cover plates shall have a minimum coefficient of friction on the top surface of 0.8 in dry condition, and 0.65 in a wet condition, as determined by ASTM F1677-05 or ASTM F1679-04. Furnish flat head stainless steel sleeve anchors in accordance with ASTM F593 Group 1 Alloy 304 for attaching sidewalk cover plates. Install sleeve anchors in accordance with the manufacturer's instructions.

458-3 Calculations and Shop Drawings.

458-3.1 All Joint Types (with the exception of Poured Joints): Submit shop drawings in accordance with Section 5 for any applicable joint system supplied. For format and required details, follow the AASHTO/NSBA Steel Bridge Collaboration "Guideline for Shop Detail Drawing Presentation". The following information must be included on the shop drawings:

1. The name and address of the joint system manufacturer, including the physical address where the fabrication is performed.

2. The joint manufacturer's instructions for proper installation, including the proper width settings for a minimum 100°F temperature range. Shop drawings that are submitted without this information will be returned without review.

3. Show all materials including project specific details and dimensions. Include the joint model number and joint movement range.

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458-3.2 Sidewalk Cover Plates: Submit shop drawings for sidewalk cover plates showing all materials, project specific details and dimensions. The submittal must include a certification from the manufacturer that the sidewalk cover plates meet the minimum coefficient of friction requirements.

458-3.3 Strip Seals: Provide the APL number in the shop drawings.

458-3.4 Modular Joints: When support boxes are supported by the deck or abutment, detail in the shop drawings a minimum of 2 inches between the bottom surfaces of the joint elements and the deck blockouts to allow easy placement of concrete and allow for proper consolidation of concrete under and around all parts of the joints.

Detail in the shop drawings at least 6 inches of clear space between the support boxes or anchorages on the ends of support boxes and the periphery of the blockout to permit placing of concrete.

Submittal of shop drawings must include a manufacturer's installation manual in accordance with this Section.

Include design calculations, signed and sealed by a Professional Engineer licensed in the State of Florida, confirming that all load bearing components are in conformance with the requirements of this Section.

458-4 Fabrication and Installation.

458-4.1 General: Install the joint in accordance with the specific requirements of this Section, the plan details, the Standard Plans, and the manufacturer's installation instructions for the particular type of expansion joint to be installed.

458-4.2 Poured Joint: Install the joint at the locations and in accordance with the details shown in the Plans and the manufacturer's recommendations.

458-4.3 Poured Joint with Backer Rod System:

458-4.3.1 Casting Joint Opening: When casting the bridge deck, approach slab or raised sidewalk adjacent to the expansion joint at temperatures other than 70°F, adjust the joint opening (Dim. A as shown in Standard Plans, Index 458-110) at 70°F by the amount of the adjustment per 10°F shown in the Structures Plans, Poured Expansion Joint Data Table. For temperatures above 70°F, decrease the opening. For temperatures below 70°F, increase the opening.

458-4.3.2 Installation of Poured Joint System: After deck profiling, grinding, and grooving operations are complete, install poured joint with backer rod in accordance with the manufacturer's recommendations, when the joint opening is plus or minus 1/4 inch of the design joint opening (Dim A at 70°F) shown in the Structures Plans, Poured Expansion Joint Data Table. The minimum opening must not be less than 1 inch at the time of installation. Place poured joint material only when the ambient temperature is between 55°F and 85°F and is expected to rise for the next three hours minimum to provide for adequate joint opening and compression of the poured joint material during curing.

458-4.4 Strip Seal System:

458-4.4.1 Glands for Joint Seal: Seals must be continuous heavy duty bridge deck glands sized in accordance with the manufacturer's recommendations, to perform satisfactorily for the opening range shown. Minimum movement classification is 4 inches.

458-4.4.1.1 Elastomeric Gland Seals: Shop vulcanization is restricted to use on horizontal turns on skewed bridges at upturn ends where the horizontal turn angle is greater than 35 degrees. Field vulcanization is not permitted.

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458-4.4.1.2 Silicone Gland Seals: Meet the following requirements in Table 458-2:

Table 458-2
Silicone Gland Seal Requirements

Property	Test Method	Range
Durometer (Shore A)	ASTM D2240	55 +/- 5
Elongation	ASTM D412	350% (min)
Tensile	ASTM D412	550 psi (min)
Tearing (die B ppil)	ASTM D624	80 lb/in (min)
Compression Set	ASTM D395	30% max at 350º F
Temperature Range		-60º F to 450º F
Specific Gravity		1.51

458-4.4.2 Edge Rail Fabrication:

1. Furnish extruded, hot rolled or machined solid steel edge rails in accordance with ASTM A709, Grade 36, 50 or 50(W). Furnish edge rails with a minimum mass of 19.2 lb/ft excluding studs, a minimum height of 8 inches, a minimum thickness of 1/2 inch and a maximum top surface (riding surface) width of 2 inches. Edge rails manufactured from built up pieces must have continuous longitudinal welds. Built-up member connections directly supporting wheel loads must use complete penetration welds.

2. Furnish anchor studs in accordance with ASTM A108, and electric arc end-weld anchor studs with complete fusion. Anchor studs may be piggy backed to achieve required lengths.

3. Perform all shop welding in accordance with the Bridge Welding Code ANSI/AASHTO/AWS D1.5. Do not weld to surfaces in contact with the elastomeric seal or the top surface (riding surface) except as shown in the shop splice detail. Do not weld inside seal cavity.

4. Fabricate edge rail assemblies upturns when required to hold the gland in place, integral to the edge rail assemblies by full length welds or extruded sections. Splices in an individual joint are only permitted where a construction joint is specifically required by the Plans, joint segment length exceeds 50 feet, or approved by the Engineer in writing. Shop splice sections of edge rail to obtain the required length by partial penetration double V-groove welds on prepared beveled edges and seal welds as shown in the shop splice detail. Weld all around the joint as far as practical to achieve a watertight seal. Do not use short pieces of edge rail less than 6 feet 0 inches long unless required at curbs, sidewalks or phase construction locations.

5. After shop fabrication, hot-dip galvanize edge rail in accordance with Section 962 and the manufacturer's recommendations.

6. Furnish temporary or sacrificial support brackets, bolts, clamps, etc. that are capable of resisting shipping, handling and construction forces without damage to the edge rail assemblies or galvanized coating and are adjustable to account for variable temperature settings. Do not use temporary or sacrificial support brackets, bolts, clamps, etc. between the faces of the edge rails.

7. Clearly match mark corresponding edge rail assemblies with joint location and direction of stationing.

458-4.4.3 Installation:

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1. Install the edge rail assemblies at proper grade and alignment before or after deck planing in accordance with the manufacturer's instructions. When installed after deck planing and grinding, install the edge rail assemblies in the block-outs on a profile tangent between the ends of the deck and/or approach slab to within a plus 0 inch and minus 1/4 inch variation. When installed before deck planing, install the edge rail assemblies 3/8 inches, plus or minus 1/16 inch, below the top surface of the deck or approach slab to compensate for concrete removal during planing and grinding.

2. Bolt, weld or clamp edge rail assemblies in position using temporary or sacrificial brackets as required. For phased construction, install edge rail assemblies in a given subsequent phase to align with those installed in an adjacent prior phase after deflection and rotation due to deck casting of adjoining spans has occurred.

3. For installation of edge rail assemblies at temperatures other than 70°F, adjust the opening of the joint (Dim. A as shown in Standard Plans, Index 458-100) by the amount of the adjustment per 10°F shown in the Structures Plans, Strip Seal Expansion Joint Data Table. For temperatures above 70°F, decrease the opening. For temperatures below 70°F, increase the opening.

4. After galvanizing, do not weld within 2 inches of edge rail surfaces exposed in the completed structure. Do not weld expansion joint components to or electrically ground to reinforcing steel or structural steel. Seal field butt joints and empty shipping and erection holes with caulk before placing deck concrete.

5. Protect galvanized edge rail assemblies during screeding operations per the manufacturer's recommendations. Provide temporary blocking material in the edge rail seal cavities to prevent concrete intrusion during deck pour and finishing.

6. Loosen any temporary or sacrificial support brackets, bolts, clamps, etc. that span across the joint after initial set of concrete, but not more than two hours after conclusion of concrete placement.

7. Install elastomeric seal after completion of deck casting. Remove all joint form material and blocking material prior to installing glands. Field install glands in accordance with manufacturer's recommendations.

458-4.5 Modular Joints

458-4.5.1 Fabrication: Perform all steel fabrication in accordance with the requirements of Section 460.

After fabrication, hot-dip galvanize all non-stainless steel metal surfaces in accordance with Section 962.

Joint systems must be designed in accordance with the latest edition of AASHTO LRFD Bridge Design Specifications or as required by the Contract Documents. Supply joint systems for which identical full-size specimens have been subjected to full life-cycle fatigue testing. Obtain all joint system components from the same manufacturer, fabricated at their approved corporate facilities, using subcomponents meeting the testing requirements of this Section.

Except for sliding plates, provide all load bearing structural steel components with a 3/8 inch minimum thickness in any direction. Construct edge rails consisting of a monolithic steel shape with a machined or extruded retainer cavity. Multiple component welded steel shapes to achieve a final member cross section or seal retainer cavity are not permitted. Attach separation beams to individual support bars with a complete joint penetration weld.

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Support each separation beam with a dedicated support bar connected by a complete joint penetration welded connection. Use of bolted connections, yokes, or other means to directly attach separation beams to support bars is not permitted. Maintain equal spacing between separation beams at all stages of movement.

Contain support bars with bearings capable of transferring all imposed loads to the structure and allow the support bar to freely move within the limits of the expansion joint.

Fabricate a full length modular joint system as one piece. Only a minimal number of splices in an individual joint may be permitted where a construction joint is specifically required by the Plans, joint segment length exceeds 50 feet, or approved by the Engineer in writing.

When phased construction is permitted or required by the Contract Documents, fabricate each segment to exactly fit that portion of superstructure, including sidewalks, under construction in each specific phase. Connect segments with a bolted splice to ensure continuity. Fit segments with temporary seals. Lubricant adhesive is not required for temporary seals. Submit watertight seal details for the splice. Shop inspection will be conducted at the discretion of the Engineer in accordance with Article 5-6.

Fabricate final seal assembly as one single, continuous component. Splicing of seals in the field is not permitted.

Provide lifting devices and devices to maintain the preset opening of the joint at a uniform spacing of not greater than 15 feet along the length of the joint. Provide at least three of these preset opening devices per joint segment. Provide lifting and preset opening devices that function and then are removed without damaging the modular joint system assemblies or galvanized coating.

Prior to shipment, preset the joint opening in accordance with the joint opening as shown in the Plans at 70°F.

Prior to installation, place the centerbeam/support bar assembly on a flat surface to verify the support bars lay in a single plane, with no part of the bottom of any support bar exceeding 0.25 inches off the surface. The subassembly may be straightened. No more than three attempts may be made to heat-straighten the subassembly.

Polish stainless steel sliding surfaces to an 8 µ-inch mirror finish.

458-4.5.2 Installation: Clean any metal surface component exhibiting surface rust and field metalize in accordance with Section 562. Replace any component exhibiting pitting and/or section loss with a new component.

Install the joint system in strict compliance with the manufacturer's instructions in the shop drawings and as directed by the manufacturer's installation technician.

458-4.5.2.1 Manufacturer's Installation Manual: Submit the manufacturer's installation manual at least two weeks prior to installation activities, containing complete and detailed installation instructions for the modular expansion joint supplied by the Contractor. The manual must include step-by-step installation instructions and all related manufacturer's recommendations, including bridge deck pouring sequence, restraints, finishing, etc., for successful installation and long term operation and serviceability of the joint.

458-4.5.2.2 Manufacturer's Installation Technician: Provide for a manufacturer's installation technician, under the direct employ of the manufacturer, to be on the jobsite prior to the first joint installation and in sufficient time to train the Contractor's joint installation crews using the shop drawings and the manufacturer's installation manual. The

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manufacturer's installation technician must remain on the jobsite and be present for all modular joint installation activities for a minimum of the first two joints for each of the Contractor's installation crews. The manufacturer's installation technician will submit written certification to the Engineer that the Contractor's installation process follows the requirements outlined in the manufacturer's installation manual.

458-4.5.2.3 Field Inspection: The Engineer will inspect the joint system for proper alignment, complete bond between neoprene gland seal and steel, and proper stud placement and effectiveness.

Bends or kinks in the joint system steel are not allowed except as necessary to follow roadway grades. Straightening of any bends or kinks in the steel, whether intentional or inadvertent, is not allowed. Any joint system exhibiting bends or kinks will be rejected, removed from the jobsite, and replaced by a new joint system. Match joint system to the finished roadway profile and grades before final acceptance.

Restore bond of any neoprene gland seal found not fully bonded to steel.

Visually inspect all stud welds. Test a minimum of 10% of the total number of stud welds at the discretion and direction of the Engineer. Any stud found to not have a complete end weld (as evidenced by a ringing sound when struck by a hammer) will require replacement. Any stud located more than one inch in any direction from location shown in the shop drawings will require removal and a new stud placed in the proper location.

458-4.5.2.4 Width: For installation at temperatures other than 70°F, adjust opening of the joint as shown in the Contract Documents by amount of adjustment per 10°F shown in the Contract Documents. For temperatures above 70°F, decrease the opening. For temperatures below 70°F, increase the opening. Release all support brackets as the concrete is being placed and no later than when the concrete takes initial set.

Remove opening devices immediately after the concrete is placed.

458-4.5.2.5 Permanent Seals: When phased construction is necessary, remove temporary neoprene seals and replace with full width permanent seals after joint system is completely installed over full width of structure, including sidewalks.

Clean (SSPC-SP6) all metal surfaces which will be in contact with permanent seals to visual standard CSP6 as defined by SSPC Vis 1-89.

458-4.5.2.6 Final Placement: After modular joint system has been set to its final line and grade, fill any deck joint blockouts with Class II (Bridge Deck) concrete or as specified in the Plans. Prepare contact surfaces in accordance with the same procedure described in this Section. Finish the uppermost surface of concrete placement in accordance with requirements of 400-15, except that machine finishing is not required. Unless otherwise noted in the Plans, include the cost of the pourback in the unit bid price of superstructure concrete.

Construction loads are not allowed on the modular joint for 72 hours after complete installation unless approved by the Engineer. In the event it is necessary to cross the modular joint before the 72 hour prohibition, bridge over the joint in a manner approved by the Engineer.

458-4.5.3 Acceptance: Acceptance of fabricated joint systems will be based on the Engineer's visual inspection at the jobsite and in accordance with requirements of this Section.

Submit certified mill test reports to the Engineer for all steel used to fabricate the joint system.

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458-4.5.3.1 Watertight Integrity Test: Test full length of joint system for watertight integrity in accordance with this Section, no more than five working days after each joint system installation is completed. In case of phased construction, perform this test after the full length of joint is installed (after all applicable phases). For the first two joints, perform the watertight integrity test and inspection in the presence of the manufacturer's installation technician and the Engineer. For all remaining joints, perform the watertight integrity test and inspection in the presence of the Engineer.

Cover full length of joint with either water ponded to a minimum 1/2 inch depth, or continuously flowing water directly over full plan area of joint for a 15 minute minimum duration. Inspect underdeck surfaces beneath the joint for any evidence of dripping water or moisture for the 15 minute duration of water application and for 45 minutes after water supply is removed. Watertight integrity of joint system is interpreted as absolutely no free dripping water or moisture on underdeck surfaces beneath joint. Document date, time, and location of joint inspections and submit the report to the Engineer.

Repair joint integrity at every location exhibiting free dripping water or moisture identified during the watertight integrity test and subsequently retest, subject to same conditions and consequences as the initial test. Retest and repair until joints pass the watertight integrity test.

458-5 Method of Measurement.

The poured joint without backer rod will be incidental to the concrete work and included in the cost of the concrete. Poured joints with backer rod, strip seal joints, and modular expansion joints will be the plan quantity length of each type of joint constructed and accepted.

458-6 Basis of Payment.

458-6.1 Basic Items of Joints. The Contract unit price per foot for joints will be full compensation for all work and materials necessary for the complete installation. Such price and payment will include, but not be limited to, the following specific incidental work:

1. Any work required to clean and prepare the adjacent bridge deck, deck block out or deck joint gap.
2. Any work to replace any rejected joints.
3. Any repairs to the galvanizing on metallic joint components.
4. Any additional work or materials required for non-standardized or special construction or installation techniques.
5. Any cost of erection and removal of any temporary supports which may be necessary for ensuring proper alignment and positioning of the joint relative to the bridge deck.
6. Any sidewalk cover plates required.
7. All costs associated with the manufacturer's installation technician.
8. All work related to performance of the watertight integrity test and any necessary repairs and retesting.

458-6.2 Payment Items: Payment shall be made under:

Item No. 458 - 1- Bridge Deck Expansion Joint - per foot.

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SECTION 459
BITUMEN COATING AND POLYETHYLENE SHEETING ON CONCRETE PILES

459-1 Description.

Furnish and apply bituminous coating and primer, or install polyethylene sheeting and lubricant to prestressed concrete piles.

459-2 Materials.

459-2.1 Bituminous Coating: Use an asphalt type bituminous coating meeting the requirements of Section 916, with a minimum viscosity (at 140ºF) of 3,000 poises and a maximum of 1,000 poises. Apply bituminous coating uniformly over an asphalt primer.

459-2.2 Primer: Meet the requirements of ASTM D41.

459-2.3 Polyethylene Sheeting: Use polyethylene sheeting that is 6 mils thick and is clean, new and has a smooth surface.

459-2.4 Lubricant: Use a lubricant between the two layers of sheeting that is either a vegetable oil or other approved environmentally and functionally acceptable lubricant.

459-3 Construction Requirements.

Before surfaces are coated with bitumen, dry and thoroughly clean them of dust and loose materials. Do not apply primer or bitumen in wet weather or when the temperature is below 65ºF.

Apply the primer to the surfaces and allow it to dry completely before applying the bituminous coating. Apply primer uniformly at the quantity of 1 gal/100 ft^2 of surface.

Apply bitumen uniformly at a temperature of not less than 300ºF, or more than 350ºF, and apply either by mopping, brushing, or spraying at the project site. Completely fill all holes or depressions in the concrete surface with bitumen. Apply the bituminous coating to a minimum dry thickness of 1/8 inch, but not less than 8 gal/100 ft^2.

Store bitumen coated piles before driving, and protect piles from sunlight and heat. Ensure that pile coatings are not damaged during storage, hauling, or handling. Take appropriate measures to preserve and maintain the bitumen coating. At the time of pile driving, ensure that the bitumen coating has a minimum dry thickness of 1/8 inch. If necessary, recoat the piles, at no cost to the Department, to comply with the requirements of this Section.

Ensure that all surfaces to be wrapped with polyethylene sheeting are dry and thoroughly cleaned of dust and loose materials.

Place the sheeting on the pile to the limits shown on the Plans. Wrap the pile with a minimum of 2 1/4 wraps of sheeting. Apply a uniform coating of a lubricant between the first and the second layers. Ensure that this coating fully covers the entire surface of the first layer of sheeting. Once the pile has been wrapped with the minimum of two and one-quarter wraps of sheeting, secure the sheeting with tape or other means that does not damage the sheeting or restrict its movement. Do not place any tape or other material other than the lubricant between the first and second layers of sheeting. Protect the sheeting from construction damage. Where sheeting has been damaged, completely remove the damaged sheet of polyethylene and replace it, at no cost to the Department, as directed by the Engineer.

Where the sheeting will not wrap the specified limits of the pile in one sheet, overlap the previous sheet with each subsequent sheet by 12 inches.

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459-4 Method of Measurement.

459-4.1 Bitumen Coating: The quantity will be paid for by the square yard of coating in place on concrete pile surfaces.

459-4.2 Polyethylene Sheeting: The quantity will be paid for by the square yard of wrapped concrete pile surfaces.

459-5 Basis of Payment.

459-5.1 Bitumen Coating: Price and payment will be full compensation for all work specified in this Section, including furnishing all labor, materials, tools, equipment, and incidentals, and doing all the work involved in applying the bituminous coating and primer, as specified in the Contract Documents.

459-5.2 Polyethylene Sheeting: Price and payment will be full compensation for furnishing all labor, materials, including primer and lubricant, tools, equipment, and incidentals, and for doing all the work involved in installing the polyethylene sheeting and lubricant, as specified in the Contract Documents.

459-5.3 Payment Items: Payment will be made under:

Item No. 459- 70-	Bitumen Coating on Concrete Piles - per square yard.
Item No. 459- 71-	Polyethylene Sheeting on Concrete Piles - per square yard.

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SECTION 460
STRUCTURAL STEEL AND MISCELLANEOUS METALS

460-1 Description.

460-1.1 General: Prepare, fabricate, assemble, erect, and perform all nondestructive testing for structural steel or miscellaneous metal structures, or portions thereof in accordance with the Contract Documents.

Obtain Structural Steel and Miscellaneous Metals from a fabricator that is currently on the Department's Production Facility Listing. Fabricators seeking inclusion on the list shall meet the requirements of Section 105.

As used in this specification, the following terms shall apply:

Main or primary load-carrying member or component: This designation refers to the following;

1. Longitudinal or transverse rolled beams or fabricated girders (I or box, curved or straight)
2. All truss members not designated as cross frames
3. Cross frames, diaphragms and connection plates of horizontally curved beams or girders
4. Rib members of steel arches
5. Bracing members subjected to and specifically designed for traffic live load and/or other loads
6. Cross frames or diaphragms at pier and abutment supports of tub or box girders (trapezoidal members) and their connection plates
7. Attachments and components of the above such as splice, cover, cross frame and diaphragm connection and gusset plates, but not transverse and bearing stiffeners (unless acting as a cross frame or diaphragm)
8. Cables, moment release pins and links, and hangers
9. All steel substructure members except those designated as secondary in the Contract Documents
10. Overhead cantilevers, trusses, spans and gantries
11. Other members as may be identified in the Contract Documents
12. Forgings and castings to be used in bridge machinery

Miscellaneous components - This designation refers to, but is not limited to, the following:

1. Steel modular joints
2. Load plates
3. Bearings
4. Laminated bearing pads
5. Aluminum J-arms
6. Roadway Gratings, inlets, and frames
7. Steel and aluminum railing

460-1.2 Fabrication Categories: As a prerequisite for being on the Department's Production Facility Listing, fabricators must currently be accredited in accordance with one of the programs in Table 460-1, by fabrication category/categories of the products that they are producing.

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Fabricators are required to submit their proposed fabrication Quality Control (QC) Plan for review by the Department.

Table 460-1 Fabrication Categories	
Structure Type	Accepted Accreditation Program
Simple Steel Bridge: Pedestrian bridge (prefabricated steel truss pedestrian bridges meeting the Category 1 conditions of FDOT Design Manual 266.4), bridge grid decking	AISC Simple Bridge
Steel Bridge: Vehicular bridge, Pedestrian bridge (all others)	AISC Advanced Bridge Fracture Critical Endorsement
Structural Highway Metal Components, Group I: bridge machinery, bridge bearings, modular joints, load plates, laminated bearing pads, cantilever, truss/span, monotube, gantry, mast arms, steel light poles, aluminum light poles, aluminum j-arms, drainage (welded gratings, frames, inlets)	AISC Components Manufacturer or AWS Welding Fabricator
Structural Highway Metal Components, Group II: bridge forgings, bridge castings, steel railing, aluminum railing, castings (manhole, grating, inlet, frame), guardrail, coated steel fence, elastomeric bearing pads, stay in-place forms	ISO 9001
Notes: An AISC fracture critical (FC) endorsement is required for all FC work. Other accreditations programs may be submitted to the FDOT State Materials Office for review and consideration in addition to the programs listed in the table above.	

460-2 Materials.

Provide the materials specified in the Contract Documents in accordance with Sections 6, 105, ASTM A6, and AASHTO/AWS D1.5, Bridge Welding Code. Fabricate all unpainted steel elements using steels with weathering characteristics as defined in ASTM A709 for grades with a "W" suffix.

Structural components designated as "fracture critical" shall conform to the provisions of the AASHTO/AWS D1.5, Bridge Welding Code, Clause 12-AASHTO/AWS Fracture Critical Control Plan for Non-Redundant Members, in addition to the requirements of the Contract Documents.

Meet the additional following requirements:

Steel and Miscellaneous Metal Items .....Section 962
Material Testing and Certifications .....Section 962
Galvanizing .....Section 962
Structural Coatings.....Section 560
Structural Coating Materials .....Section 975

460-3 Pre-Assembly Requirements.

460-3.1 Shop Drawings: When shop drawings are required, submit such drawings in accordance with Section 5. For drawing presentation format, refer to the AASHTO/NSBA Steel Bridge Collaboration "Guidelines for Shop Detail Drawing Presentation".

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460-3.2 Welding Procedures: Submit all shop and field welding procedures to the Engineer. Such procedures shall contain a notation that they have been reviewed by a Certified Welding Inspector, and shall be signed, dated and stamped accordingly.

460-3.3 Pre-Assembly Meeting: Prior to commencing work, a meeting shall be held between the Contractor and the Engineer. Representatives of the Fabricator, Suppliers or subcontractors may attend the meeting if requested by the Engineer or Contractor. During this meeting, the Engineer may review various aspects of the job, including but not limited to, any of the following:

1. Plant and Personnel Certification.
2. Organizational Structure of Contractor personnel.
3. Traceability of Materials to Pre-Qualified Fabricator.
4. Shop Drawing requirements, submittal, review and approval process.
5. Fabrication Procedures, especially shop assembly, welding and painting.
6. Sampling and Testing Procedures.
7. Project specific areas of concern for fabrication, inspection and testing.
8. Handling of Material Test Reports.
9. Work Schedule.
10. Lines of Communication.
11. Availability of Quality Control and Verification Inspectors during specific fabrication/erection operations.
12. Loading and Transporting.
13. Handling of non-conformance and repair issues.
14. Special Requirements.
15. Consistency between fabrication shop drawings and the Erection Plan, specifically between the fabrication shop blocking diagrams and available site locations for temporary support during erection.

460-3.4 Access to Fabrication Facilities: Provide the Engineer full access of facilities or sites where the product is being stored, fabricated, assembled, coated or erected.

Provide and maintain office facilities at the fabrication facility for the Department's inspectors that ensure a reasonable amount of privacy, are clean, properly illuminated, heated or air-conditioned as necessary and are relatively free of noise, dust and odors. Locate the office reasonably close to the work and provide access any time fabrication, assembly or erection operations are in progress. Provide a desk, chair, and a four-drawer locking file cabinet for the use by each inspector and the Engineer. Provide a telephone within the office with an outside line suitable for modem communication. Provide ready access to adequate parking, fax and copy machines, and clean, contractor-maintained restrooms within a reasonable distance to the office.

The Engineer may observe any or all activities and perform nondestructive testing of materials, components and the fabricated product to the extent considered necessary to confirm the conformance with Contract Documents.

460-3.5 Notification Prior to Commencement of Assembly: Notify the Engineer at least one week prior to beginning assembly, when conducted in-state, and at least two weeks prior to beginning assembly, when conducted out-of-state.

460-4 Shop Workmanship and Assembly.

460-4.1 Handling, Transporting and Storage of Materials:

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460-4.1.1 General: Handle, transport and store plates, shapes, assemblies, fastener components and other parts in a manner that protects them from damage and facilitates subsequent inspections in a safe manner.

Provide storage which will keep materials, assemblies, other components and parts clean, and free from dirt, grease, other foreign matter, unacceptable corrosion or coating deterioration, and any other adverse environmental conditions.

460-4.1.2 Bulk Materials: Ensure that all bulk materials, such as shear studs, are stored together in individual LOTs and that the outside of each container has a list and description of the contents. Maintain a separate list of the weights of all tools and erection materials.

460-4.1.3 Fastener Assemblies (Bolts, Nuts and Washers): Transport and store fastener assemblies in sealed, watertight containers. Label the side of each container with the supplier's name and LOT identification number, and marked to identify the contents and size of the fastener components. Ensure that all surfaces of the nuts are lubricated prior to their placement in watertight containers. Provide containers for components that are capable of protecting them from moisture and other harmful materials. Maintain containers in their sealed conditions until they are opened for use at their assembly locations.

Do not remove more fastener assemblies from the protected area than can be installed and tightened during a work shift. Leave the containers unopened until needed for assembly. At the end of the work shift, return unused fastener assemblies to the protected storage area for future use. Protect opened storage containers from contamination.

460-4.1.4 Coatings: Store coatings in accordance with Sections 962, and 975 and the manufacturer's recommendations. Notify the Engineer if the manufacturer's recommendations vary from that provided in the Contract Documents.

460-4.1.5 Anchor Rods and Nuts: Ship anchor rods and nuts as an assembly. Washers may be shipped separate from the assembly.

460-4.2 Material Traceability:

460-4.2.1 General: All materials arriving at the shop shall be properly identified in accordance the requirements of ASTM A6. Document all main load-carrying member material, high-strength fastener assemblies, and weld materials incorporated into the work through the entire fabrication process. Document this material traceability in a report type format that correlates heat numbers to their respective locations in the completed members. Submit diagrams and sketches as requested by the Engineer for clarity.

At the fabrication facility, maintain the records of the material testing and certification processes and component/part identification as part of the fabricator's permanent project records for a period of not less than two years as measured from the last shipment of materials from the fabricator's facility. Submit all project-related records to the Engineer.

Mark the weight on members weighing more than three tons, in a visible location.

460-4.2.2 Match Marking of Members and Assemblies: Match mark all connecting members or parts that have been reamed or drilled while assembled. The fabricator shall submit a diagram showing all marks and clearly indicate the location of all the marks on the shop drawings.

Use painted marks, attached metal tags, other durable methods which do not degrade the finish of the piece, including plasma etching or low-stress type steel die stamps to identify and match mark pieces. If steel die stamps are used, they must be blunt nosed or

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interrupted dot dies, manufactured to produce impressions that are rounded at the bottom of the impression. Re-mark coated type markings as necessary to maintain continuity in traceability. Plasma etching using robotic equipment may be used to mark the surface of a steel plate when done at 10 amps and at 150 inches per minute. Plasma etching outside of these parameters requires Engineer approval.

Mark splice plates and girders so that upon erection, the mark on the splice plate is located opposite a matching mark on the girder. Place the mark on web splice plates, midway down the long side of the plate, on either the right or left side, to correspond with the girder to which the splice plate will be temporarily attached for shipping to the erection site. Make a matching stamp on the girder web opposite the mark on the splice plate.

Place the mark on top or bottom flange splice plates, on the right or left end of the plate, corresponding to the girder to which the plate will be attached for shipment to the erection site. Place a corresponding mark on the girder flange opposite the mark in the splice plate.

As an alternate location for tub girder bottom flange splice plates, place the mark midway down the long side of the plate, on either the right or left side, to correspond with the girder to which the splice plate will be temporarily attached for shipping to the erection site. Make a matching mark on the girder flange opposite the mark on the splice plate.

Mark girders and beams on the left end, according to the orientation shown in the shop drawings, near the top flange. Mark diaphragms in the middle upper portion of the web. Mark cross-frames in the middle of the top or bottom horizontal member.

When heat numbers and other identification marking are applied by die stamping to fracture critical members, low stress dies shall be used.

Low-stress die stamp markings applied to fracture critical members shall be placed in locations or zones shown or described in the approved shop drawings. Low-stress or compression areas are preferred.

Ensure that during fabrication, the heat number is maintained on each primary load-carrying component by paint until the component is permanently joined into a piece marked member or assembly.

460-4.3 Workmanship:

460-4.3.1 Cutting, Shearing and Machining: Cutting (including burning and sawing), shearing, and machining shall be accomplished in accordance with the AASHTO/AWS 1.5, Bridge Welding Code and the following requirements:

Plane, mill, grind or thermally cut the sheared edges of main load-carrying member plate components greater than 5/8 inch thick to a depth of 1/4 inch.

Cut and fabricate steel plates so that the primary direction of rolling is parallel to the direction of the member or component main stress. For flanges and webs, the direction of rolling is parallel to the flanges unless noted otherwise in the Contract Documents. Web splice plates may be rolled parallel to their length.

460-4.3.2 Bending:

460-4.3.2.1 Cold Bending: Fracture critical and non fracture critical plates and bars shall be cold bent, unless otherwise permitted according to the provisions of Section 460-4.3.2.2.

The minimum bend radii measured to the concave face of the plate, shall be taken as 5.0(t) for all grades and thicknesses of steel conforming to structural steel for bridges, AASHTO M 270M/M 270 (ASTM A709/A709M), where ‘t’ is the thickness of the plate

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in inches. For cross-frame or diaphragm connection plates up to 0.75 inches, the minimum bending radii may be taken as 1.5(t). For all other grades of steel the minimum bend radii recommendations from the plate fabricator shall be followed, but the radii shall not be less than the minimums specified herein.

Wherever possible, bend lines shall be oriented perpendicular to the direction of final rolling of the plate. If the bend lines are parallel to the direction of final rolling, the minimum bend radii shall be increased to 7.5(t).

460-4.3.2.2 Hot Bending: Fracture critical and non-fracture critical plates and bars may be bent hot subject to the approval of the Engineer. Heat-shrink methods as described in 460-4.3.4 are also permitted. If hot bending is to be employed, the heating and bending procedure shall be submitted for review and approval by the Engineer. The plates and bars shall be bent hot at a temperature above the blue brittle temperature of steel (700° F), not to exceed the temperature limits in Table 460-2. The minimum radii of the hot bend must satisfy the requirements of 460-4.3.2.1.

460-4.3.3 Straightening: Member components, such as plates, angles or shapes, are to be straightened before the parts are assembled. Perform straightening such that no cracking or other damage occurs in the part. If heat is to be used for straightening, follow the provisions of 460-4.3.4.

460-4.3.4 Heat Application:

460-4.3.4.1 General: At various points during the fabrication of structural steel, applications of heat may be necessary for hot-bending, cambering, curving or straightening. Use the temperature limits and guidelines given in this Section, unless alternate procedures have been approved by the Engineer. Routine straightening of material other than quenched and tempered material shall be done in accordance with the temperature limits and guidelines as specified herein, but do not require a submitted procedure.

Heat curving may be used in conjunction with a cut-curve procedure, in which a portion of the curvature is obtained by cutting the plates to all or part of the required radius, except as limited by 460-4.3.4.4.

460-4.3.4.2 Heating Process and Equipment:

460-4.3.4.2.1 Maximum Temperatures: The maximum allowable temperature to which the material can be heated is given in Table 460-2, Maximum Temperature Limits for Heat Applications.

Table 460-2
Maximum Temperature Limits for Heat Applications

ASTM A709 Grade	Maximum Temperature, °F
36, 50, 50S, 50W & HPS 50W	1,200
HPS 70W & HPS 100W	1,100

460-4.3.4.2.2 Timing of Heat Applications: Conduct heating operations prior to the application of coatings.

460-4.3.4.2.3 Allowable Preload Stresses: Preload compressive stresses will be permitted up to 0.5 times the minimum specified yield strength (Fy) of the material. This stress limit is applicable to all steels covered by this specification as listed in Table 460-2. If jacks are used, energize and lock off prior to the application of heat.

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460-4.3.4.2.4 Heating Tips: Apply heat using orifice tips only. Select tip sizes proportional to the thickness of the heated material.

460-4.3.4.2.5 Torches: Manipulate the heating torches to guard against general and surface overheating. In addition, place heat reflective sheet material against the web before applying heat to the inside flange surface. When heating the inside flange surface, point the torches to prevent applying heat directly to the web.

460-4.3.4.2.6 Heating Patterns: Fundamental heating patterns (such as vee, line, edge, spot, and strip) may be used separately or in combination. Mark vee and strip heat patterns on the material surfaces prior to heating. When heating, bring the steel within the planned pattern to the specified heating temperature as rapidly as possible without overheating the steel. Apply heat in accordance with the approved procedure.

460-4.3.4.2.7 Thin Wide Plates: Prevent buckling of thin wide plates by not applying excessive heat.

460-4.3.4.2.8 Verification of Temperatures: Use temperature-sensitive crayons, pyrometers, or infrared non-contact thermometers for verifying temperatures during heating operations. When heating patterns are used, make regular verifications of the temperatures throughout the pattern. Remove the heating flame from the material before taking measurements.

460-4.3.4.2.9 Cooling: Prior to the use of any artificial cooling, allow steel to cool below 600°F. Use only dry compressed air. Do not quench with water or a water and air mixture.

460-4.3.4.2.10 Reheating: Reheat only after the material has cooled below 250°F.

460-4.3.4.2.11 Over Heating: The Engineer may reject the product, if any portion of the material is exposed to heating higher than the allowable temperature.

460-4.3.4.3 Heat-Curving of Bridge Members (Weak Axis Shaping):

460-4.3.4.3.1 General: Rolled beams and girders may be heat-curved at the job site, provided that the heating is performed in accordance with the Engineer's approval.

460-4.3.4.3.2 Sequence of Operations: Heat curve members prior to the attachment of longitudinal stiffeners.

460-4.3.4.3.3 Web Position: When the radius is less than 1,000 feet, heat curve members with the web in the horizontal position or preloaded to induce stress prior to heating. Otherwise, members may be heat-curved with the web in either the vertical or horizontal position.

460-4.3.4.3.4 Subsequent Heats: If multiple locations are to be heated, do not reheat the same location until after at least three heats at other locations.

460-4.3.4.3.5 Locating Heating Patterns: Space the heating patterns along the full length of each flange to produce a circular (not parabolic) curvature. Adjust the heating patterns to produce the necessary curvature. Compensate for differences in flange thickness and width as necessary. Use enough heating patterns in each piece to eliminate chording effects.

460-4.3.4.4 Minimum Radius for Heat-Curving: Heat-curving of beams and girders is allowed when the horizontal radius of curvature measured to the centerline of the member web is greater than both values calculated by Equations 4.1 and 4.2 below, and greater

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than 150 feet at any and all cross sections throughout the length of the member. Do not heat curve steels with a minimum specified yield strength greater than 50 ksi, other than ASTM A709, Grade HPS 70W.

$$R = \frac{14bD}{\sqrt{F_y \psi t}} \text{ in.} \qquad \text{(Equation 4.1)}$$

$$R = \frac{7500\,b}{F_y \psi} \text{ in.} \qquad \text{(Equation 4.2)}$$

where:

Fy = specified minimum yield point of member web, ksi;
ψ = ratio of the total cross section area to the cross-sectional area of both flanges;
b = width of the widest flange, inch;
D = clear distance between flanges, inch;
t = web thickness, inch;
R = radius, inch.

In addition to the above requirements, do not heat curve if the radius is less than 1,000 feet when the flange thickness exceeds 3 inches or the flange width exceeds 30 inches.

460-4.3.4.5 Heat-Cambering (Strong Axis Shaping):

460-4.3.4.5.1 General: Procedures for cambering of built-up plate girders shall be submitted as a part of the Producer Quality Control (QC) Plan. In the procedures, address any proposed preloading and heat application and control. Minor heat adjustments in camber at the finishing stage of the girder do not require approval if the patterns and temperatures are followed in accordance with the approved procedures.

Do not utilize heat-cambering as the primary source of vertical camber in horizontally curved main load-carrying members; cut the web plate to the required position. Only use heat-cambering on horizontally curved main members to adjust cut cambering with the approval of the Engineer.

460-4.3.4.5.2 Web Position: Support members to be heat-cambered with the web vertical. Space supports to take maximum advantage of dead load in the member prior to the application of heat.

460-4.3.4.5.3 Subsequent Heats: If multiple locations are to be heated, do not reheat the same location until after at least three heats at other locations.

460-4.3.4.5.4 Rolled Beams: Rolled beams may be heat-cambered to provide the required curvature at the producing mill. Attach all detail material, such as connection plates, bearing stiffeners and gusset plates, after the beam has been heat-cambered.

460-4.3.4.6 Heat-Straightening Damaged Structural Steel:

460-4.3.4.6.1 General: Submit procedures for heat-straightening for the Engineer's review prior to beginning the work. Describe in detail the distortion to be corrected and all details for preloading, heating, cooling, verifying final dimensions, and nondestructive testing.

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460-4.3.4.6.2 Cracking: As a minimum, visually examine all heat-straightened areas. Notify the Engineer when suspected areas of cracking are found. Examine these areas by one or more of the following methods, as directed by the Engineer:

1. Visual examination;
2. Liquid penetrant examination
3. Magnetic particle examination
4. Ultrasonic examination
5. Radiographic examination

460-4.3.4.6.3 Restraining Forces: Restraining forces (usually jacks) shall be set to restrain the steel during heating, but allow free contraction during cooling. In addition, apply the restraining forces in a direction tending to restore the member and limit the magnitude so that the material is not overstressed during heating.

460-4.3.4.6.4 Heating: Heat the steel in a single pass following the specified pattern and allow it to cool to below 250°F prior to reheating. Select heating patterns and sequences appropriate for the type of damage and shape of the cross section. Simultaneous vee heats may be used provided the clear spacing between vees is greater than the width of the plate element.

460-4.3.4.6.5 Subsequent Repair: Heat cambered members damaged after cambering may be repaired. However, do not repair previously heat-straightened members in the same region of damage without the approval of the Engineer.

460-4.3.4.7 Heat Treatment:

460-4.3.4.7.1 General: When any special form of heat treatment is required, it will be described in the Contract Documents. Perform heat treatments prior to any boring, machining or straightening operations.

460-4.3.4.7.2 Stress Relief: Where required, perform thermal stress relief in accordance with the procedure outlined in the AASHTO/AWS D1.5, Bridge Welding Code. Provide welding materials consistent with the stress relieving process utilized.

460-4.3.4.7.3 Normalizing and Annealing: Where required by the Contract Documents, perform normalizing and annealing as defined in ASTM A941. Maintain temperatures uniformly throughout the furnace during heating and cooling so that the temperatures at any points on the member do not differ by more than 130°F.

460-4.3.4.8 Contact and Bearing Surfaces: Provide surface finishes of bearings, base plates, and other contact surfaces in accordance with the ANSI surface roughness requirements as defined in ANSI B46.1, Surface Roughness, Waviness and Lay, Part I, given in Table 460-3, ANSI Surface Roughness Requirements.

Table 460-3
ANSI Surface Roughness Requirements

Steel slabs	ANSI 2000 micro-inch
Heavy plates in contact with shoes to be welded	ANSI 1000 micro-inch
Milled ends to compression members, milled or ground ends of stiffeners or rockers	ANSI 500 micro-inch
Bridge rollers and rockers	ANSI 250 micro-inch
Sliding bearings	ANSI 125 micro-inch
Pins and pin holes	ANSI 125 micro-inch

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460-4.3.4.9 Cleaning and Coating (Including Galvanizing):

460-4.3.4.9.1 General: Clean and coat the work in accordance with 460-2 and/or 460-7.2 and Sections 560, and 562.

460-4.3.4.9.2 Removal of Lubricants: Remove lubricants from the exposed surfaces of installed fastener assemblies and other surfaces in accordance with the approved Producer QC Plan or the paint manufacturer's recommendations prior to painting. Demonstrate the procedures to the Engineer prior to preparations for painting. Bring to the Engineer's attention any manufacturer's processes or procedures that conflict with those specified in the Contract Documents.

460-4.3.5 Bolt Holes:

460-4.3.5.1 General: Unless shown otherwise in the Contract Documents, the bolt hole geometry is to be as shown in Table 460-4, Bolt Hole Geometry.

Table 460-4
Bolt Hole Geometry

Bolt Diameter (d), inch	Standard (Diameter, inch)	Oversize (Diameter, inch)	Short-Slotted (Width, inch by Length, inch)	Long-Slotted (Width, inch by Length, inch)
1/2	9/16	5/8	9/16 x 11/16	9/16 x 1 1/4
5/8	11/16	13/16	11/16 x 7/8	11/16 x 1 9/16
3/4	13/16	15/16	13/16 x 1	13/16 x 1 7/8
7/8	15/16	1 1/16	15/16 x 1 1/8	15/16 x 2 3/16
1	1 1/16	1 1/4	1 1/16 x 1 5/16	1 1/16 x 2 1/2
> 1 1/8	d + 1/16	D + 5/16	(d + 1/16) x (d + 3/8)	(d + 1/16) x (2.5 x d)

Note: Except as shown elsewhere in the Contract Documents, bolt holes in the connections of primary members are to be standard size.

460-4.3.5.2 Holes, Tolerances and Quality: Make bolt (and anchor rod) holes using any method suitable to the Fabricator and as specified below; except holes for high strength fasteners in main or primary load-carrying members which are not to be punched full size, but may be thermally cut in accordance with 460-4.3.5.4 and ground smooth with the approval of the Engineer.

The misalignment of holes in a bolt group relative to the same holes in the component or components it is joined to in a connection, shall not exceed 1/32 inch for 85% of the bolt holes in that group. Bolt holes are to be normal to the work and have no tears, cracks, fins, dirt, loose rust, burrs or other anomalies, and the surface is to be flat within a slope of 1/20. Bolt holes are to be round within plus or minus 1/32 inch and within plus or minus 1/32 inch of the specified size. For subsize holes, a pin 1/8 inch smaller than the subsize holes must be able to pass through all assembled plies in at least 75% of the locations prior to reaming. Holes inclined more than 3 degrees to a surface in any direction must have a hardened beveled washer provided at that face. Unless specified elsewhere in the Contract Documents, it is not required to coat the inside of the bolt holes.

460-4.3.5.3 Slotted Holes: Slots may be made by a single punch, or by joining two adjacent drilled or punched holes when punching is permitted. When joining holes, thermal cutting is to follow the common tangent to the two holes, and this cut is to be ground. Do

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not make slotted holes more than 1/32 inch in width nor 1/16 inch greater in length than specified. Grind smooth any flame cut portions of the slot to ANSI 1000 micro-inches.

460-4.3.5.4 Holes in Plates Not Subjected to Tensile Stress: Large diameter holes in heavy plates not subjected to tensile stress (such as bearing plates) and slotted holes in materials not subject to tensile stress may be thermally cut, followed by appropriate grinding to smooth the periphery. Stop the practice if gouges or other defects occur, or if directed by the Engineer. These holes are to meet the following criteria:

Do not thermally cut holes in ASTM A709, GradeHPS 100W steel. Provide hole centerlines aligned within plus or minus 1/16 inch of theoretical. The inside (cut) faces of the hole are to be perpendicular to the plane of the plate. Eighty-five percent of the (open) hole diameter is not to exceed that specified in the Contract Documents, plus or minus 1/16 inch. Local notches, gouges or the maximum diameter shall not exceed that specified in the Contract Documents plus or minus 3/32 inch.

460-4.3.5.5 Punching: Material forming parts of a member composed of five thicknesses or less of metal may be punched full-size. When more than five thicknesses of material are joined, material shall be subdrilled or subpunched and then reamed full-size, or drilled full-size while in assembly. Subpunched or subdrilled holes, when required, must be at least 3/16 inches smaller than the finished hole size.

Holes in cross frames, lateral bracing components, and the corresponding holes in connection plates between girders and cross frames or lateral components may be punched full size. Holes in longitudinal main load-carrying members, transverse floorbeams, and any components designated as fracture critical (FCMs) shall not be punched full-size.

460-4.3.5.6 Edge Distance: Provide minimum as-fabricated distance from the center of a bolt hole to an edge as given in Table 460-5, Edge Distances, unless otherwise shown in the Contract Documents.

Table 460-5
Edge Distances

Fastener Size, Inch	Sheared Edge, Inch	Rolled Edges of Plates or Shapes or Gas Cut Edges Inch
5/8	1-1/8	7/8
3/4	1-1/4	1
7/8	1-1/2	1-1/8
1	1-3/4	1-1/4

460-4.3.5.7 Bolted Splice Gaps: Unless shown elsewhere in the Contract Documents, the tolerance for bolted splice gaps (open distance face-of-web/flange to face-of-web/flange) shall be from zero (no gap between faces) to a maximum of 1/8 inch greater than the gap shown on the Plans. If no gap is shown in the Plans, assume that a nominal gap of 3/8 inch is required. In addition, meet the edge distance requirements, provided above.

460-4.3.5.8 Maximum Edge Distance: Unless otherwise specified in the Contract Documents, the maximum fabricated distance from any edge to the center of the hole shall be 8 times the thickness of the thinnest outside plate, not to exceed 5 inches with no additional tolerance allowed.

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460-4.3.5.9 Spacing of Bolt Holes: Space bolt holes within plus or minus 3/16 inch of that shown in the Contract Documents.

460-4.3.5.10 Holding of Plies: When drilling or reaming is accomplished through multiple plies of material, do not hold the materials together by welds not specified in the Contract Drawings.

460-4.4 Member Geometry:

460-4.4.1 General:

460-4.4.1.1 Tolerances: Provide dimensional tolerances as follows:

1. Rolled shapes, plates, bars, wide flange sections and miscellaneous steel in accordance with ASTM A6;

2. Fabricate girders in accordance with the AASHTO/AWS D1.5, Bridge Welding Code and as described below;

3. For built-up members not specifically covered by AASHTO/AWS D1.5, apply AASHTO/AWS D1.5, Bridge Welding Code, except as noted below or as directed by the Engineer.

460-4.4.1.2 Camber and Sweep: Tolerances for camber and sweep of continuous and simply supported girders of any shape shall be as described in the AASHTO/AWS D1.5, Bridge Welding Code. The camber and sweep tolerances for steel pier caps shall be the same as those specified for girders. Measure sweep for horizontally curved members from the theoretical centerline for comparison to the aforementioned requirements.

460-4.4.1.3 Alternate Sections: Rolled sections or fabricated sections of equal or slightly greater dimensions than the section specified may be proposed for the Engineer's approval. Changes that reduce fatigue resistance or significantly affect splice design or deflection will require complete design calculations.

460-4.4.1.4 Web Flatness: Maximum deviation from flatness for webs of curved and/or cambered sections shall be the same as for straight built-up girders. Measure curved girder web flatness using a straightedge oriented perpendicular to the flanges ("vertical", flange to flange).

460-4.4.1.5 Girder Length: If measuring girder length with a device that is free of thermal effects, appropriately adjust the measurements to the reference temperature shown in the Contract Documents. Measure the length of horizontally curved girders along the arc.

460-4.4.2 Specialty Structures:

460-4.4.2.1 Box Members as Bent Caps:

460-4.4.2.1.1 Tolerances: Unless otherwise shown in the Contract Documents, submit tolerances for bearing planes and box twist to the Engineer for review and approval. Prior to submitting these tolerance values for approval, coordinate between the Erector and the Fabricator.

460-4.4.2.1.2 Bearings: Unless otherwise specified in the Contract Documents, each bearing is to be true to a tolerance of 1/32 inch across its entire width in either direction.

460-4.4.2.1.3 Beam Trueness: Unless otherwise specified in the Contract Documents, the plane of beam supports on the box girder (the bearing area specifically attached to the box girder) is to be true to the box girder bearing within 1/16 inch in the short direction and true to the vertical axis of the nesting girders (those girders attached to or resting on the box girder) within 1/16 inch.

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460-4.4.2.2 Trapezoidal Bridge Members: As a minimum, trapezoidal bridge members (tub or box girders) shall meet AASHTO/AWS D1.5, Bridge Welding Code dimensional tolerances. Camber may be verified with the girder in its upright position, supported to avoid dead load deflections.

460-4.4.2.3 Pinholes: Unless shown elsewhere in the Contract Documents, bore pinholes:

1. True to the specified diameter;
2. Smooth to ANSI 3 (125 micro-inches);
3. At right angles with the axis of the member;
4. Parallel with each other; and
5. With a diameter of the pinhole not exceeding that of the pin by more than 0.015 inch for pins 5 inches or less in diameter, or 1/32 inch for larger pins.

460-4.4.2.4 Truss Chord Joints: Abutting joints in truss chords not specified to be mill-to-bear shall have openings of 1/4 inch, plus or minus 1/8 inch.

Abutting joints in truss chords specified to be mill-to-bear shall be faced and brought into bearing. When assembled, provide 85% or more of the abutting surfaces in full contact. Allowable visible gaps shall not exceed 1/64 inch.

460-4.4.2.5 Horizontally Curved Beams and Skewed Steel Girders: Account for torsion induced deflections for horizontally curved beams and skewed steel girders. Unless otherwise defined in the Contract Documents, a horizontally curved beam or girder is a longitudinal or transverse bridge component with a radius less than 10,000 feet anywhere along its continuous length.

460-4.5 Shop Assembly:

460-4.5.1 General: Ensure the fit of all connections and the geometry of all components. Unless specified elsewhere in the Contract Documents, check the fit of all longitudinal girder/beam lines in accordance with 460-4.5.1.1. Perform this prior to transporting the pieces in question to the site for erection.

460-4.5.1.1 Progressive Girder or Truss Assembly: Assemble the structure for a minimum of three spans, panels, field sections, segments or longitudinal chords of the structure. Successive assemblies shall consist of at least one longitudinal segment of the previous assembly, repositioned as necessary for accurate alignment, plus two or more longitudinal segments added at the advancing end. For entire structures less than 150 feet in length or less than three segments, assemble the entire longitudinal line. Meet the requirements of 460-4.5.1.4 when utilizing computer-numerically-controlled drilling equipment.

When a transverse structural steel member or members is required for the continuation of the uninterrupted girder or beam line, truss, arch rib, bent tower face or rigid frame, and is designated elsewhere in the Contract Documents to be shop assembled, the Fabricator may include this member or component in a separate subassembly and not the three segment longitudinal assembly (discussed above). If combined in a different subassembly, include the longitudinal member(s) or component(s), as designated elsewhere in the Contract Documents to be shop assembled, that frame directly into the transverse structural member. Do not include the transverse member(s) in the longitudinal assembly unless directed so elsewhere in the Contract Documents or by the Engineer. Account for end rotations and deflections as necessary, and submit the procedure to the Engineer for review.

460-4.5.1.2 Progressive Chord Assembly: When specified elsewhere in the Contract Documents, assemble the truss chords for a minimum of three panels or longitudinal

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segments of the structure. Successive assemblies shall consist of at least one longitudinal segment of the previous assembly, repositioned as necessary for accurate alignment, plus two or more longitudinal segments added at the advancing end. For entire structures less than 150 feet in length or less than three segments, assemble the entire longitudinal line. Meet the requirements of 460-4.5.1.4 when using computer-numerically-controlled drilling equipment.

Account for transverse members indicted elsewhere in the Contract Documents to be included in the shop assembly as in 460-4.5.1.1.

When assembled in accordance with this subsection, the holes of the connections will be so located that they will be drilled to the final geometric angles. This will require that the truss members, when erected under the no load (or practically no load or stress) condition, must be bent and forced to fit the end conditions. This condition will introduce an initial reverse secondary stress that will theoretically wane when the structure assumes the loading for which it is cambered. Submit the procedure to the Engineer for review.

460-4.5.1.3 Special Complete Structure Assembly: When specified elsewhere in the Contract Documents, this type of shop assembly will include assembling the entire structure including the diaphragms, cross frames, integral steel substructure and floor components. Miscellaneous components are not included unless directed elsewhere in the Contract Documents. Establish procedures for each structure or structure type including consideration of incremental erection, temporary field support locations, stage construction and final tightening of field connections. Submit the procedures for review by the Engineer.

460-4.5.1.4 Computer-Numerically-Controlled (CNC) Drilling Associated with Progressive Girder, Truss or Chord Assembly: If the Fabricator chooses to drill the holes in all plies of all connections of the continuous main girder or beam line, truss, arch rib, bent, tower face or rigid frame and any intersecting (transverse) members utilizing computer-controlled-numerical drilling procedures, piece-wise assembly of the entire continuous girder or beam line, truss, arch rib, bent, tower face or rigid frame is not required if the following requirements are met:

Prior to transporting to the site, perform a check fit of the first three spans, panels, field sections, segments or longitudinal chords; or entire first bent, tower face or rigid frame of the structure to ensure the accuracy of the CNC procedures and equipment.

As selected by and at the discretion of the Engineer and prior to transporting to the site, perform another check fit of a different assembly of three spans, panels, field sections, segments or longitudinal chords; or another entire bent, tower face or rigid frame of the structure to ensure that the accuracy of the CNC procedures and equipment is maintained. If either of the above fails to meet the Contract requirements, assemble the entire girder or beam line, truss, arch rib, bent, tower face or rigid frame as originally prescribed in 460-4.5.1.1 or 460-4.5.1.2 as prescribed elsewhere in the Contract Documents. Account for transverse members indicated elsewhere in the Contract Documents to be included in the shop assembly as in 460-4.5.1.1.

460-4.6 Evaluation of Work: The Engineer will evaluate and accept materials and work conforming to the Contract Documents. These evaluations may take place prior to or following delivery of the materials to the site of the structure. Materials or work that fails to meet Contract requirements will be rejected.

The Engineer may, at his sole discretion, permit further inspections and testing of materials or work that fail to meet Contract requirements for acceptance. The cost of such inspections and tests shall be borne by the Contractor.

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Bring to the attention of the Engineer, all nonconforming work and or materials that cannot be brought into conformance with the Contract Documents using pre-established procedures as outlined in the Department approved Producer QC Plan. Submit the following information to the Engineer:

A cover letter prepared on the Contractor's letterhead and addressed to the Engineer briefly describing the nonconforming work and the proposed credit to the Contract proportionate to the nonconformance. For each fabricating facility and for each project within that fabrication facility, submittals must be numbered consecutively beginning with the number 1, at the start of each project. Erectors will start with one for each individual project.

A completed Department Nonconforming Structural Steel and Miscellaneous Metal Component Data Sheet prepared by the Contractor and countersigned by the Engineer's designated representative to indicate agreement between the Contractor and the Department regarding the nonconformance, not any solution, resolution or credit. If the Contractor and the Engineer's designated representative are not in agreement regarding the nonconformance, the Engineer's designated representative will either reject the submittal indicating the reason(s) for the rejection or modify the submittal and forward to the Engineer. In the event of modification, the Contractor will initial the submittal before being forwarded to the Engineer, thereby indicating the Contractor's concurrence with the modification.

A list of supporting information such as sketches, documentation, calculations, pictures, etc., must be included in the appropriate space on the Nonconforming Component Data Sheet. Supporting information regarding Contract Document noncompliance in the form of separate documents is only necessary when space on the Department Nonconforming Structural Steel and Miscellaneous Metal Component Data Sheet is inadequate for the required data. All of the supporting information required for the form must be prepared by, or under the supervision of, the Specialty Engineer who will sign and seal the supporting information.

If requested by the Engineer, submit a structural and durability evaluation of the proposed repair and/or remediation. This evaluation must be conducted under the supervision of a Specialty Engineer and the submittal is to bear the Specialty Engineer's signature and seal.

460-4.7 Member or Component Certification: Coordinate with the Engineer to schedule final inspection of the completed work within two weeks prior to shipment or erection to verify that all Contract Document requirements have been met. After verification that all Contract Document requirements have been met and all necessary repairs have been satisfactorily completed, the Quality Control Manager shall certify, by initials and/or signature, such materials, components or members. The record shall include certification for:

1.Items being shipped or stored prior to final assembly. Affix a certification in the form of a stamp or tag in accordance with 460-4.2 and as indicated in the Producer Q C Plan, and with a copy of the certification placed in the Contractor's permanent project records,

2. Work being placed into its final position. Document in the Contractor's permanent project records.

Submit a summary certification at the least once a month or with each payment request that includes the following or similar wording. "The undersigned, being a responsible official of (insert Contractor identification) certifies that the materials, components or members listed herein have been produced under strict quality control and meet the requirements of the Contract Documents" Include a positive identification in the certification such that the applicable materials, components and/or members can be uniquely identified utilizing just the summary certification document. The Quality Control Manager shall sign this summary certification.

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460-5 Bolted Connections.

460-5.1 General: High strength bolts are described as follows:

1. ASTM F3125 Grade A325 or as Grade A325
2. ASTM F3125 Grade A490 or as Grade A490

Use bolts as follows:

1. Use galvanized Grade A325 Type 1 bolts in all field installed bolted structural steel connections for painted steel.
2. Use either black or galvanized Grade A325 Type 1 bolts in all shop installed bolted structural steel connections that will be shop painted.
3. Use black Grade A325 Type 3 bolts in all bolted structural steel connections for weathering steel that is to remain unpainted.
4. Use the bolts as specified for connected assemblies or parts that are designated as miscellaneous components where the fastener type is specified elsewhere in the Contract Documents.

Tighten Grade A325 bolts in accordance with the procedures specified below for turn-of-nut or direct-tension-indicator (DTI) tightening.

Lubricate and maintain consistency in lubrication of fastener assembly during Rotational Capacity (RC) testing and installation. Assemblies that exhibit a loss of lubrication, as determined by the Engineer, may be re-lubricated and retested prior to installation.

Use Grade A490 bolts only with the approval of the Engineer. Submit procedures in accordance with ASTM F3125 Grade A490 for the handling, lubrication, installation, tightening and testing of such bolts. Do not install Grade A490 bolts without prior approval of the procedures by the Engineer.

When the Engineer approves ASTM A307 bolts for use in miscellaneous components, tighten them such that the plies of the joint are in firm contact. Use three to five impacts of an impact wrench or the full effort of a person using an ordinary spud wrench to obtain a snug connection.

Fasten aluminum, other materials or assemblies of dissimilar materials in accordance with the Contract Documents.

Install ordinary rough or machine bolts and nuts in accordance with the Contract Documents.

460-5.2 Testing:

460-5.2.1 Rotational Capacity (RC) Tests: At the location of and prior to installation of permanent high-strength fasteners in main or primary load-carrying member connections, perform RC tests in accordance with FM 5-581 (for long bolts) or FM 5-582 (for short bolts) to ensure that the fasteners are capable of developing the specified strength and that the fasteners are properly lubricated. As a minimum, test two assemblies per LOT designation. The bolt, nut and washer shall come from the same LOT and be packed in the same container (or group of containers assigned the same LOT), except in special cases where nuts and washers have only one production LOT number for each size.

Short bolts may also be tested using FM 5-583 with DTIs calibrated with long bolts installed in a Tension Measuring Device.

Washers are required for RC tests even though they may not be required for jobsite installation. Where washers are not required for jobsite installation, LOT identification is not required. The washer coating shall be the same as that for the bolt and nut.

If any of the required tests fails, the entire LOT will be rejected.

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460-5.2.2 Verification of Direct Tension Indicator (DTI) Device Performance: On a daily basis (when DTI devices are being installed) and at the location of installation, perform DTI Verification tests in accordance with FM 5-583. Perform this test on a minimum of two high-strength fastener assemblies from each fastener assembly LOT and position of the DTI prior to production installation. If either assembly fails, test additional fastener assembly LOT/DTI combinations as requested by the Engineer to verify that the Requirements of the Contract Documents have been satisfied. These two tests are in addition to the RC tests required in 460-5.2.1. If, after additional testing, the DTI fails to meet the requirements of FM 5-583, the LOT will be rejected by the Engineer.

460-5.3 Reuse and Retightening: Do not reuse Grade A490 bolts or galvanized Grade A325 bolts. Black Grade A325 bolts with free spinning nuts may be reused one time with the Engineer's approval. Previously tightened bolts that may have been loosened by the tightening of adjacent bolts can be further tightened from the original position. Ensure proper lubrication prior to retightening. Discard and replace fractured or damaged bolts.

460-5.4 Assembly of Bolted Connections:

460-5.4.1 General: Verify that the faying surfaces are in accordance with the Contract Documents, are free of dirt or other foreign materials, and that the geometry of the bolt holes and the connection meets the requirements of 460-4.3.5.

Install fastener assembly components of the same LOT and of the size and quality specified in the Contract Documents. Provide final bolts, cylindrical erection pins or other fit-up bolts as indicated in the Erection Plan.

When it is impractical to turn the nut, tighten the fastener by turning the bolt while preventing the nut from rotating. During this tightening operation, do not allow the rotation of the part of the fastener assembly not turned by the wrench.

460-5.4.2 Preparation of Faying Surfaces: Provide coated and non-coated faying surfaces in accordance with the Contract Documents. Faying surfaces specified as blast-cleaned must satisfy SSPC SP-10 'Near-White Blast Cleaning.'

When painting of the slip-critical faying surface of bolted connections is required, use only the prime coat. Prepare and coat the faying surfaces prior to installation of the fasteners. Provide certification of the slip critical classification required in the Contract Documents.

Submit certification to the Engineer that galvanized faying surfaces meet or exceed a Class C slip critical classification, unless a different classification is required elsewhere in the Contract Documents. Mechanically roughen galvanized faying surfaces in accordance with the galvanizer's recommendations.

460-5.4.3 Reaming: Do not over size bolt holes by reaming (or any other method) without the approval of the Engineer.

460-5.4.4 Drifting: Do not over size, stretch or otherwise damage bolt holes by improper and excessive drifting.

460-5.4.5 Splice Plate Filler Material: Unless otherwise specified in the Contract Documents, provide filler material edges within 1/8 inch of the adjacent splice material edge. Where required for proper alignment at a bolted flange splice, additional filler material may be added provided that the total thickness of filler plates is less than 1/4 inch.

460-5.4.6 Installation of Fastener Assemblies: Unless shown otherwise in the Erection Plan, install the bolts of the connection by progressing systematically from the most rigid part of the connection to the free edges. Install bolts in all holes of the connection and bring

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them to a “snug tight” condition. Following the sequence indicated in the Erection Plan, further tighten all the bolts in the connection.

For Grade A325 bolts, obtain the required bolt tension as shown in Table 460-6, Minimum Required Fastener Tension in accordance with the turn-of-nut method specified in 460-5.4.8, or when DTIs are used, the DTI tightening method specified in 460-5.4.9.

For connections (such as large main load-carrying members or truss joints) in which previously tightened high strength bolts become loose and require retightening upon the tensioning of others, install into a minimum of ten percent of the holes fully tensioned bolts prior to final tensioning of the permanent bolts. Distribute these first bolts randomly throughout the connection. If directed by the Engineer, remove the initial bolts and install permanent bolts at each location, otherwise retighten in accordance with 460-5.3.

Table 460-6
Minimum Required Fastener Tension

Bolt Size, inch	Tension Grade A325 bolts, kips
5/8	19
3/4	28
7/8	39
1	51
1-1/8	64
1-1/4	81
1-3/8	97
1-1/2	118

460-5.4.7 Bolt Tension: Provide a Skidmore-Wilhelm Calibrator, or other equivalent bolt tension measuring device, wherever final connections are being made. Confirm the accuracy of the tension measuring device by having it calibrated by an approved testing agency once a year.

460-5.4.8 Turn-of-Nut Tightening: For each work shift, perform tests utilizing a representative sample of five fastener assemblies, from each LOT to be installed that shift. Perform the tests using the tension measuring device, following the same procedure to be used for actual installation of the fastener assemblies, to a snug-tight tension and corresponding torque, which, when the additional turns required in Table 460-7, Nut Rotation from the Snug-Tight Condition are added, will result in at least 1.05 times the minimum required fastener installation tension as shown in Table 460-6. Place a washer under the part turned in the tightening of the bolt. Consider the job inspection snug-tight torque as the average of three test values determined after rejecting the high and low-test values.

For fastener assemblies too short to fit in the tension measuring device, modify the determination of the job inspection snug-tight torque in accordance with FM 5-582.

460-5.4.8.1 Snug-Tight Condition: In the turn-of-nut method, first bring all the fastener assemblies of the connection to a “snug-tight” condition to ensure that all parts of the connection are in firm contact with each other. For the purposes of this specification, “firm contact” shall mean the condition that exists on a faying surface when the plies are solidly seated against each other, but not necessarily in continuous contact. Regard snug-tight as the tightness

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required to produce the bolt tension, which following the final applied rotation, produces at least 1.05 times the minimum required bolt tension in accordance with Table 460-6, Minimum Required Fastener Tension. In the presence of the Engineer, and on a daily basis, determine the job inspection snug-tight torque as specified herein.

460-5.4.8.2 Final Tightening: After verification of the snug-tight condition in accordance with 460-5.4.11 by the Engineer, tighten all fastener assemblies in the joint by applying the applicable amount of nut rotation specified in Table 460-7, Nut Rotation from the Snug-Tight Condition. Once snug-tight, bring all fasteners to the required tension within the same work shift.

Table 460-7
Nut Rotation from the Snug-Tight Condition

Bolt Length Measured from Underside of Head to End of Bolt	Both Faces Normal to Bolt Axis	One Face Normal to Bolt Axis and Other Face Sloped Not More than 20:1. Bevel Washer not Used.	Both Faces Sloped Not More than 20:1 from Normal to Bolt Axis. Bevel Washers not Used.
Up to and Including Four (4) Diameters	1/3 turn	1/2 turn	2/3 turn
Over Four (4) Diameters but not Exceeding Eight (8) Diameters	1/2 turn	2/3 turn	5/6 turn
Over Eight (8) Diameters but Not Exceeding Twelve (12) Diameters	2/3 turn	5/6 turn	1 turn

Notes:
1. Nut rotation is relative to the bolt, regardless of the element being turned.
2. Tolerance for bolts installed by 1/2 turn or less is ± 30 degrees. For bolts installed by 2/3 turn or more, the tolerance is ± 45 degrees.
3. Nut rotations given are only applicable to connections in which all material within the grip of the bolt is steel.
4. For bolt lengths exceeding 12 diameters, establish the required rotation by performing actual tests in a suitable tension device simulating the actual conditions. Submit procedures to the Engineer for review.

460-5.4.9 Direct-Tension-Indicator (DTI) Tightening: After complying with the requirements of 460-5.2.2, install and tighten DTI devices following the procedures described in the DTI Verification Test. Do not permit the DTI to turn during installation and tightening. Provide washers in accordance with 460-5.4.10.

460-5.4.9.1 Snug-Tight Condition: Install the bolts as specified through Step 3 (Snug-Tight Condition) of the DTI Verification test. If the 0.005 inch feeler gage is refused in more gaps than shown in the table in Step 3.5 of the test, or the DTI device becomes loose and can be spun by hand, remove the bolt and DTI device, discarding the DTI device. Provide a new DTI device and reinstall the assembly and bring to the snug-tight condition.

460-5.4.9.2 Final Tightening: After verification by the Engineer that the snug-tight condition for all bolts has been met, tighten all fastener assemblies in the joint such that the number of spaces in which the 0.005 inch thickness gauge is refused is equal to or greater than the number shown in Table 460-8, DTI Device Tightening Criteria. Once snug-tight, bring all fasteners to the required tension within the same work shift.

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Table 460-8 DTI Device Tightening Criteria						
Number of Spaces in DTI	4	5	6	7	8	9
Minimum Spaces in which Gage is Refused	2	3	3	4	4	5

Do not tighten the assembly beyond the smallest gap permitted in Step 3.5 of FM 5-583. Remove and replace bolts, discarding the DTI, which have a DTI with a smaller gap or no gap.

460-5.4.10 Washers:

460-5.4.10.1 General: Provide ASTM F436 hardened steel washers as follows:

1. For connections (and all associated testing) using Grade A490 bolts, use a hardened washer under each element.
2. For connections using Grade A325 bolts, use hardened washers under the turned element.
3. Use hardened steel washers as part of the Rotational Capacity tests.
4. Where the outer face of the bolted parts has a slope of greater than 20:1 with respect to a plane normal to the bolt axis, use a hardened, beveled washer to compensate for the lack of parallelism.
5. Where bolts are to be installed in a oversized or slotted hole in an outer ply, provide a single washer satisfying ASTM F436, or continuous bar satisfying ASTM A709: for Grade A325 bolts, provide a thickness of at least 5/16 inch; and for Grade A490 bolts, provide a thickness of 3/8 inch. Provide these washers or bars to completely cover the slot after installation. Provide a finish consistent with the bolt specified.
6. In non-Direct-Tension-Indicator (DTI) applications, clip washers on one side to a point not closer than 7/8 of the bolt diameter from the center of the washer, if necessary.

460-5.4.10.2 Use of Washers with Direct-Tension-Indicators (DTIs) Devices: When DTIs are used; use ASTM F436 hardened washers as follows:

1. When the nut is turned and the DTI is located under the bolt head, a hardened washer is to be located under the nut.
2. When the nut is turned and the DTI is located under the nut, a hardened washer is to be located between the nut and the DTI.
3. When the bolt head is turned and the DTI is located under the nut, a hardened washer is to be located under the bolt head.
4. When the bolt head is turned and the DTI is located under the bolt head, a hardened washer is to be located between the bolt head and the DTI.

460-5.4.11 Inspection:

460-5.4.11.1 Turn-of-Nut Tightening:

1. Once the snug-tight condition is achieved for all of the fastener assemblies of the connection, within 24 hours of snugging the first bolt in the connection and in the presence of the Engineer, verify for a minimum of three (3) bolts [two (2) for two bolt connections] or 10% of the fastener assemblies, that the job inspection snug-tight torque has been attained. These fasteners are to have a snug-tight torque equal to or exceeding that specified

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in 460-5.4.8. Perform this check using the same torque wrench used in 460-5.4.8. For bolts tested in accordance with FM 5-583 or when multiple torque wrenches are required, provide a calibrated torque wrench or wrenches.

2. If the tested fasteners do not obtain the job inspection snug-tight torque, test all remaining untested fastener assemblies using the torque wrench in the connection in question. Following testing of all assemblies, bring to snug-tight all assemblies and retest as stated above. Re-snug and retest as necessary using the calibrated torque wrench until the minimum testing stated above is performed favorably.

3. Following confirmation of the snug-tight condition as performed by the Contractor, and in the presence of the Engineer, match mark the fastener assemblies on the end of the bolt thread and on the nut, and then tighten the nut the amount of rotation specified in Table 460-7, Nut Rotation from the Snug-Tight Condition. The Engineer will accept the connection as fully tightened when all of the following conditions are met:

a. the rotation specified in Table 460-7 has been achieved,
b. there are no loose assemblies in the connection,
c. all plies of the connection are in firm contact,
d. there are no indications that excessive stretching or yielding has occurred in the fastener assembly,
e. bolt stick-through is consistent per LOT.

460-5.4.11.2 Direct-Tension-Indicator (DTI) Tightening: Prior to bringing the connection to a snug-tight condition, verify in the presence of the Engineer that the 'dimples' of the DTI are not deformed or damaged. Bring the connection to a snug-tight condition and tighten in accordance with the requirements of 460-5.4.9. The Engineer will accept the connection as fully tightened when all of the following conditions are met:

1. The requirements of 460-5.4.9 have been achieved,
2. There are no loose assemblies in the connection,
3. All plies of the connection are in firm contact,
4. There are no indications that excessive stretching or yielding has occurred in the fastener assembly,
5. Bolt stick-through is consistent per LOT.

460-6 Welding.

460-6.1 General: Perform all shop and field welding in accordance with the applicable AWS Welding Code. This requirement includes the use of qualified welders, qualified weld procedures, and qualified inspection personnel.

460-6.2 Welding on Non-Dynamically Loaded Elements: Perform welding on miscellaneous components and other statically (non-dynamically, non-cyclically, etc.) loaded structural elements in accordance with the AWS D1.1, Structural Welding Code, or the AASHTO/AWS D1.5, Bridge Welding Code.

460-6.3 Electroslag Welding: Perform NGI-ESW welding in accordance with the AASHTO/AWS D1.5, Bridge Welding Code.

460-6.4 Welding of Hollow Structural Steel Sections (Pipes and Tubes): Except as noted in the Contract Documents, perform all shop and field welding of Hollow Structural Shapes in accordance with the AWS D1.1, Structural Welding Code as amended herein.

460-6.4.1 Highway Sign, Lighting and Traffic Signal Support Structures: For structural steel supports for signs, lighting, and traffic signals, comply with the AWS D1.1 Structural Welding Code as amended by the following.

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Unless otherwise shown in the Plans, perform ultrasonic testing (UT) or radiographic testing (RT) on complete joint penetration welds at the following frequency (use the AWS D1.1 Tubular Connections Class R Criteria for UT and Cyclically Loaded Criteria for RT.

One hundred percent of each joint subject to tension or reversal of stress.

Twenty-five percent of each joint subject to only compression or shear. If discontinuities are found in the joint, the remainder of the joint shall be tested.

Perform Magnetic Particle Testing at the following frequencies:

A minimum of 25% of all fillet or partial penetration groove welds in main members (Use the AWS D1.1 Tubular Connections Criteria). If discontinuities are found, the remainder of the welds on the members shall be tested.

460-6.4.2 Tubular Bridge: Comply with the requirements of the AWS D1.1 Structural Welding Code as amended by the following:

Unless otherwise shown in the Plans, perform ultrasonic testing (UT) or radiographic testing (RT) on complete joint penetration welds at the following frequency (use the AWS D1.1 Tubular Connections Class R Criteria for UT and Cyclically Loaded Criteria for RT).

One hundred percent of each joint subject to tension or reversal of stress.

Twenty-five percent of each joint subject to only compression or shear. If unacceptable discontinuities are found in the joint, the remainder of the joint shall be tested.

Perform Magnetic Particle Testing at the following frequencies:

A minimum of 25% of all fillet or partial penetration groove welds in main members (Use the AWS D1.1 Tubular Connections Criteria). If unacceptable discontinuities are found, the remainder of the welds on the members shall be tested.

460-6.4.3 Overhead Sign Structures and Toll Gantries: Comply with the requirements of the AWS D1.1 Structural Welding Code as amended by the following:

Unless otherwise shown in the Plans, perform 100 percent ultrasonic testing (UT) or radiographic testing (RT) on all complete joint penetration welds.

Prior to galvanizing, perform Magnetic Particle Testing (MT) at the following frequencies:

One hundred percent of all fillet or partial penetration groove welds in the upright columns. A minimum of 25% of all other fillet or partial penetration groove welds in main members other than upright columns. If unacceptable discontinuities are found, the remainder of the welds on the member shall be tested.

After members are galvanized, perform one hundred percent MT of all fillet welds in the upright columns.

For acceptance, use AWS D1.1 Tubular Connection Criteria for MT, Tubular Connection Class R Criteria for UT, and Cyclically Loaded Criteria for RT.

460-6.5 Field Welding: Field weld only with the approval of the Engineer or as shown in the Plans. All field welding operations must be conducted in accordance with AWS D1.5 and in the presence of a Certified Welding Inspector.

460-6.6 Tack Welds: Do not weld or tack any fill plates, brackets, clips, shipping devices, or other materials not required by the Contract Documents or allowed by the AASHTO/AWS D1.5 Bridge Welding Code.

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460-7 Erection.

460-7.1 Pre-erection Requirements:

460-7.1.1 Erection Quality Control (QC) Plan: Submit an Erection QC Plan for review and approval of the Engineer.

460-7.1.2 Submittals: Meet the requirements of Sections 5 and 103 for any required submittals. Provide submittals to the Engineer for review by the Department in accordance with Section 5 and the Contract Documents.

460-7.1.3 Erection Plan: Submit, for the Engineer's review, an Erection Plan locating all primary members, lifting equipment and temporary supports or braces, and bolting pattern tightening procedures not considered routine. Ensure that the plan includes the Specialty Engineer's signature and stamp. Include supporting calculations indicating that the design unit stresses indicated in the Contract Documents have not been exceeded. Submit this plan or plans to the Engineer three weeks before erecting the piece or pieces.

Include the following information in the Erection Plan:

1. A plan of the work area showing all substructure units and foundations; surface roads and railroads; all streams, creeks and rivers; all overhead utilities; and any underground utilities that could possibly impact, or be adversely affected by, erection operations as determined by the Specialty Engineer.
2. The erection sequence for all primary load-carrying members and all primary load-carrying member bracing. Note any and all permanent or temporary support and/or bracing locations, including crane-holding positions.
3. The center of gravity locations, pick weight and delivery orientation for all primary load-carrying members.
4. Identify any bolting requirements not considered routine.
5. Locate all pick crane work points.
6. Identify all temporary works and staging areas such as barges, mats and temporary excavation support.
7. Include capacity charts on the drawings for each crane configuration and boom extension utilized.
8. Details of all temporary bracing, falsework, towers and shoring.
9. Submit any procedures requested by the Engineer and not contained in the Erection Plan.

460-7.2 Special Requirements for Uncoated Weathering Steel:

460-7.2.1 General: Do not use marking materials (grease sticks, crayons) that leave behind a residual film that may affect the weathering process of the steel. Store the girders as required for non-weathering steels.

460-7.2.2 Steel Preparations: Prior to erection, perform the following as appropriate:

Blast clean the exposed fascia of the exterior girders (both I and box) to meet SSPC-SP10 criteria; blast clean the remaining exposed surfaces of steel trapezoidal girders, not required to be prepared otherwise, to meet SSPC-SP6 criteria; for steel I-girders, if a non-uniform mill scale finish has developed, as determined by the Engineer, blast clean all remaining exposed surfaces, not required to be prepared otherwise, to SSPC-SP6 criteria; coat the inside of box members including, but not limited to, all bracing members, cross frames and diaphragms in accordance with Section 560. Coat the exterior face of box girder end diaphragms and all interior

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surfaces of box girders extending beyond the end diaphragm with an inorganic zinc coating system in accordance with Section 560.

460-7.2.3 Concrete Substructure Preparations:

460-7.2.3.1 Substructure Areas Not Receiving Class 5 Finish: Prior to erection of the girders, cover all exposed substructure concrete surfaces to protect them against staining from the weathering steel components. Leave the covering in place until after placement of the concrete deck. As directed by the Engineer, clean all visible stains on concrete in areas not receiving a Class 5 Finish by sandblasting and follow-on cleaning using a stain remover or commercial cleaner after completion of the structure in accordance with Section 400.

460-7.2.3.2 Substructure Areas Receiving a Class 5 Finish: If the Class 5 Finish is to be applied prior to the placement of the concrete deck, cover all finish concrete surfaces after application and curing of the Class 5 Finish to protect them from staining from the weathering steel components. Leave the covering in place until after placement of the concrete deck. Upon removal of the covering, reapply the Class 5 Finish to cover any stains which may be present.

If the Class 5 Finish is to be applied after placement of the concrete deck, no substructure covering will be required.

460-7.2.4 Structure and Site Clean Up: Upon the completion of construction, remove all oil, dirt, grease or other foreign material, including excessive or uneven mill scale from the steel. Remove lubricants from the exposed surfaces of installed fastener assemblies and other surfaces in accordance with the manufacturer's recommendations. Follow procedures specified in Section 560 as appropriate. Final surface finish is to be an even mill scale as approved by the Engineer.

460-7.3 Coordination with Substructure: Prior to the erection of primary load-carrying members, conduct a survey to document the vertical, longitudinal and transverse position of all substructure units and anchor rod locations. Appropriately account for ambient temperature in the survey.

Should a discrepancy be identified with the Contract Documents, submit the necessary details to the Engineer for resolution.

460-7.4 Placing Anchor Rods: Locate and place anchor rods within the tolerance shown in the Contract Documents or within 1/4 inch of the theoretical location shown. If anchor rods cannot be located to the specified tolerance, place only with the approval of the Engineer. Unless shown otherwise in the Contract Documents, provide galvanized anchor rods, nuts and washers as follows:

1. Set the anchor rods in preformed holes vertical to the plane of the bridge seat.
2. Provide 4 inch diameter holes.
3. Provide non-shrink grout/mortar of a strength greater than or equal to that of the substructure concrete strength, or as shown elsewhere in the Contract Documents.
4. Install the rods in accordance with the grout/mortar manufacturer's recommendations.
5. Clean the threads of the anchor rods as necessary without damaging the coating.

460-7.5 Preparation of Bearing Areas and Setting of Bearings: Prior to placing superstructure bearing units (including but not limited to neoprene pads and masonry plates), prepare the top of concrete pad (bearing area) in accordance with Section 400. If a discrepancy is identified, report it to the Engineer for resolution.

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For expansion bearings with slotted holes for anchor rods, which allow movement of the superstructure with respect to the substructure, vary the location of the slotted plate in relation to the anchor rods, in accordance with the prevailing temperature at the time of setting.

For fixed bearings at multiple adjacent piers, if necessary, horizontally jack the substructure units to correctly set the centerline of bearing. Adequately account for temperature.

Unless specified elsewhere in the Contract Documents, locate the theoretical centerline of bearings to within 1/16 inch transverse to longitudinal girder lines; and in the direction parallel to the longitudinal girder line locate the theoretical centerline of bearing within 1/4 inch of the theoretical centerline of bearing.

After setting the bearings and installing anchor rod nuts, washers and any other associated hardware specified in the Contract Documents, clean the protruding/exposed surfaces of the assembly of all deleterious material. Finish-coat metal parts in accordance with 460-4.3.4.9.

460-7.6 Tightening of Anchor Bolt/Rod Nuts:

460-7.6.1 Fixed and Expansion Pot Bearing: Tighten anchor bolts or rod nuts to a 'snug tight' condition such that the different mating surfaces (such as the top of concrete, neoprene and steel) are in firm contact. The nut or bolt is to be tight enough to develop friction between surfaces to prevent sliding, but not over-tightened that bulging or damage occurs in any of the mating materials.

460-7.6.2 Fixed and Expansion Bearings with Elastomeric Bearing Pads: Draw down the lower nut such that a total gap of 1/2 inch exists between the nut and bearing plate. Tighten a second nut of the same specification to a snug tight condition against the lower nut maintaining the required gap.

460-7.7 Bolted Connections: For splice connections of primary members, as well as connections of diaphragms or crossframes, fill at least 50% of the holes prior to crane release. The 50% may be either erection bolts in a snug tight condition or full size erection pins, but at least half (25% of all holes) shall be bolts, and sufficient pins shall be used near outside corners of splice plates and at member ends near splice plate edges to ensure alignment. Filled holes should be uniformly distributed between the web and flange connections for primary members such that approximately 50% of the web connections are filled and approximately 50% of the flange connections are filled. For diaphragms or cross-frames, the filled holes should be uniformly distributed between all the bolt groups connecting the diaphragm or crossframe to the primary member. The 50% requirement may be waived if a reduced percentage is calculated as sufficient and shown on the approved Erection Plan. Primary member splice connections that are made up on the ground (prior to erection) shall be 100 percent complete prior to any lifting operation. Fully tighten all bolts prior to installation of deck forming for each unit.

460-7.8 Final Position of Girder Webs: Unless shown elsewhere in the Contract Documents, detail the girders and cross frames as directed by the Engineer. The final condition is to be defined as with the deck and parapets cast, but without any future wearing surface. A web will be considered plumb if it is within a tolerance horizontally between the top and bottom of the web of 3/32 inch per foot of web depth compared against the theoretical position as required in the Contract Documents. Measure the out-of-plumb perpendicular to the face of the web. Erect trapezoidal girders to the geometry shown in the Contract Documents to the same 3/32 inch per foot of web depth tolerance.

460-7.9 Inspection and Final Acceptance:

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460-7.9.1 General: Perform Quality Control inspections of all phases of the work. The inspection frequency and depth shall be sufficient to ensure that all materials and workmanship incorporated into the work meet the requirements of the Contract Documents and that the processes are controlled to ensure that the final finished product(s) conform to the physical characteristics and dimensions required by the Contract Documents. The Quality Control Manager shall be responsible for all inspection operations. An adequate number of Quality Control Inspectors shall be available to ensure review of all materials and fabrication processes are preformed in accordance with the Producer QC Plan. Weekly meetings shall be held with the Engineer to review inspection findings. The review of this information is to identify any refinements and/or improvements in the process being utilized in the work. The frequency of the meetings may be altered by the Engineer.

460-7.9.2 Inspection/Final Acceptance: Ensure the final alignment, profile and fastening of the erected steel is in accordance with the Contract Documents.

460-8 Method of Measurement.

460-8.1 General: The quantities to be paid for will be the items covered by this Section, following acceptance by the Engineer. Partial payments may be made for fabricated components yet to be assembled into larger components, members and assemblies as allowed for elsewhere in the Contract Documents.

460-8.2 Deductions and Allowances: No deductions from the computed weight of rolled or fabricated structural steel or miscellaneous components will be made for sheared edges, punchings, holes, milling, plaining or other items of waste associated with the finished components or parts.

460-8.3 Weights of Structural Steel and Miscellaneous Materials: The weights of structural steel will be taken as nominal weights as reported in the AASHTO LRFD Bridge Construction Specifications and ASTM Specifications, in that order of precedence, using the dimensions shown in the Contract Documents.

460-8.4 Structural Steel and Miscellaneous Metals: The quantity of structural steel and miscellaneous metals becoming part of the completed structure and accepted by the Engineer will be paid for at the plan quantity shown in the Contract Documents, or as modified by the Engineer, measured in pounds, or by the Contract lump sum price for Structural Steel.

460-8.5 High-Strength Fastener Assemblies: The weight of high-strength fastener assemblies (including nuts and washers) installed by the Contractor and accepted by the Engineer will be computed on the basis of an average length in accordance with Table 460-9:

Table 460-9
Weights of High-Strength Fastener Assemblies

Diameter of High-Strength Fasteners, inch	3/4 inch	7/8 inch	1 inch	1-1/8 inches	1-1/4 inches
Weight per 100, pounds	52	100	135	182	238

The weight of high-strength fastener assemblies will be included in the determination of the weight of the completed structure in determining the quantity paid when

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payment is not by Lump Sum. The Engineer will determine values for sizes of high-strength fastener assemblies not shown.

460-8.6 Welding and Welds; Fasteners Not Designated as High-Strength; Anchor Rods, Nuts, Bolts and Associated Washers; Transporting; Handling; and Erection: Welding and welds; fastener assemblies not designated as high-strength; anchor rods, nuts, bolts and associated washers; transporting; handling; and erection are considered incidental to the work and will not be paid for separately.

460-8.7 Shims and Fill Plates: The quantity of shims and fill plates will be included in the determination of the weight of the completed structure in determining the quantity paid when payment is not by Lump Sum.

460-8.8 Coatings: The preparation, application, clean-up and the consumables used in the coatings process are considered incidental to the work and will not be paid for separately.

460-8.9 Weathering Steel Preparation, Handling and/or Clean-up: The preparation, handling, and/or clean-up of weathering steel or the “rust" marks on other items (concrete units, etc.) caused by the development of the patina are considered incidental to the work and will not be paid for separately.

460-8.10 Shear Connectors: Shear connectors are considered incidental to the work and will not be paid for separately.

460-8.11 Span Jacking (Fixed Bridge): Jacking of substructure units of adjacent fixed piers required to set bearing in accordance with the Contract Documents is considered incidental to the work and will not be paid for separately.

460-9 Basis of Payment.

460-9.1 General: Prices and payments will be for full compensation for all work specified in this Section completed and accepted, including but not limited to testing, bolting, welding, cleaning and coating, temporary works and erection. No separate payment will be made for falsework or other erection expense.

460-9.2 Payment Items: Payment will be made under:

Item No. 460- 1-	Structural Steel - Rehab - per pound.
Item No. 460- 2-	Structural Steel - New/Widening - lump sum.
Item No. 460- 6-	Ladders & Platforms - lump sum or per pound.
Item No. 460- 71-	Metal Traffic Railing - per linear foot.
Item No. 460- 81-	Rivet or High-Strength Bolt Replacement - each.
Item No. 460- 95-	Structural Steel Repair - per pound.
Item No. 460- 98-	Pipe Hanger - each.
Item No. 460-112-	Anchor Bolt Replacement - each.

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SECTION 461
MULTIROTATIONAL BEARINGS

461-1 Description.

Furnish and install multirotational bearings in accordance with the recommendations of the manufacturer and details shown in the Plans. Obtain all multirotational bearings from a fabricator that is currently on the Department's Production Facility Listing. Provide bearings on each bridge from the same manufacturer. This Section covers the following types of multirotational bearings:

1. pot bearings.
2. disc bearings.

461-2 Materials.

Provide materials in accordance with the AASHTO LRFD Bridge Design Specifications and as follows.

461-2.1 Structural Steel:

Furnish structural steel conforming to ASTM A709 Grade 50W.

461-2.2 Stainless Steel:

Furnish stainless steel conforming to ASTM A240, Type 316, 16 gage minimum thickness.

461-2.3 Metalizing Wire:

Furnish metalizing wire in accordance with ASTM B833, having an 85% zinc/15% aluminum (Z30700) composition.

461-2.4 Anchor Rods, Nuts and Washers:

Furnish galvanized anchor rods, nuts and washers in accordance with Section 962.

461-3 Design.

Design bearings in accordance with the AASHTO LRFD Bridge Design Specifications. Design bearing connections to allow for bearing replacement without having to remove the masonry plate or sole plate. Detail all steel bearing components with sliding surfaces (e.g., stainless-steel plates or PTFE plates), masonry plates and elastomeric components to be replaceable. Welded attachments are not considered a replaceable connection.

Design guided bearings for the lateral load shown in the Plans or 10% of the vertical load capacity of the bearing shown in the Plans, whichever is greater.

For disc bearings, provide steel limiting rings around the top and bottom of the polyether urethane disc except if using the following: a minimum 62 Type (Shore) D durometer disc, a shear restraint device, and surface friction between the disc and steel plates.

461-4 Shop Drawings.

Submit shop drawings in accordance with Section 5. Include design calculations, signed and sealed by a Specialty Engineer, confirming that all components are in conformance with the requirements of this Section. Include the following information on the shop drawings:

1. Items listed in AASHTO LRFD Bridge Construction Specifications Article 18.1.1.
2. The bearing manufacturer's instructions for proper installation, including the proper positioning settings for a minimum 100°F temperature range.
3. Items required in 461-6.1.

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461-5 Fabrication.

Fabricate bearings in accordance with the AASHTO LRFD Bridge Construction Specifications and the following requirements.

Shop metalize and seal all steel surfaces, except PTFE-stainless steel sliding surfaces, the insides of pots and the bottoms of pistons in accordance with SSPC-CS23.00/AWS C2.23M/NACE No. 12, “Specification for the Application of Thermal Spray Coatings (Metalizing) of Aluminum, Zinc, and Their Alloys and Composites for the Corrosion Protection of Steel”. Prepare surfaces prior to metalizing to a "near white" metal condition in accordance with SSPC-SP10 using abrasives meeting the requirements of 560-2. Achieve a sharp angular blast anchor profile meeting the requirements of ASTM D4417, Method C, 3 mils plus or minus 1 mil (75 µm plus or minus 25 µm). Provide a metalizing thickness of 10 mils minimum and 20 mils maximum. Prepare a sample coupon using the same processes used to prepare the surfaces and apply the coating to the bearing. Test the coating bond strength on the coupon in accordance with ASTM D4541. The bond strength must be a minimum of 700 psi. If the bond strength of the coating on the coupon is deficient, test the coating on the bearing. If the required bond strength is achieved, repair the coating on the bearing.

Prior to shipment, bearings shall be packaged in such a manner to ensure that during shipment and storage the bearings will be protected against damage from handling, weather, or any normal hazard. Secure bearing assemblies in the fabrication plant with temporary metal bolts or straps to avoid separation during transport and installation.

461-6 Testing and Certification.

461-6.1 General:

Test the materials used to fabricate the bearings and the completed bearings themselves in accordance with the AASHTO LRFD Bridge Construction Specifications. Submit all test results including visual documentation of the bearing both during testing and upon disassembly after testing to the Engineer.

461-6.2 Long-Term Proof Load Test: Conduct long-term proof load testing on full-size bearings on a per LOT basis using the reactions, rotations and movements shown in the Plans for each type of bearing.

461-6.3 Long-Term Deterioration Test: Long-term deterioration testing requirements will be considered satisfied by either of the following:

1. Testing of full-size bearings on a per LOT basis.
2. Prequalification in accordance with Materials Manual Chapter 11.1. The capacity of successfully tested bearings must be within 25% of the required demand specified in the Plans (reactions and resultant compressive stresses, rotations, and movements) for prequalification testing to be considered satisfied for a project. Test results for bearings of a given type and configuration are valid for five years from the original date of testing.

Production bearings must be manufactured using the same materials, methods, and quality control procedures as those used for testing.

461-7 Installation.

Store multirotational bearings delivered to the bridge site under cover on a platform above the ground surface. Protect bearings at all times from damage and ensure they are clean, dry and free from dirt, oil, grease or other foreign substances before placement. Install the bearings in accordance with the recommendations of the manufacturer, contract drawings, and as may be directed by the Engineer. If there is any discrepancy between the recommendations of the

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manufacturer, these Specifications, and Contract Drawings, the Engineer will be the sole judge in reconciling any such discrepancy.

Obtain the services of a qualified technical representative, employed by the manufacturer of the bearings, to supervise the first installation of each type of bearing (expansion pot, fixed pot, expansion disc, fixed disc or other type as defined by the Engineer) but for only one size of each type. Submit to the Engineer a certified statement from the manufacturer that its representative has the necessary technical experience and knowledge to supervise bearing installations and to train Contractor personnel about proper bearing installation procedures and methods. Do not install the bearings before the Engineer receives the certification and the representative is on the job site. Assume this responsibility at no further expense to the Department.

Perform any required touchup repair and field metalizing as directed by the Engineer.

461-8 Method of Measurement.

Quantities for fixed and expansion bearings will be the plan quantity number of each type of bearing constructed and accepted.

461-9 Basis of Payment.

461-9.1 Basic Items of Bearings: The Contract unit price per each for bearings will be full compensation for all work and materials necessary for the complete installation. Such price and payment will include, but not limited to, the following specific incidental items:

1. testing,
2. tools and equipment required for installation,
3. any work to replace rejected bearings,
4. any repairs to the metalized coating on the bearings,
5. all costs associated with the manufacturer's installation technician,
6. sole plate, masonry plate, high strength bolt assemblies, and anchor rod assemblies.

461-9.2 Payment Items:

Payment will be made under:

Item No. 461-113- Multirotational Bearing Assembly - Fixed - each.

Item No. 461-114- Multirotational Bearing Assembly - Expansion - each.

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SECTION 462
POST-TENSIONING

462-1 Description.

1. Furnish, test, transport, store, handle, and install all components of Post-Tensioning (PT) systems, in accordance with the requirements of this Section and the component manufacturer's recommendations. Constituent components of PT systems include, but are not limited to, anchorage assemblies, filler containment assemblies, filler material, and related steel reinforcement. Use the most stringent requirements, as determined by the Engineer, of those specified in this Section or the component manufacturer's recommendations for protecting components from damage due to environmental exposure, improper handling, or improper installation.

2. With the exception of mild reinforcing and prestressing steel, furnish all PT system components from a single supplier (vendor).

3. Submit PT system shop drawings in accordance with Section 5. Perform PT system testing in accordance with Section 960. Include in the PT system testing all possible combinations of components to be incorporated into the structure.

4. Use only PT systems meeting the requirements of Section 960 and approved by the Engineer in accordance with Section 5.

a. Use only PT systems of appropriate type and size required to construct tendons shown in the Contract Documents.

b. Use only the exact manufacturer and/or model of major components, as defined in 960-2, that were used in system testing and as listed on the approved PT system shop drawings.

c. With the exception of local zone reinforcement, do not substitute, modify, or delete any major components, as defined in 960-2, of a PT system approved by the Engineer for use on the project.

5. Provide a mockup test in accordance with this Section. PT system acceptance testing may be performed concurrent with mockup testing if performed prior to installation of any PT system hardware.

6. Just prior to PT tendon installation, blow oil-free dry compressed air meeting ASTM D4285 through the duct. Provide visual confirmation that the duct is free of water and moisture.

7. Install the PT tendon (e.g., strands, wires, or bars) in duct. Stress the PT tendon to a predetermined load, anchor ends directly against hardened concrete and install permanent anchorage caps.

8. Just prior to wax filler injection, blow oil-free dry compressed air meeting ASTM D4285 through the duct. Provide visual confirmation that the duct and tendon are free of water and moisture.

9. Inject ducts with filler to completely fill voids and install protection at anchorages.

10. Submit all required documents in accordance with this Section and Section 5 to the Engineer for review and written approval.

11. Arches, cable supported and extradosed bridges are not covered by this Specification.

12. Install duct filler. Provide fully filled duct and anchorage assemblies free from leaks, blockages, and voids. Submit test data to the Engineer to verify that the work meets the requirements of this Section. Perform filler injection operations in accordance with 462-7.4.

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462-2 Materials.

462-2.1 General:

Approval of any material by the Engineer will not preclude subsequent rejection if material is damaged or otherwise found to not meet the requirements of this Section or Section 960.

462-2.2 Steel Reinforcing:

462-2.2.1 Mild Steel:

1. Provide reinforcing steel per Section 931.
2. Final design and details of local zone reinforcement are system specific and are the responsibility of PT system supplier (vendor). Design system specific local zone reinforcement for the number of strands or wires a particular PT system can accommodate at maximum allowable strand or wire force; do not design project specific local zone reinforcement for a reduced system capacity.
3. Submit signed and sealed project specific local zone reinforcement details to the Engineer for review and written approval.

462-2.2.2 Prestressing:

462-2.2.2.1 Strand:

1. Provide prestressing strands per Section 960.
2. Strand couplers are not permitted.

462-2.2.2.2 Bar:

1. Provide prestressing bars per Section 960.
2. For permanent applications, use and location of bar couplers is subject to written approval by the Engineer.

462-2.2.2.3 Parallel Wire:

1. Provide prestressing parallel wire assemblies per Section 960.
2. Wire couplers are not permitted.

462-2.3 Duct Filler: Use only grout and flexible filler meeting the requirements of Section 938 and are listed on the Department's Approved Product List (APL).

462-2.3.1 Grout:

1. Select grout for use in PT system by application: repair, horizontal, or vertical.
2. Mix grout per manufacturer's instructions with potable water meeting requirements of Section 923.
3. Do not combine different grout products.

462-2.3.2 Flexible Filler: Prepare flexible filler for installation in accordance with the manufacturer's instructions. Do not combine different flexible filler products.

462-2.4 Other Material References:

Meet the requirements of this Section, as well as the following:

Class 5 Applied Coating*	Section 975
Elastomeric Coating System*	Section 975
Epoxy Compound*	Section 926
Magnesium Ammonium Phosphate Concrete*	Section 930
Methacrylate*	Section 413
Water	Section 923

*Use products listed on the Department's Approved Product List (APL).

462-2.5 Component Samples:

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462-2.5.1 Prestressing Steel:

1. Furnish samples per Section 933 from each manufacturer of prestressing strand, wire, and bar to be used on project.

2. The Engineer will collect sample materials from prestressing steel used for PT operations on the Project.

3. Samples, properly identified and tagged per 462-6, will be stored by the Engineer.

462-2.5.2 Grout:

1. The Engineer may sample grout packages at random, not to exceed a total quantity of one bag per LOT or shipment. A LOT is defined as a quantity of material from a single production batch or shipment

2. Grout sample may be virgin package mix, liquefied state, or solid state; Engineer will determine at what frequency, interval, sample phase (powder, liquid or solid) and location those samples will be recovered from the project.

3. Sample, properly identified and tagged per 462-6, will be stored by the Engineer.

4. Submit the following samples from each manufacturer per each production LOT of grout to be used on the project. These samples will be used by the State Materials Office for product testing.

a) Submit three 2” x2” x2” hardened grout cube samples from a trial batch using the same water source and grout to be used for production grouting.

b) One bag of grout.

Submit samples a minimum of four weeks prior to initial production grouting. Do not commence grouting operations until grout test results are available and approved by the Engineer. Mock-up testing per section 462-7.4.1.1 (5) may proceed prior to grout approval.

462-2.5.3 Flexible Filler:

1. The Engineer may sample flexible filler at random, not to exceed a total quantity of one gallon per LOT. A LOT is defined as a quantity of material from a single production batch or shipment not to exceed 1,000 gallons.

2. Sample may be virgin product in liquefied state or solid state. The Engineer will determine at what frequency, interval, sample phase (liquid or solid) and location those samples will be recovered from the project.

3. Sample, properly identified and tagged per 462-6, will be stored by the Engineer.

462-3 Alternate PT System Designs.

Designs using a PT scheme different from that shown in the Contract Documents may be submitted for the Engineer’s approval provided proposed scheme fulfills the design requirements, and the Contractor demonstrates compliance with these requirements:

1. PT system type and size meets all requirements of this Section.

2. Net compressive stress in the concrete after all prestress losses is equivalent to or greater than that provided by the PT scheme shown in original Contract Documents.

3. Distribution of individual tendons at each cross section generally conform to the distribution shown in original Contract Documents.

4. Proposed PT scheme meets the ultimate strength requirements of the American Association of State Highway and Transportation Officials Load and Resistance Factor Design,

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AASHTO LRFD Bridge Design Specifications Section 5, and is equivalent to or greater than service and strength limit states provided in original Contract Documents.

5. Stresses in concrete and PT steel at all sections and at all stages of construction meet requirements of the Design Criteria shown in original Contract Documents.

6. All Design Criteria provisions noted in original Contract Documents are satisfied.

7. Show complete design and detail of all elements for proposed locations of alternate PT scheme.

8. Submit the following for the Engineer's approval:

a. design calculations including short and long term prestress losses

b. complete shop drawings including PT scheme and system, reinforcing steel, and concrete cover

9. Any alternate PT system approved by the Engineer resulting in a change in quantity from that shown in the Contract Documents is paid based on comparison of the following:

a. quantity actually used and accepted or original plan quantity, whichever is less, and

b. unit bid price.

If approved alternate PT scheme or system is under a Cost Savings Initiative Proposal (CSIP), method of payment will be in compliance with CSIP agreement.

10. Submit alternate PT scheme signed and sealed by the Contractor's Engineer of Record.

462-4 Qualifications.

Provide all project personnel and crew foreman in accordance with Section 105.

462-5 Submittals.

1. Submit to the Engineer all necessary information, Plans, shop and working drawings, and manuals in accordance with this Section and Section 5. Submit to the Engineer signed and sealed PT related shop drawings designed by the Contractor's Engineer of Record.

2. Prepare shop drawings addressing all requirements stated in the Contract Documents and requirements of this Section. Show details of PT hardware components, tendon geometry and locations complying with the Contract Documents and limitations of selected PT system. Include all inlets, outlets, high point inspection port details, anchorage inspection details, permanent anchorage caps, protection system materials, and application limits. If applicable, include details of the duct dehumidification system.

462-6 Transport, Handling and Storage.

462-6.1 General:

Store all materials in a weatherproof building, shed, covering, or container until time of use.

462-6.2 LOT Identification:

1. Assign an individual LOT number and tag items shipped to project in a manner that allows each LOT to be clearly identified at project site for all PT system components, filler, bars of each size from each mill heat of steel, and all strands from each manufactured reel.

2. Submit records to the Engineer identifying assigned LOT numbers with heat or reel of material represented if applicable.

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3. All unidentified prestressing components, strands, wires, bars, or filler received at the site will be rejected.

4. Loss of positive identification of these items at any time will be cause for rejection.

5. Submit filler Quality Control Data Sheets from the manufacturer, to the Engineer for each LOT of filler on the project.

462-6.3 Prestressing Steel:

1. Protect all prestressing steel against physical damage and corrosion at all times.

a. Package prestressing steel in containers for protection against physical damage and corrosion during shipping and storage.

b. Place a corrosion inhibitor, which prevents rust, in package or incorporate it into a corrosion inhibitor carrier type packaging material.

c. Corrosion inhibitor must have no deleterious effect on steel, filler, concrete, or bond strength of steel to concrete.

d. Inhibitor carrier type packaging material must conform to provisions of Federal Specification MIL-P-3420.

e. Immediately replace or restore damaged packaging to original condition.

f. Clearly mark shipping package with a statement that package contains high-strength prestressing steel, care to be used in handling, include type, kind, and amount of corrosion inhibitor used, date when placed, safety orders, and instructions for use.

2. The Engineer will reject prestressing steel that has sustained physical damage.

3. Remove and discard lengths of strand found to contain broken wires.

4. Wire must be bright and uniformly colored, with no foreign matter or pitting on its surface.

462-6.4 Filler:

1. Maintain filler in environmental exposure conditions (e.g., temperature, humidity) in strict conformance with manufacturer's recommendations at all times from manufacture to installation.

2. Storage in the open must be on a raised platform with adequate waterproof covering to protect the filler.

3. On site storage of grout filler on a raised and covered platform is limited to a maximum period of one week. The allowable on site storage time may be extended by the Engineer if the grout filler is in a climate-controlled structure. Grout filler material with a total time from manufacturer in excess of six months must be removed from the jobsite and replaced with new material.

4. Flexible filler may be stored on site on a raised and covered platform up to the manufacturer's expiration date. Do not use flexible filler that has exceeded the manufacturer's recommended usage date. Remove all such filler from the jobsite and replace with new material.

462-6.5 Duct and Pipe:

1. Protect ducts against ultraviolet degradation, crushing, excessive bending, dirt contamination, corrosive elements, or any other damage or contamination during transport, storage, and handling.

2. Furnish ducts with end caps to prevent contamination inside duct. Do not remove duct end caps until duct is incorporated into the bridge component.

3. Ship capped duct in bundles that are covered during transport and storage.

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4. Store on a raised platform and completely covered to prevent contamination.

5. If contamination is discovered, immediately flush duct with potable water per 462-7.2.4 before use.

462-7 Construction.

462-7.1 General:

1. Prior to installing any PT system hardware:

a. Submit to the Engineer a list of all PT systems chosen for the project.

b. For each PT system, submit a package to the Engineer meeting the requirements of Section 960-3.6.

c. For each PT system, submit to the Engineer written certification that all major components, as defined in 960-2, furnished to the project and shown on the approved PT system shop drawings exactly match the major components used in PT system testing.

2. Use methods to place and consolidate concrete that will not displace or damage any PT ducts, anchorage assemblies, splices and connections, reinforcement, or other embedded items.

3. Conduct all stressing and filler injection operations in the presence of the Engineer.

462-7.2 System Installation:

Accurately and securely fasten all PT anchorages, ducts, inlet and outlet pipes, miscellaneous hardware, reinforcing bars, and other embedded items at locations shown in the Contract Documents or on approved shop or working drawings or as otherwise approved by the Engineer in writing.

If the anchorage caps will be fastened to the anchorage bearing plates, install the anchorages such that the top and bottom holes of the anchorage cap will form a vertical axis oriented 90 degrees from horizontal as required by 462-7.3.3.2.

462-7.2.1 Ducts:

1. Construct tendon ducts using the minimum number of splices as practical.

2. Accurately position and align ducts at locations shown in the Contract Documents, or according to approved shop or working drawings, or as approved in writing by the Engineer.

3. Securely fasten all internal ducts at regular intervals not exceeding 30 inches for steel pipes, 24 inches for round plastic ducts, and 12 inches for flat ducts to prevent movement, displacement, or damage from concrete placement and consolidation operations.

4. Show method and spacing of duct supports on appropriate shop drawings.

5. Ensure external tendon ducts are straight between connections to internal ducts at anchorages, diaphragms, and deviation saddles and are supported at intermediate locations according to the Contract Documents including approved shop drawings.

6. Ensure all alignments, including curves and straight portions, are smooth and continuous with no lips, kinks, or dents. This also applies to curves in pre-bent steel pipe.

7. Check and repair all ducts in accordance with 462-7.5 as necessary before placing any concrete.

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8. Ensure ducts at end connections to anchorages, splices, inlets, outlets, drains, and all other duct openings are sealed at all times after installing ducts and until tendon installation is complete.

9. Provide an absolute seal of anchorage and duct termination locations per the approved system drawings.

10. Use of tape, caulking, epoxy or other sealants is not permitted to make connections or sealing for any reason.

11. Use heat welding techniques, in accordance with duct manufacturer's instructions, to make splices between sections of smooth plastic duct or make connection with electrofusion duct coupler as shown on the approved PT system shop drawings.

12. When connecting steel pipe to plastic pipe with a boot, use a 3/8 inches wide power seated band and clamps in accordance with 960-2.2 on each end of a duct boot to seal against filler leakage. Install band per manufacturer's instructions.

13. Ducts for prestressing used exclusively for temporary erection where PT will be removed from structure are not required to be coupled across segment joints.

14. Briefly open low point drains to allow for drainage of any water that may be present within the duct.

462-7.2.1.1 Installation Tolerances:

1. Ensure final position of PT ducts is within the tolerances in the following table:

Table 462-1
Duct Installation Tolerances

Type	Vertical Position (inches)	Horizontal Position (inches)
Horizontal tendons in slabs or in slab regions of larger members	±1/4	±1/2
Longitudinal draped superstructure tendons in webs: Tendon over supports or in middle third of span	±1/4	±1/4
Tendon in middle half of web depth	±1/2	±1/4
Longitudinal, generally horizontal, superstructure tendons usually in top or bottom of member	±1/4	±1/4
Horizontal tendons in substructures and foundations	±1/2	±1/2
Vertical tendons in web	Longitudinal Position ±1	Transverse Position ±1/4
Vertical tendons in pier shafts	±1/2	±1/4
All other cases	±1/4	±1/4

2. Ensure entrance and exit angles of tendon paths at anchorages, duct joints, and/or at faces of concrete are within plus or minus 3 degrees of desired angle measured in any direction.

3. Accomplish any deviations in alignment with smooth unkinked transitions.

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4. Locate anchorages within plus or minus 1/4 inch of desired position laterally and plus or minus 1 inch along tendon except that minimum cover requirements must be maintained.

5. Position local zone anchorage confinement reinforcement in the form of spirals, multiple U-shaped bars, or links centered around duct and anchorage (±1/4 inch tolerance) and starting within 1/2 inch of the back of the main anchorage plate.

6. If conflicts exist between reinforcement and a PT duct/anchorage and other non-local zone reinforcement, the position of duct prevails. Adjust the non-local zone reinforcement with the Engineer's written approval.

462-7.2.2 Splices and Joints:

1. All splices, joints, couplings, connections (inlet and outlet), and valves are part of approved PT system.

2. Fabricate all duct splices to prevent duct kinks during concrete placement.

3. Use mandrels as needed to maintain duct alignment and shape.

462-7.2.3 Inlets, Outlets, Drains and Ports:

1. Place filler inlets, outlets, drains and ports at locations shown in the Contract Documents including approved shop drawings.

2. Equip all filler inlets, outlets, drains and ports with approved positive shut-off devices (e.g., valves).

3. At a minimum, place filler inlets, outlets or ports in the following positions and those shown in Standard Plans, Index 462-001:

a. Top of tendon anchorage;

b. Top and bottom of anchorage cap;

c. At high points of duct profile when vertical distance between highest and lowest point is more than 2 feet;

d. At major change in duct cross section; and,

e. At other locations required by the Engineer.

4. For all tendons other than grouted top slab transverse tendons in box girders, place drains at the geometric low points of all duct profiles, or as close as is practical to the geometric low points of all duct profiles, except where an inlet, outlet or anchorage that can serve as a drain is located at a low point. Locate drains, and inlets and outlets serving as drains, at the bottom of the duct cross section. Do not locate drains within the limits of diabolos.

5. Extend filler and drain tubes a sufficient distance out of concrete member to allow for proper closing of valves.

6. Direct inlets, outlets, drains and ports exiting on vertical or predominantly vertical surfaces of box and I-girders toward the inside face of exterior I-girders or toward the interior of box girders.

462-7.2.4 Tendons:

1. Store the PT tendon in such a way that it remains completely dry and free of moisture prior to installation within the duct.

2. Do not exceed 14 calendar days between first installation of PT strand within duct and completion of the stressing and filler injection operation.

3. Do not exceed 21 calendar days between the first installation of PT bars within duct and completion of the stressing and filler injection operations.

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4. With written approval of the Engineer, the maximum number of calendars days allowed between the first installation of the PT tendon within the duct and completion of the stressing and filler injection operations is 30 for PT strand and 45 for PT bars by monitoring and continuously maintaining the relative humidity of air within the duct below 40%. Use a closed dehumidification system or other means approved by the Engineer. The dehumidification system must be installed and operational within 24 hours of first installation of the PT tendon within the duct and remain operational until just prior to filler injection.

5. The use of temporary corrosion inhibitor powder is not permitted as a method to increase the allowed number of calendar days between the first installation of the PT tendon within the duct and completion of the stressing and filler injection operations.

6. Any light surface corrosion forming during the period of time described in (1), (2), (3) or (4) of this Article will not be cause for rejection of the PT tendon.

7. Failure to inject filler into duct within the number of calendar days specified, will result in stoppage of work, except when waived by the Engineer in writing.

8. Just prior to PT tendon installation, briefly open low point drains to allow for drainage of any water that may be present within the duct. Close all low point drains and ports except the inlet and outlet ports at the anchorage caps. Blow oil-free dry compressed air meeting ASTM D4285 through one of the anchorage cap ports until the relative humidity measured at the inlet and outlet ends are less than 40% and continuing blowing for an additional 30 minutes. Stop blowing, wait a minimum of 15 minutes, and take humidity measurements at the inlet and outlet ends of blowing. Further blowing is not required if both humidity readings are less than 40%. If the humidity readings are 40% or greater, then repeat the process of blowing and waiting for 15 minutes until the humidity measurements at the inlet and outlet end of blowing are less than 40%. Take humidity measurements of air within the duct at the inlet end and outlet end of blowing using separate humidity meters. Use humidity meters approved by the Engineer.

9. Provide visual confirmation that the duct is free of water, moisture, and debris at the anchorages and low points of the tendon profile before installing the PT tendon within the duct.

10. Flushing of filler is not permitted without written approval of the Engineer and is only permitted as defined in this Article.

11. For grouted operations, vacuum injection is required to repair all voids and blockages as subject to provisions of 462-8.3.2. For flexible filler operations, use the repair procedure described in the approved Wax Injection Operations Plan.

12. For tendon ducts subjected to contamination with chlorides (e.g., uncapped ducts that have been subjected to salt spray), flush duct with potable water containing slack lime (i.e., calcium hydroxide) or quicklime (i.e., calcium oxide) in the amount of 0.17 pounds per gallon.

a. Test for presence of chlorides and oils in discharged water before placing tendon.

b. If chloride levels in flush water outflow exceed 300 ppm, continue to flush duct until chloride level in flush water outflow is below 250 ppm.

c. After the chloride level of flush water is below 250 ppm, open low point drains to allow for drainage of flush water within the duct. Perform the blowing process described in (8) of this Article. Provide visual confirmation that the duct is free of water and moisture for its entire length before installing the PT tendon within the duct.

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13. Push or pull strands and wires through ducts to make up a tendon using methods that will not snag on any lips or joints in ducts.

14. Round off end of strands and wires that are pushed or fit advancing end with smooth protective cap.

15. Do not intentionally rotate strands or wires by any mechanical means during installation of PT strand into duct.

16. For superstructure tendons, provide sufficient strand and wire length beyond dead end anchorages to allow for second end stressing as needed for reconciliation of jacking force versus measured elongation.

17. Alternatively, tendons may be pulled through duct using a special steel wire sock or other device attached to advancing end. Strands may be brazed together for pulling as long as one foot of strand from the brazed end is removed by cutting after installation. Do not electric arc weld strand ends together for this purpose.

18. Cut tendons in accordance with 462-7.3.2.7.

19. Strand installation aids (i.e. wire/nylon ties around strand bundle, strand spacers, etc.) must be removed prior to stressing

20. Do not install permanent tendons before completion of testing as required by this Section or the Contract Documents. The only two exceptions are:

a. Tendon to be tested by “Theoretical Elongation Verification” may be installed for test; and,

b. Transverse tendons may be pre-installed in precast segmental boxes prior to concrete casting such that they meet 462-8.3.1.

462-7.3 Post-Tensioning Operations:

1. Do not apply PT forces until concrete has attained compressive strength specified in the Contract Documents.

2. Conduct all stressing operations in presence of the Engineer.

3. With the written approval of the Engineer, revise PT operations so final tendon force is in agreement with the Contract Documents.

462-7.3.1 Stressing Equipment:

Only use equipment furnished by supplier of PT system.

462-7.3.1.1 Jacks and Gauges:

Equip each jack with pressure gauge for determining jacking pressure that has a minimum dial diameter of six inches.

462-7.3.1.2 Calibration:

1. Calibrate each jack and its gauges as a unit.

2. Calibration must consist of three test cycles with cylinder extension of jack in various positions (e.g., two-inch, four-inch, eight-inch stroke).

3. At each pressure increment, average forces from each test cycle to obtain an average force.

4. Perform calibration with equipment (e.g., jack, pump, hoses, etc.) setup in same configuration intended for use on Project.

5. Jack and gauge calibration is to be initially performed by PT supplier or an independent laboratory.

6. Use load cells calibrated within the past 12 months to calibrate stressing equipment.

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7. Supply documentation denoting the load cells calibration date and tractability to National Institute of Standards and Technology (NIST) along with jack/gauge calibration.

8. Submit to the Engineer certified calibration charts and curves for each jack and gauge unit used on the project prior to start of work and every six months thereafter or as requested by the Engineer.

9. Calibrations subsequent to initial calibration with a load cell may be accomplished with use of a master gauge. Supply master gauge to the Engineer in a protective waterproof container capable of protecting calibration of gauge during shipment to a laboratory. Provide a quick-attach hydraulic manifold to enable quick and easy installation of master gauge to verify permanent readings. Master gauge will remain in the possession of the Engineer for duration of project and will be returned to the Contractor after final acceptance of project by the Engineer.

10. Any jack repair, such as replacing seals or changing length of hydraulic lines, requires recalibration using a load cell.

11. No extra compensation will be allowed for initial or any subsequent calibrations or use of master gauge required by the Engineer.

462-7.3.2 Stressing Tendons:

1. Tension all PT steel so PT force is not less than that required by the Contract Documents or as otherwise approved by the Engineer in writing.

2. Do not use monostrand jacks to stress straight tendons with five or more strands or wires, or for curved tendons with two or more strands or wires.

3. 4-strand curved top slab transverse tendons in box girders are permitted to use a monostrand jack.

4. Use of curved stressing noses or chairs is not permitted.

5. If the anchorage caps will be fastened to the wedge plates, maintain the position of both the stressing end and dead end wedge plates throughout the jacking process such that the top and bottom holes of the anchorage cap will form a vertical axis oriented 90 degrees from horizontal as required by 462-7.3.3.2.

462-7.3.2.1 Jacking Maximum Stress:

Maximum temporary stress (i.e., jacking stress) in PT steel must not exceed 80% and 75% of Guaranteed Ultimate Tensile Strength (GUTS) for PT strands and bars, respectively. The maximum temporary jacking stress must not exceed 50% of GUTS for PT bars that will be reused.

462-7.3.2.2 Initial and Permanent Stresses:

1. PT steel must be anchored at initial stresses resulting in long term retention of permanent stresses or forces of no less than those shown in the Contract Documents.

2. Unless otherwise approved by the Engineer in writing, initial stress after anchor set must not exceed 70% of GUTS at anchorages and 74% of GUTS at all other locations between anchorages.

3. Permanent stress and permanent force are stress and force remaining in PT steel after all losses, including long term creep and shrinkage of concrete, elastic shortening of concrete, relaxation of steel, losses in PT steel from sequence of stressing, friction, and unintended wobble of ducts, anchor set, friction in anchorages, and all other losses particular to the specific PT system.

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462-7.3.2.3 Stressing Sequence:

1. Permanent PT tendons must be stressed from both ends, except as noted in the Contract Documents.

2. Required force may be applied at one end and subsequently at other end or simultaneously at both ends.

462-7.3.2.4 Elongation:

1. Ensure forces being applied to tendon and resulting elongation of tendon can be measured at all times.

2. Measure elongations to nearest 1/16 inch.

3. For required tendon force, observed elongation must agree within 7% of theoretical elongation or entire operation must be halted, checked, and source of error determined and remedied to satisfaction of the Engineer before proceeding.

4. Do not overstress tendon to achieve theoretical elongation.

5. If agreement between observed and theoretical elongations at the required force falls outside acceptable tolerances, additional tests may be required, at the Engineer's discretion and without additional compensation to the Contractor, for Tendon Modulus of Elasticity and/or In Place Wobble and Friction Test, or Lift-Off Test.

462-7.3.2.5 Friction:

1. Provide actual expected friction and wobble coefficients and anchor set in the shop drawings; submit calculations and show a typical tendon force diagram on shop drawings based upon expected actual coefficients and values for the PT system to be used.

2. Graphite may be used as a lubricant when friction must be reduced, subject to written approval of the Engineer.

462-7.3.2.6 Tendon Wire Failure:

1. Multi-strand PT tendons with wires which fail by breaking or slipping during stressing may be accepted provided these conditions are met:

a. Completed structure has a final PT force of at least 98% of original total design PT force;

b. PT force across a mating joint is at least 98% of PT force required by the Contract Documents for that mating joint for that stage of construction for precast or cast-in-place segmental construction. This 98% minimum PT force requirement applies to segmental construction, or any similar construction, that has members post-tensioned together across a common joint face at any stage of construction; and,

c. Any single tendon must have no more than a 5% reduction in cross-sectional area of PT steel due to wire failure.

2. When conditions permit the Contractor to propose acceptable alternative means of restoring PT force lost due to wire failure, any of the above conditions may be waived at discretion of and with approval of the Engineer in writing.

462-7.3.2.7 Cutting of PT Steel:

1. Cut PT steel using an abrasive saw or plasma torch within 3/4 inches to 1-1/2 inches away from the anchorage.

2. Flame cutting of PT steel is not permitted.

3. Do not cut tendon to final length prior to acceptance.

462-7.3.2.8 Post-Tensioning Operations Record:

1. Keep a record of these PT operations for each tendon installed:

a. Project name, Financial Project ID (FPID);

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b. Contractor and/or subcontractor;
c. Tendon location, size, and type;
d. Date tendon was first installed in duct;
e. Reel number for strands and wires and heat number for bars;
f. Tendon cross-sectional area;
g. Modulus of elasticity;
h. Date stressed;
i. Jack and Gauge numbers per tendon end;
j. Required jacking force;
k. Gauge pressures at the pump and at the inlet;
l. Elongations (theoretical and actual);
m. Anchor sets (anticipated and actual);
n. Stressing sequence (i.e., sequential order of tendon stressing by number);
o. Stressing mode (single-end, dual-end, simultaneous);
p. Witnesses to stressing operations (Contractor and Inspector);
q. Any other relevant information.

2. Submit to the Engineer a complete set of stressing operation records within five days of completed tendon installation.

462-7.3.3 System Protection:

462-7.3.3.1 Tendon:

1. Seal all other duct openings other than installing anchorage caps within four hours after tendon stressing.

2. Install anchorage caps after tendon has been accepted. If acceptance of tendon will be delayed more than four hours after stressing, immediately provide temporary weatherproofing of tendons at open ends of anchorages. If tendons and anchorages are temporarily weatherproofed, install anchorage caps within 1 day of tendon being accepted.

3. If tendon contamination occurs and if directed by the Engineer, remove tendon, flush duct with potable water per 462-7.2.4, and replace with new tendon.

462-7.3.3.2 Anchorage:

1. Install the anchorage cap such that the top and bottom holes form a vertical axis oriented 90 degrees from horizontal.

2. Provide the following at anchorages as shown on Standard Plans, Index 462-002:

a. Temporary drain holes at the bottom of open top blockouts.

b. Temporary weatherproof plugs for upwardly oriented access or vent holes.

3. Cap all filler inlets/outlets with plugs meeting the requirements of Section 960.

4. Construct anchorage pour-backs and place elastomeric coatings at anchorages as indicated in the Contract Documents and as shown on Standard Plans, Index 462-002 within seven days of completing filler injection operations (see 462-7.4 for filler injection operations). For anchorages which require acrylic aliphatic polyurethane top coating,

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apply the acrylic aliphatic polyurethane top coating after the elastomeric coating has fully cured. See Standard Plans Index 462-002 and the Contract Documents for details on anchorages which require acrylic aliphatic polyurethane top coating. Construct anchorage pour-backs using reinforced concrete, magnesium ammonium phosphate concrete, or a Type Q epoxy grout meeting the requirements of Section 926.

a. Remove all laitance, grease, curing compounds, surface treatments, coatings, and oils by grit blasting or water blasting. Flush surface with water and blow dry. Surfaces must be clean, sound, and without any standing water. Test substrate at all pour-back locations using ACI 503 and develop a minimum of 175 psi tension (e.g., pull-off value). Testing frequency may be reduced, as determined by the Engineer, after the Contractor has demonstrated an ability to prepare substrate surfaces for bonding as indicated by the result of the ACI 503 test.

b. Mix and apply epoxy grout and magnesium ammonium phosphate concrete in accordance with the manufacturer's current standard technical guidelines. Construct all pour-backs in leak proof forms creating neat lines. Epoxy grout may require pumping for proper installation. Construct forms to maintain a liquid head to ensure intimate contact with concrete surface. Use vents as needed to provide for escape of air to ensure complete filling of forms.

5. Coat exposed surfaces of pour-backs and anchorage caps as shown on Standard Plans, Index 462-002 with an elastomeric coating system meeting the requirements of Section 975 and having a thickness of 30 mils to 45 mils. Apply the acrylic aliphatic polyurethane top coating to a dry film thickness of 5 to 6 mils. Ensure concrete, anchorage caps, or other substrates are structurally sound, clean, and dry. Concrete must be a minimum of 28 days old. Remove all laitance, grease, curing compounds, surface treatments, coatings, and oils by grit blasting or water blasting using a minimum 3,000 psi nozzle pressure. Blow surface with compressed air to remove dust or water. Apply the elastomeric coating within 90 days of filler injection. Apply the acrylic aliphatic polyurethane top coat and the manufacturer's approved primer over the elastomeric coating before applying Class 5 coating, if required.

6. Prior to application of elastomeric coating, construct a 2 foot x 4 foot concrete test block with a similar surface texture to surfaces to be coated. Coat a vertical face with chosen elastomeric coating system. Determine number of coats required to achieve the specified thickness without runs and drips. Mix and apply elastomeric coating as per manufacturer's current standard technical specifications. Spray application is preferred; roller application is permitted. Have coating manufacturer representative on site to supervise and comment on application of elastomeric coating onto test block. Apply coating using approved and experienced personnel with a minimum of three years experience applying similar polyurethane systems. Submit credentials of these persons to the Engineer for review and consideration for approval.

462-7.4 Filler Injection Operations:

462-7.4.1 Grouting Operations: Conduct all grouting operations in the presence of the Engineer.

462-7.4.1.1 Grout Injection Operations Plan:

1. Submit a Grouting Operations Plan to the Engineer for approval at least six weeks in advance of any scheduled grouting operation.

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2. Written approval of Grouting Operations Plan by the Engineer is required before any grouting of permanent structure takes place.

3. At minimum, Grouting Operations Plan will address and provide:

a. Names and proof of training for grouting crew and crew supervisor in conformance with this Specification;

b. Type, quantity, and brand of materials to be used in grouting, including all required certifications;

c. Type of equipment to be used, including capacity in relation to demand and working conditions, as well as, standby equipment and spare parts;

d. General grouting procedure;

f. If applicable, procedures for monitoring and continuously maintaining less than 40% relative humidity of air within the duct;

g. Method to be used to control rate of flow within ducts;

h. Theoretical grout volume calculations;

i. Mixing and pumping procedures in accordance with the manufacturer's recommendations;

j. Direction of grouting accounting for grade and/or slope of tendon;

k. Sequence of inlet and outlet pipes use;

l. Procedures for handling blockages;

m. Procedures for possible post grouting repair.

4. Conduct a joint meeting of the Contractor, grouting crew, and the Engineer before grouting operations begin. Discuss Grouting Operations Plan, required testing, corrective procedures, and any other relevant issues at the meeting.

5. Prior to production grouting, demonstrate to the Engineer's satisfaction successful grout injection by injecting full-scale mockups that are constructed with all associated PT system components using the mockup tendon profiles shown in the Plans and the proposed Grouting Operations Plan. Utilize smooth duct and associated couplers and fittings meeting the requirements of Section 960 for all mockups. Utilize smooth duct for the mockups which has an inside diameter required for a given mockup tendon size. If the mockup is also being used to perform PT system acceptance testing, use the duct type appropriate for the PT system location. Place the mockup tendons specified in the Plans inside the ducts to simulate the in-place PT tendons. Stress mockup tendons to the minimum values shown in the Plans by using jacks or other methods approved by the Engineer. Perform pressure tests on the mockups in accordance with 462-8.2.1 prior to grout injection. For the grout injection operations, utilize the same grout material and types and sizes of grout injection equipment that will be used on the project including but not limited to mixers, pumps, hoses, valves and pressure gauges. Inject grout into the mockups using the proposed Grouting Operations Plan. Allow the grout to harden a minimum of 24 hours after injection before inspecting the mockup. Inspect the mockup in accordance with the requirements of 462-8.3.2.1 and then carefully cut open the duct at all high points and other locations as directed by the Engineer to check for voids. Prepare a report documenting the findings and submit it to the Engineer. If voids are found, determine the cause and revise the proposed Grouting Operations Plan accordingly. If directed by the Engineer, construct additional mockups and repeat the grout injection operation using the revised Grouting Operations Plan as many times as are required until the results are acceptable.

462-7.4.1.2 Inlets and Outlets:

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1. Ensure connections from grout pump hose to inlets are free of dirt and are air-tight.

2. Inspect valves to ensure they can open and close properly.

462-7.4.1.3 Supplies:

Provide an adequate supply of water and compressed air for clearing and testing ducts, as well as, mixing and pumping grout before grouting operations start.

462-7.4.1.4 Equipment:

1. Provide grouting equipment consisting of measuring devices for water, a high-speed shear colloidal mixer, a storage hopper (e.g., holding reservoir) and pump with all necessary connecting hoses, valves, and pressure gauge.

2. Provide pumping equipment with sufficient capacity to ensure PT ducts can be filled and vented in not more than 30 minutes without interruption.

3. Provide an air compressor and hoses with sufficient output to perform required functions.

4. Have vacuum grouting equipment (i.e., volumetric measuring type) and experienced operators available to meet the timeframe requirements of 462-8.3.2.1-6.

462-7.4.1.4.1 Mixer and Storage Hopper:

1. Provide colloidal grout machinery with a charging tank for blending and a holding tank. Blending tank must be equipped with a high speed shear colloidal mixer capable of continuous mechanical mixing producing a homogeneous and stable grout free of lumps and un-dispersed cement. Holding tank must be kept agitated and at least 10% full at all times during pumping operations to prevent air from being drawn into duct.

2. Add water during primary mixing phase in the colloidal mixer by use of a flow meter or calibrated water reservoir with measuring accuracy equal to 1% of total water volume.

462-7.4.1.4.2 Pumps:

1. Provide pumping equipment capable of:

a. continuous operation which includes a system for circulating and agitating grout when actual grouting is not in progress,

b. maintaining pressure on grouted ducts,

c. fitted with a valve that can be closed off without loss of pressure in duct.

2. Grout pumps will:

a. be positive displacement type,

b. provide a continuous grout flow

c. be able to maintain a discharge pressure of at least 145 psi.

3. Use pumps constructed with seals to prevent oil, air, or other foreign substances from contaminating grout and prevent loss of grout or water.

4. Specify pump capacity adequate to maintain the specified grouting rate.

5. Place pressure gauges with full scale reading of no more than 300 psi at the pump and at the duct inlet.

6. Grout hoses to be compatible with pump output (diameter and pressure rating).

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462-7.4.1.4.3 Vacuum Grouting: Provide vacuum grouting equipment meeting these minimum requirements:

1. Volumeter for measurement of void volume;
2. Vacuum pump with a minimum capacity of ten cubic feet per minute and equipped with a flow-meter, graduated hopper, or other acceptable means approved by the Engineer capable of measuring the amount of grout being injected.
3. Manual colloidal mixers, manual high speed shear mixers, or other mixing methods recommended and approved by the grout manufacturer, in writing, for the specific project covered by this Section for voids less than 5.5 gallons in volume. However, mix a minimum of one full bag of grout regardless of the size void to be grouted.
4. Standard colloidal mixers for voids 5.5 gallons and greater in volume.

462-7.4.1.4.4 Standby Equipment: Provide a standby colloidal grout mixer and pump during grouting operations.

462-7.4.1.5 Grouting:

1. Maintain grout fluidity in strict compliance with grout manufacturer's recommendations.
2. In the presence of the Engineer, perform a test to confirm accuracy of grouting equipment volume-measuring components each day of use before performing any grouting operations. Testing in a warehouse or similar condition is acceptable. Use either water or grout for testing using standard testing devices with volumes of 0.5 gallon and 6.5 gallon and an accuracy of equal to or less than four ounces. Perform one test with each device. Results must verify accuracy of grouting equipment void volume-measuring component within 5% of test device volume and must verify accuracy of grouting equipment grout volume component within 10% of test device volume for the 0.5 gallon test device. When testing the 6.5 gallon device, ensure an accuracy of 3% (test device volume) and 6% (grout volume).
3. Do not use grout that tests outside allowable flow rates.
4. Perform grouting in accordance with procedures set forth in approved Grouting Operations Plan.
5. Grout all ducts.

462-7.4.1.5.1 Temperature:

1. At inlet end of grout hose, the maximum limit for grout temperature is 90°F for normal grouting procedures and 85°F when performing repair operations with vacuum grouting.
2. Condition grout material to maintain mixed grout temperature below maximum limit.
3. Grouting operations are not permitted when ambient temperature is below 40°F or is expected to fall below 40°F within one day subsequent to grouting.
4. Postpone grouting operations if freezing temperatures are forecasted within two days subsequent to grouting.

462-7.4.1.5.2 Mixing and Pumping:

1. Mix grout with a metered amount of water.
2. Mix materials to produce a homogeneous grout.
3. Continuously agitate grout until grouting operations are complete.

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4. Reject bags of grout containing clumps.

462-7.4.1.5.3 Production Test:

1. Test grout fluidity to verify it is within limits established by grout manufacturer during grouting operations. Target fluidity rate is established by manufacturer's representative based on ambient weather conditions.

2. Determine grout fluidity in accordance with Section 938.

a. Perform a fluidity test using flow cone on grout discharged from anchorage cap outlet immediately after uncontaminated uniform consistency discharge begins for each tendon greater than 50 feet in length. For tendons 50 feet or less, perform a fluidity test on a per batch basis. For fluidity tests done on a per batch basis, perform test after new batch has been transferred from mixing tank to holding tank and thoroughly mixed with remains of the previous batch to produce a new homogenous mixture. During mixing process, continually re-circulate grout from hose into holding tank. Ensure measured grout efflux time is not less than efflux time measured at injection end of grout hose.

b. Additionally, check grout fluidity using Wet Density method contained in Section 938. Density at discharge outlet must not be less than grout density at inlet. Continuously discharge grout until density requirements are met. Discard grout used for testing fluidity.

3. Perform fluidity test for each tendon to be grouted without modifying water-cement ratio.

4. Check temperature of grout at inlet end of grout hose hourly to verify conformance to this Section.

5. Obtain a sample from first production batch of grout and perform a wick induced bleed test on this sample in accordance with Section 938 at beginning of each day's grouting operation. Begin grouting operations after sample is obtained.

6. Once grouting has begun, if zero bleed requirement is found to not have been achieved in the wick induced bleed test at any time during required test time period, complete grouting of any partially grouted tendons currently being grouted but do not begin grouting any new or additional tendons. Immediately inform the Engineer when grouting operations have ceased due to non-compliance of the wick induced bleed test.

7. Do not re-start grouting operations until such time that testing shows grout meets specified requirements.

462-7.4.1.5.4 Grout Injection Operations:

1. Briefly open low point drains to allow for drainage of any water that may be present within the duct. If water is present:

a. Capture and measure the water removed from the duct and retain for further testing as directed by the Engineer; blow the duct with oil free dry compressed air meeting the ASTM D4285 with the end vent port open.

b. Obtain written authorization from the Engineer to proceed with grouting injection operations.

2. Open all grout outlets before starting grouting operation.

3. Inject grout into duct in accordance with approved Grouting Operations Plan.

4. Pump grout at the lowest possible pressure practical.

5. Conduct normal grouting operations at a pressure range of 10 psi to 50 psi measured at grout inlet.

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6. Do not exceed a pumping pressure of 145 psi anywhere within the system. Do not exceed a pumping pressure of 75 psi at the grout inlet for flat ducts.

7. Use grout pumping methods that ensure complete filling of ducts and complete encasement of steel.

8. Grout must flow from first and subsequent outlets until any residual water or entrapped air has been removed prior to closing outlet.

9. Pump grout through duct and continuously discharge it at anchorage and anchorage cap outlets until all free water and air are discharged and consistency of grout is equivalent to that of grout being pumped into inlet. Close anchorage outlet and discharge a minimum of two gallons of grout from anchorage cap into a clean receptacle. Close anchorage cap outlet.

10. Elevate grout pressure to the equivalent realized pumping pressure while grouting the duct, seal inlet valve, and wait two minutes to determine if any leaks exist after all outlets have been bled and sealed. If leaks are present repair all identified leaks using methods pre-approved by the Engineer and repeat steps until no leaks are present. Bleed pressure to 5 psi and wait a minimum of ten minutes for any entrapped air to flow to high points if no leaks are present. Increase pumping pressure not to exceed actual realized pumping pressure of duct and discharge grout at each high point outlet to eliminate any entrapped air or water after specified ten minute period has expired. Complete process by locking a pressure of 30 psi into tendon duct.

11. If actual grouting pressure exceeds maximum allowed, close inlet and pump grout at next outlet which has just been closed or is ready to be closed as long as a one-way flow is maintained. Do not pump grout into a succeeding outlet from which grout has not yet flowed. Fit outlet/inlet to be used for pumping with a positive shut-off valve as shown in the approved system drawings and pressure gauge if this procedure is used.

12. Stop grouting operation if complete grouting of tendon cannot be achieved by the steps stated and in compliance with the approved Grouting Operations Plan. After waiting 48 hours, vacuum grout duct in accordance with this Section.

462-7.4.1.5.5 Vertical Grouting:

1. Provide a reservoir, equivalent to a minimum of 2% of the total anticipated grout volume used on a particular tendon, at upper end of tendon to store bleed water and grout; maintain grout level above level of prestressing plate and anchorage for all vertical tendons. Design and size this device to maintain level grout at an elevation that ensures potential bleed will not drop below the highest point of upper anchorage device. Design reservoir to allow all bleed water, if any, to rise into reservoir.

2. Discharge grout and check grout fluidity as described in this Section. Immediately add grout if level of grout begins to drop, potentially allowing bleed water into the upper anchorage device and tendon duct. Remove reservoir after grout has hardened. Visually inspect for voids using a borescope or probe in presence of the Engineer. Fill all voids found in duct using volumetric measuring vacuum grouting process in accordance with this Section.

3. Allow grout to flow from each outlet until all air and water have been purged prior to using a higher elevation outlet for pumping. Pump grout at increasingly higher outlets which have been or are ready to be closed, as long as one-way grout flow is maintained for vertical tendons within allowable grouting pressures.

462-7.4.1.5.6 Grouting Operations Report:

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1. Submit grouting report signed by the grouting Contractor within five days of each grouting operation for review by the Engineer.

2. Record theoretical quantity of grout anticipated as compared to actual quantity of grout used to fill duct. Notify the Engineer immediately of shortages or overages.

3. Information to be noted in this report must include at a minimum, but not necessarily be limited to:

a. identification of tendon;
b. date grouted;
c. number of days from tendon installation to grouting;
d. type of grout;
e. injection end;
f. verification that water or moisture is not present within the duct;
g. daily duct humidity readings if applicable;
h. Pressure gauge readings at the pump and at the inlet;
i. Ratio of actual to theoretical grout quantity;
j. Number of grout bags mixed;
k. Total quantity of water used to mix grout;
l. Summary of any problems encountered; and,
m. corrective action taken,
n. description and results of the post grouting operations and inspection.

462-7.4.2 Flexible Filler Operations:

1. Inject flexible filler with or without using vacuum assistance for tendons with vertical or predominately vertical profiles as shown on Standard Plans, Index 462-001.

2. Inject flexible filler using vacuum assistance for all other tendon profiles shown on Standard Plans, Index 462-001.

462-7.4.2.1 Microcrystalline Wax: Conduct all wax injection operations, repairs, and inspections in the presence of the Filler Injection Foreman, Filler Injection QC Inspector and the Engineer.

462-7.4.2.1.1 Wax Injection Operations Plan:

1. Prepare a Wax Injection Operations Plan in cooperation with the PT system vendor and the PT wax manufacturer.

2. Submit the Wax Injection Operations Plan to the Engineer for approval at least six weeks in advance of any scheduled injection operation.

3. Written approval of the Wax Injection Operations Plan by the Engineer is required before any injection of permanent structure can begin.

4. At a minimum, the Wax Injection Operations Plan will address and provide the following:

a. Names and qualifications for wax injection crew and crew supervisor in conformance with this Specification;

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b. Type, quantity, and brand of materials to be used in wax injection including all required certifications;

c. Type of equipment to be used, including capacity in relation to demand and working conditions, as well as, standby equipment and spare parts;

d. Personal Protective Equipment (PPE);

e. Communication equipment to be used during injection;

f. Location and sequence of ducts to be injected;

g. Calculation of temporary elongation of tendons due to wax injection temperature;

h. Procedures for checking the presence of water or moisture in the duct, blowing oil-free dry compressed air, and measuring humidity of air within the duct;

i. If applicable, procedures for monitoring and continuously maintaining less than 40% humidity of air within the duct;

j. General wax injection procedure for all duct geometries and types;

k. Duct pressure test and repair procedures;

l. Method to be used to control rate of flow within ducts and anchorage assembly;

m. Theoretical wax volume calculations;

n. Injection rate;

o. Maximum injection pressure during injection and locking pressure;

p. Vacuum (gauge) pressure requirements, vacuum tests and repair procedures;

q. Heating, mixing and pumping procedures in accordance with the manufacturer's recommendations;

r. Direction of wax injection accounting for grade and/or slope of tendon;

s. Location of all high points and all low points accounting for grade and/or slope of tendon;

t. Sequence of valve operations at PT system inlets and outlets, including minimum wax discharge quantities;

u. Procedures for handling blockages;

v. Procedure for sealing duct after wax injection;

w. Procedure for inspecting the PT system after wax injection, filling voids created by inspection procedures, and sealing duct after PT system inspection;

x. Procedures for possible post injection repair;

y. Method(s) and material(s) that will be used to protect concrete surfaces from wax spills, leaks, etc. during wax injection, post injection inspection and post injection repair;

z. Safety and clean-up procedures;

5. Conduct a joint meeting of the Contractor, wax injection crew, and the Engineer before wax injection operations begin. Discuss Wax Injection Operations Plan, required testing, corrective procedures, and any other relevant issues at the meeting.

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6. Prior to production wax injection, demonstrate to the Engineer's satisfaction successful wax injection by injecting full-scale mockups that are constructed with all associated PT system components using the mockup tendon profiles shown in the Plans and the proposed Wax Injection Operations Plan. Utilize smooth duct and associated couplers and fittings meeting the requirements of Section 960 for all mockups. Utilize smooth duct for the mockups which has an inside diameter required for a given mockup tendon size. If the mockup is also being used to perform PT system acceptance testing, use the duct type appropriate for the PT system location. Place the mockup tendons specified in the Plans inside the ducts to simulate the in-place PT tendons. Stress mockup tendons to the minimum values shown in the Plans by using jacks or other methods approved by the Engineer. Perform pressure tests on the mockups in accordance with 462-8.2.1 prior to wax injection. If vacuum assisted wax injection is required to be used, perform vacuum tests on the mockups in accordance with 462-8.2.1 prior to wax injection. For the wax injection operations, utilize the same wax material and types and sizes of wax injection equipment that will be used on the project including but not limited to heaters, pumps, hoses, valves and pressure gauges. Inject wax into the mockups using the proposed Wax Injection Operations Plan. Allow the wax to cool a minimum of 24 hours after injection before inspecting the mockup. Inspect the mockup in accordance with the requirements of 462-8.3.2.2.1 and then carefully cut open the duct at all high points and other locations as directed by the Engineer to check for voids. Prepare a report documenting the findings and submit it to the Engineer. If voids are found, determine the cause and revise the proposed Wax Injection Operations Plan accordingly. If directed by the Engineer, construct additional mockups and repeat the wax injection operation using the revised Wax Injection Operations Plan as many times as are required until the results are acceptable.

462-7.4.2.1.2 Inlets and Outlets:

1. Ensure connections from wax pump hose to inlets are free of dirt and are air-tight.

2. Inspect valves to ensure they can open and close properly.

3. Provide clear hose and connections to outlet valves compatible with heated wax injection for discharging excess wax. Kinks and clogs in the vent hoses are not permitted during pumping operations.

462-7.4.2.1.3 Supplies:

1. Provide an adequate supply of compressed air for clearing and testing ducts before wax injection operations start.

2. Provide clean receptacles for collecting excess wax at outlet locations.

3. Provide supplies for stopping wax leaks including rags and buckets of cold water.

462-7.4.2.1.4 Equipment:

1. Provide equipment consisting of measuring devices for wax, wax melting unit(s), wax mixer for maintaining uniform temperature, a storage holding reservoir, pump, and volumetric flow rate and displacement volumetric meters with all necessary connecting hoses, valves, pressure gauges, timer, and temperature gauge.

2. Provide pumping equipment with sufficient capacity to ensure PT ducts can be filled and vented in not more than time specified by the wax manufacturer and this Specification.

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3. Provide an air compressor and hoses with sufficient output to perform required functions.

4. For filling of air voids in an incomplete wax injection, have the required equipment and personnel as stated in the approved Wax Injection Operations plan available to meet the timeframe requirements of 462-8.3.2.2.1-6.

5. For vacuum assisted injection, provide vacuum pump equipment able to measure and have sufficient capacity to ensure a minimum of 90% vacuum in the PT system prior to filler injection. Provide a continuously running vacuum pump or vacuum reservoir capable of maintaining vacuum during the wax injection process.

6. Ensure that all injection and inspection equipment is maintained in accordance with equipment manufacturer's instructions and is calibrated and in good working condition.

7. Provide equipment for dislodging congealed wax blockages.

8. Provide standby pumping and vacuum equipment on the project site during injection operations.

462-7.4.2.1.4.1 Storage Reservoir and Mixing:

1. Provide heated holding tanks for wax injection.

a. Holding tanks must be equipped with a heating system capable of producing a melted wax free of lumps within the temperature limits specified by the manufacturer.

b. Holding tanks must be kept at least 10% full at all times during pumping operations to prevent clogs and air from being drawn into duct

c. Holding tanks must have at time of injection a quantity of heated wax required to inject the PT system. The quantity of heated wax required to inject the PT system is calculated as 25% more than the total quantity to fill the duct and anchorages, to discharge wax at outlets, to fill pumping equipment and hoses, and to maintain the minimum amount of wax in the holding tanks during pumping operations.

2. Provide equipment to ensure uniform temperature of heated wax, either by mixing or other methods.

462-7.4.2.1.4.2 Pumps:

1. Provide pumping equipment capable of the following:

a. continuous operation which includes a system for heating pump components when wax injection is not in progress;

b. maintaining pressure on wax injected ducts;

c. fitted with a valve that can be closed off without loss of pressure in duct.

2. Wax pumps will:

a. be positive displacement type;

b. provide a continuous wax flow;

c. be able to maintain a discharge pressure of at least 75 psi;

d. provide an injection of filler into duct in a velocity range of 40-70 ft/min.

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3. Use pumps constructed with seals to prevent oil, air, or other foreign substances from contaminating wax and prevent loss of wax.

4. Pumps with hoppers are not permitted.

5. Specify pump capacity adequate to maintain the wax injection rate.

6. Place pressure gauge with full scale reading of no more than 300 psi at pump and duct inlets.

7. Wax injection hoses to be compatible with pump output (diameter, pressure rating and temperature).

462-7.4.2.1.4.3 Vacuum Wax Injection:

1. If vacuum wax injection is to be used for filling voids in incomplete wax filling operations, provide vacuum wax injection equipment meeting these minimum requirements:

a. Volumeter for measurement of void volume;

b. Vacuum pump with a minimum capacity of ten cubic feet of air per minute and equipped with a flow-meter, graduated reservoir, or other acceptable means approved by the Engineer capable of measuring the amount of wax being injected.

c. Mixers and heaters, or other mixing and heating methods recommended and approved by the wax manufacturer, in writing, for the specific project covered by this Section.

2. For vacuum assisted injection, provide vacuum wax injection equipment meeting these minimum requirements:

a. Vacuum pump with a minimum capacity of ten cubic feet of air per minute (free air) with the capability of removing 90% of standard atmospheric pressure within the PT system and equipped with a vacuum pressure gauge;

b. Hoses, vacuum reservoirs, and connections required for attachment to the PT system.

462-7.4.2.1.4.4 Heaters: Use a heater and temperature monitoring system capable of liquefying the entire mass of PT wax to be used for a given injection operation within the temperature limits specified by the PT wax manufacturer. The heater systems must apply a uniform heat to the PT wax and avoid locally high temperatures that may damage the PT wax or container. Use a heater and temperature monitoring system which complies with the recommendations of the PT wax manufacturer.

462-7.4.2.1.5 Wax Injection:

1. Maintain wax temperature in strict compliance with the wax manufacturer's published product data sheet and within the limits of this Section.

2. Perform wax injection in accordance with procedures set forth in approved Wax Injection Operations Plan.

3. Inject hot wax into specified duct inlet.

462-7.4.2.1.5.1 Temperature:

1. Condition wax to maintain its temperature during injection between 212°F and 240°F.

2. Wax injection operations are not permitted when ambient temperature is below minimum temperatures specified by the wax manufacturer.

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462-7.4.2.1.5.2 Production Test:

1. Check wax temperature to verify it is within established limits during operations.

2. Do not start operations until such time that testing shows wax meets specified requirements.

462-7.4.2.1.5.3 Wax Injection Operations:

1. Briefly open low point drains to allow for drainage of any water that may be present within the duct. If water is present:

a. Capture and measure the water removed from the duct and retain for further testing as directed by the Engineer;

b. Obtain written authorization from the Engineer to proceed with blowing of compressed air.

2. Just prior to wax injection, close all low point drains and ports except the inlet and outlet ports at the anchorage caps. Blow oil-free dry compressed air meeting ASTM D4285 through one of the anchorage cap ports until the humidity measured at the inlet and outlet ends are less than 40% and continuing blowing for an additional 30 minutes. Stop blowing, wait a minimum of 15 minutes, and take humidity measurements at the inlet and outlet ends of blowing. Further blowing is not required if both humidity readings are less than 40%. If the humidity readings are 40% or greater, then repeat the process of blowing and waiting for 15 minutes until the humidity measurements at the inlet and outlet end of blowing are less than 40%. Take humidity measurements of air within the duct at the inlet end and outlet end of blowing using separate humidity meters. Use humidity meters approved by the Engineer.

4. Provide visual confirmation that the duct and tendon are free of water, moisture and debris at the anchorages and low points of the tendon profile.

5. Protect concrete surfaces from wax spills, leaks, etc.

6. Inject wax in accordance with approved Wax Injection Operations Plan.

7. Use pumping methods that ensure complete filling of ducts and anchorage assembly with wax.

8. Ensure the entire mass of wax is fully liquefied prior to and throughout injection operations. Establish a non-turbulent, laminar system circulation by continuously recirculating the wax between the pump and the storage container prior to injecting the wax into the duct. Pump components must be at wax injection temperature prior to wax injection into duct. Do not allow wax to free fall during recirculation or injection operations. Maintain a positive head of liquid wax above all withdrawal and recirculation ports and do not allow air intrusion into the pumping system. Do not pour liquid wax into an open pump or hopper.

9. Inject PT wax at a continuous and steady rate in accordance with the approved Wax Injection Operations Plan at a flow rate through duct at a velocity between 40 and 70 feet per minute and pressure limited to 75 psi at the duct inlet and 145 psi at the pump.

10. For tendons in which vacuum assisted injection is used, provide a minimum of 90% vacuum in the duct prior to injection. Connect both the

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anchorage outlet and the cap outlet to the vacuum system. After the vacuum is established, lock off the air supply to the duct and monitor the vacuum for 1 minute. If the loss of vacuum after 1 minute exceeds 10%, repair leaks as directed by the Engineer and retest the duct. If the results are acceptable, reestablish and maintain a minimum 90% vacuum using the outlets at the higher end anchorage shown on Standard Plans, Index 462-001 while injecting wax using the inlet at the lower end anchorage shown on the same Standard. Close all outlets, inlets, and ports other than at injection and vacuum locations during injection procedure. Pump wax into inlet and continuously vacuum air at the outlet. After the duct is fully injected with wax and the wax reaches the vacuum end, close the outlet valve, turn off the vacuum pump and continue the injection pump. Bleed all outlets starting at the anchorage cap at the injection end and proceed to bleed every valve thereafter from injection end to vacuum end, ending with the anchorage cap at the vacuum end. When bleeding each valve, collect a minimum of two gallons of continuously flowing wax free from air before closing the valve. After all outlet valves are closed, close inlet valve with locking pressure between 30 psi and 45 psi. Do not reuse discharged wax.

11. For tendons in which vacuum assisted injection is not used, inject wax under pressure at locations shown on Standard Plans, Index 462-001. Allow wax to flow from duct and anchorage discharge points until a steady flow of wax free from air is continuously discharged. Collect a minimum of two gallons of continuously flowing wax free from air at discharge point before closing outlet valve. Do not reuse discharged wax. After all outlets are closed, close the inlet valve at locking pressure between 30 and 45 psi.

12. Record the total volume of wax injected into the system.

13. Upon completion of wax injection, seal the duct in accordance with the approved PT system drawings. Remove all excess wax from exposed surfaces.

462-7.4.2.1.5.4 Wax Injection Operations Report:

1. Submit the wax injection report signed by the wax injection Contractor within five days of each wax injection operation for review by the Engineer.

2. Record theoretical quantity of wax anticipated as compared to actual quantity of wax used to fill duct. Notify the Engineer immediately of shortages or overages.

3. Information to be noted in this report must include at a minimum, but not necessarily be limited to:

a. Identification of duct;
b. Date of duct pressure test;
c. Date wax injected;
d. Number of days from tendon installation to wax injection;
e. Wax product identification;
f. Daily duct humidity readings if applicable;
g. Humidity readings from blowing compressed air through duct;
h. Verification that water or moisture is not present within the duct prior to wax injection;

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i. Pressure gauge readings at the pump and at the inlet;

j. Final locking pressure of wax in PT system;

k. Reservoir temperature at time of initiation of wax injection;

l. Theoretical volume of wax required to completely fill the duct;

m. Volume of wax injected into duct;

n. Volume of wax collected at discharge points;

o. Injection rate including timing of duct inlet opening and closing;

p. Ambient temperature;

q. Summary of any problems encountered and any deviations from the Wax Injection Operations Plan;

r. Corrective action taken;

s. Description and results of the post wax injection operations and inspection;

t. Vacuum gauge pressure and percent vacuum in duct prior to injection;

4. Maintain daily wax injection operations reports at the job site for review by the Engineer. Submit all daily reports to the Engineer on a weekly basis or as directed by the Engineer.

462-7.4.2.1.6 Manufacturer's Installation Technician: Provide for a PT system vendor installation technician, certified by the vendor as having sufficient knowledge and expertise to oversee the wax injection personnel. The vendor's technician shall be under the direct employ of the vendor and shall be present for all wax injection activities for a minimum of the first two days of wax injection for each of the Contractor's wax injection crews. The vendor's technician shall submit written certification to the Engineer that the Contractor's installation process is in conformance with the approved Wax Injection Operations Plan.

462-7.5 Repair: Perform no remedial or repair work without the Engineer's approval in writing.

462-7.5.1 Lifting and Access Holes:

1. Repair all holes with magnesium ammonium phosphate concrete meeting requirements of Section 930 or Type Q epoxy grout meeting requirements of Section 926. Immediately before casting concrete (i.e., within 24 hours), mechanically clean and roughen the mating concrete surfaces to remove any laitance and expose small aggregate. Use grit blasting or water blasting using a minimum 10,000 psi nozzle pressure. Flush surface with water and blow dry. Form, mix, place, and cure material in strict compliance with manufacturer's recommendations.

2. Upon completion of deck grooving, coat repaired holes, block-outs, and an area extending six inches outside perimeter of repair with a high molecular weight methacrylate (HMWM) meeting the requirements of Section 413. Prepare surface to be coated

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and apply HMWM in accordance with Section 413. Friction (skid) tests per Section 413 are not required.

462-7.5.2 Inlets, Outlets, Drains and Ports:

1. Place threaded plastic plugs in all inlet, outlet, drain and port locations required in the Contract Documents.

2. Fill inlet, outlet, drain and port recesses as shown in the Contract Documents using a Type Q epoxy compound, Type E epoxy compound, or Type F-1 epoxy compound meeting requirements of Section 926.

3. Prepare surface to receive epoxy compounds in compliance with manufacturer's recommendations.

462-7.5.3 Duct:

1. Repair the following ducts using heat-shrink wrap material designed for duct repair:

a. Smooth plastic ducts that will be encased in concrete;

b. Corrugated plastic ducts;

c. External smooth plastic ducts after the flexible filler injection procedure has been completed.

Install heat-shrink wrap in accordance with manufacturer's instructions.

2. Repair external smooth plastic ducts before the flexible filler injection procedure has been completed using elastomer sleeves and stainless steel band clamps.

462-8 Acceptance and Testing.

462-8.1 Contractor Material Testing:

1. The following tests are not required on post-tensioned, precast flat slab bridges, and double-tee bridges, but are required on all other PT applications.

2. Include cost for Contractor Tendon Modulus of Elasticity Test and In-Place Wobble and Friction Test in price of PT system.

462-8.1.1 Tendon Modulus of Elasticity Test:

Perform a tendon modulus of elasticity test in accordance with the following procedure if required in the Contract Documents or ordered by the Engineer.

1. Bench test two samples of each size tendon prior to stressing tendons to determine modulus of elasticity for purpose of accurately determining tendon elongations while stressing.

2. Bench length between anchorages must be at least 40 feet and tendon duct at least two inches clear of tendon all around for purpose of this test.

3. Test procedure must consist of stressing tendon at an anchorage assembly with a load cell at dead end.

4. Tension test specimen 80% of GUTS in ten increments and then detention from 80% of GUTS to zero in ten decrements.

5. Record gauge pressure, elongations, and load cell forces for each increment and decrement.

6. Note elongations of tendon for both ends and the central 30 feet, measured to an accuracy of plus or minus 1/32 inches.

7. Correct elongations for actual anchor set of dead end.

8. Calculate modulus of elasticity as follows:

$$E = PL/Adl$$

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where,
P = force in tendon
L = distance between pulling wedges and dead end wedges or exact length in the center 30 feet of tendon
A = cross sectional area of tendon
dl = tendon elongation within length, L, for load, P

9. Submit revisions to theoretical elongations to the Engineer for approval if bench test varies from modulus of elasticity used for shop or working drawings by more than 1%.

10. Additional Tendon Modulus of Elasticity Tests may be required when observed tendon elongations in erected structure fall outside acceptable tolerances or to otherwise settle disputes to the satisfaction of the Engineer.

11. Additional test series of substantiation from previous projects, not to exceed two per source, will be required if source of prestressing steel changes during project.

12. Apparatus and methods used to perform the test must be submitted to the Engineer for approval in writing.

13. Tests must be conducted in the Engineer's presence.

462-8.1.2 In-Place Wobble and Friction Test:

1. Test in-place a minimum of one tendon per tendon group performing the same function for tendons in excess of 100 feet long.

2. Functional tendon groups are cantilever tendons, continuity tendons, draped external tendons, or continuous profiled tendons passing through one or more spans.

3. Selected tendon will represent the size and length of tendon group being tested.

4. In-place test is not required on projects with straight tendons used in flat slabs or precast voided slabs.

5. Test procedure consists of stressing tendon at an anchorage assembly with a load cell or a second certified jack at dead end.

6. Stress test specimen to 80% of GUTS in eight equal increments.

7. For each increment, record gauge pressure, elongations, and load cell force (if a load cell is used).

8. Take into account any wedge seating in both live end (i.e., back of jack) and dead end (i.e., back of load cell) and any friction within anchorages, wedge plates, and jack as a result of slight deviations of strands or wires through these assemblies.

9. Keep an accurate account of elongation at jacking end allowing for intermediate wedge seating and slip of the jack's wedges for long tendons requiring multiple jack pulls with intermediate temporary anchoring.

10. If elongations fall outside the plus or minus 7% range compared to anticipated elongations, investigate reason and make detailed calculations confirming final tendon forces are in agreement with requirements of the approved Contract Documents.

11. Do not vary value of expected friction and wobble coefficients by more than plus or minus 10% in reconciling theoretical and actual elongations.

12. Submit for written approval by the Engineer a plan to correct or compensate for elongation discrepancies if necessary.

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13. The Engineer will require one successful test for each tendon group for the project.

14. The Engineer may require additional in-place tests if there are irreconcilable differences between forces and elongations or other difficulties during the course of routine stressing operations.

15. Submit apparatus and methods used to perform test to the Engineer for approval in writing.

16. Conduct all in-place tests in the Engineer's presence.

462-8.1.3 Required Reports:

1. Submit the test report for "Tendon Modulus of Elasticity Test" to the Engineer at least 30 days before installing tendon.

2. Submit the test report for "In-Place Wobble and Friction Test" to the Engineer within two weeks after successful installation of tested tendon.

462-8.1.4 Test Results Application:

1. Reevaluate theoretical elongations shown on PT shop or working drawings using results of "Tendon Modulus of Elasticity Test" and "In-Place Wobble and Friction Test," as appropriate, and correct calculations as necessary.

2. Submit revisions to theoretical elongations to the Engineer for approval in writing.

462-8.2 Contractor Field Tests:

462-8.2.1 Prior to Concrete Placement:

462-8.2.1.1 All Tendons Except as Noted:

1. Test all PT system components utilized on the project, except those used for internal longitudinal tendons in precast box-girder segments in the casting cell (e.g., cantilever tendons).

2. In the formwork, pressure test each duct with all assemblies used in a single structural component (e.g. segment, beam, etc.).

3. Test assemblies in their final position just prior to concrete placement by sealing them at their anchorages or construction joint termini and then applying compressed air in accordance with this Section to determine if assembly connections are pressure tight.

4. In presence of the Engineer, pressurize duct to 7.5 psi and lock-off outside air source. Record pressure loss for one minute. If pressure loss exceeds 0.75 psi, or 10%, find and repair leaks in duct assembly using repair methods approved by the Engineer and retest.

462-8.2.1.2 Tendons for Which Vacuum Assisted Filler Injection Will Be Used:

1. Test all PT system components utilized on the project except those used for internal longitudinal tendons in box-girder segments.

2. In the formwork, perform a vacuum test for each duct with all assemblies used in a single structural component (e.g. segment, beam, etc.).

3. Test assemblies in their final position just prior to concrete placement by sealing them at their anchorages or construction joint termini and then applying a vacuum in accordance with this Section to determine if assembly connections are pressure tight.

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4. In presence of the Engineer, apply a 90% vacuum and lock-off outside air source. Record vacuum loss for five minutes. If vacuum loss exceeds 10%, find and repair leaks in duct assembly using repair methods approved by the Engineer and retest.

462-8.2.2 Post Concrete Placement:

1. After stressing and before injecting filler into duct, install all anchorage caps, inlets and outlets and test the duct with compressed air in accordance with this Section to determine if duct connections require repair.

2. In the presence of the Engineer, pressurize duct to 50 psi and lock-off outside air source. Record pressure loss for one minute. A pressure loss less than 25 psi, or 50%, is acceptable for ducts with a length of equal to or less than 150 feet and a pressure loss less than 15 psi is acceptable for ducts longer than 150 feet.

3. If the pressure loss exceeds allowable, repair leaking connections using methods approved by the Engineer and retest.

462-8.3 Contractor Inspections:

462-8.3.1 Post Concrete Placement/Prior to Filler Injection Operations:

1. Upon completion of concrete placement and except as otherwise described, prove PT ducts are free and clear of any obstructions or damage and are able to accept intended PT tendons by passing a torpedo through ducts.

2. Use a torpedo having same cross-sectional shape as duct that is 1/4 inches smaller all around than clear, nominal inside dimensions of duct. Make no deductions to torpedo section dimensions for tolerances allowed in manufacture or fixing of ducts. For straight ducts, use a torpedo at least two feet long. For curved ducts, determine length so that when both ends touch outermost wall of duct, torpedo is 1/4 inches clear of innermost wall. The Engineer will reject member if torpedo will not travel completely through duct and workable repair cannot be made to clear duct. Torpedo must pass through duct easily when pushed through by hand, without resorting to excessive effort or mechanical assistance.

3. Alternatively, four strand tendons in flat ducts used for transverse PT of segmental box-girders may be preplaced prior to concrete casting. Prove PT ducts are free and clear of any obstructions or damage by moving the group of strands back and forth in duct for a minimum distance of one foot in each direction. Move strands easily, by hand, without resorting to excessive effort or mechanical assistance.

462-8.3.2 Post Filler Injection Operations:

462-8.3.2.1 Post Grouting Operations:

1. Inspect all tendons. Complete the inspection of a given tendon within 96 hours after grouting of that tendon.

2. Do not open or remove inlets, outlets, drains or ports until grout has cured for a minimum of 24 hours.

3. Perform inspections within one hour after removal of all inlets and outlets and drains located at anchorages and points along the tendon.

4. Drill into grout ports at all high points along tendon as well as inlets or outlets located at anchorages for inspection. Drill through hardened grout to penetrate full-length of grout port access piping to top of trumpet or duct. If drilling of inlets or outlets is not feasible with conventional equipment, propose an alternative method of tendon inspection for approval by the Engineer in writing. Use drilling equipment that will automatically shut-off when steel is encountered. Do not drill into anchorage cap unless anchorage caps are determined to have voids by sounding.

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5. Perform all inspections using borescopes or probes and in presence of the Engineer.

6. Fill voids using volumetric measuring vacuum grouting process within 4 days from grouting.

7. Seal and repair all anchorage and inlet/outlet voids that are produced by drilling for inspection purposes as specified within four hours of completion of inspections if no additional voids are detected in tendon ducts or anchorages.

8. Remove inlet/outlet to a minimum depth of two inches below face of concrete and seal the surface as specified within 4 hours of inlet/outlet removal. Use an injection tube to extend to bottom of holes for backfilling with epoxy grout.

9. Drill into duct and explore voided areas with a borescope if grouting operations were prematurely terminated prior to completely filling duct. Probing is not allowed. Determine location and extent of all voided areas. Fill voids using volumetric measuring vacuum grouting equipment in accordance with this Section.

462-8.3.2.2 Post Flexible Filler Injection Operations:

462-8.3.2.2.1 Microcrystalline Wax:

1. Inspect all tendons. Complete the inspection of a given tendon within 96 hours after injecting that tendon with wax.

2. Do not open or remove inlets, outlets, drains or ports until wax has cooled for a minimum of 24 hours.

3. Perform inspections within one hour after removal of all inlets/outlets located at anchorages and high points along the tendon.

4. Visually inspect existing ports at all high and low points along tendon as well as all ports located at anchorages. Repair wax leaks according to the Wax Injection Operations Plan.

5. Between 24 and 48 hours following wax injection, perform the following inspection operations for each tendon:

a. Sound external ducts with a rubber mallet to ensure the system is free from voids,

b. Remove all inspection port caps and visually inspect to ensure the system is free from voids,

c. If a void is detected and the void is deeper than 1/2 inch or if the strands are exposed and uncoated, address the void using this section and methods described in the approved Wax Injection Operations Plan;

d. Fill voids created by inspection procedures and replace all inspection port caps and seal in accordance with the approved Wax Injection Operations Plan.

6. Fill voids using the methods described in the approved Wax Injection Operations Plan within 4 days from filler injection.

7. Seal and repair all anchorage and inlet, outlet and port voids that are produced for inspection purposes as described in the approved Wax Injection Operations Plan within four hours of completion of inspections if no additional voids are detected in tendon ducts or anchorages.

8. Inspect duct and explore voided areas with a borescope if wax injection operation was prematurely terminated prior to completely filling duct. Determine

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location and extent of all voided areas. Fill voids using gravity feed or injection, do not use vacuum repair injection unless proven by a mockup and approved by the Engineer.

462-9 Method of Measurement.

1. Quantity of PT tendons to be paid for under this Section will be computed weight, in pounds, of permanent PT steel tendons installed in the completed structure and accepted.

2. Quantity is determined by theoretical plan length measured from anchorage to anchorage (measured from front face of bearing plate) with no allowance made for waste or extension past bearing faces.

3. No measurement will be made for temporary PT which is considered incidental to Pay Item 462-2, Post Tensioning Tendons.

4. Use these unit weights for quantity determination:

Table 462-2 PT
Strand and Bar Weight per Unit Length

Prestressing System	Weight per Unit Length, Lb/Ft
1/2 inch diameter 7-wire strand	0.52
0.6 inch diameter 7-wire strand	0.74
5/8 inch high strength deformed bar	0.98
3/4 inch high strength deformed bar	1.49
1 inch high strength deformed bar	3.01
1-1/4 inch high strength deformed bar	4.39
1-3/8 inch high strength deformed bar	5.56
1-3/4 inch high strength deformed bar	9.10
2-1/2 inch high strength deformed bar	18.20
3 inch high strength deformed bar	24.09

Note: Weight per unit length of high strength deformed bars is based on values given in ASTM A722.

462-10 Basis of Payment.

462-10.1 General:

1. PT tendons will be paid for at the Contract unit price per pound of steel tendon, completed and accepted.

2. Payment will be full compensation for furnishing, installing, stressing, and filler injection of all temporary and permanent, internal and external ducts. Payment also includes anchorage assemblies and associated supplemental reinforcing steel required by supplier, PT system hardware not embedded in concrete, ducts, grout and grouting operations, flexible filler and filler injection operations, all testing, including construction of and filler injection into mockups, Tendon Modulus of Elasticity Test and In-Place Wobble and Friction Test, protection of PT anchorages, inlets, outlets, drains, and all labor, materials, tools, equipment, and incidentals necessary for completing the work in accordance with the Contract Documents. This payment also includes lubricants in tendon ducts for friction control and flushing lubricants or contaminants from ducts.

3. Anchorage components, ducts, and similar items of PT system hardware embedded within precast components or cast-in-place concrete will be deemed to be included in cost of precast component or cast-in-place concrete in which it is embedded.

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4. Payment is based on unit price bid extended by either quantities shown in the Contract Documents or actual quantities used and accepted, whichever is less, if the Contractor constructs structure with an accepted alternate not detailed in the Contract Documents.

5. Permanent PT strand, wire, or bar tendons which are an integral part of individual precast concrete segments or units will be measured and paid for under this item and will not be considered incidental to cost of those precast concrete segments or units.

6. Payment for PT will be made following successful placement, stressing, filler injection, inspection, repair, protection, and written approval by the Engineer.

7. Full payment for PT tendons within precast segmental concrete structure units may occur prior to erection of segments into final position when ducts have been injected and anchorage protection system applied and the segmental unit otherwise approved in writing for placement by the Engineer.

462-10.2 Pay Items:

Payment will be made under:

Item No. 462- 2- Post-Tensioning Tendons - per pound.

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SECTION 470
TIMBER STRUCTURES

470-1 Description.

Furnish and erect treated timber into various structures.

470-2 Materials.

Meet the following requirements:

Timber.....Section 952
Preservative.....Section 955

Use timber as specified in the Plans.

470-3 Timber Handling.

Handle treated timber with rope slings, without sudden dropping, breaking of outer fibers, bruising, or penetration of the surface with tools. Do not use cant dogs, hooks, or pike poles.

470-4 Cutting and Framing.

Before treatment, cut and frame all timbers which are shown by the Plans to be furnished in special lengths or framed to detailed dimensions. Limit the cutting of treated timber to minor fitting which might be necessary and that is authorized by the Engineer. For all places where the surface is broken, by cutting or otherwise, thoroughly coat with the preservatives and by the methods specified in AWPA M4.

470-5 Bolt Holes.

The Contractor may drill holes in the field. For timbers originally treated with pentachlorophenol, creosote, creosote solutions, or waterborne preservatives, field treat all cuts, abrasions, bolt holes, and recesses that occur after treatment with two liberal applications of a compatible preservative in accordance with the requirements specified in AWPA Standard M4, Standard for the Care of Pressure-Treated Wood Products.

470-6 Pile Caps.

Ensure that pile caps have full even bearing on all piles in the bent, and secure them to each pile by a 3/4 inch diameter drift bolt extending at least 9 inches into the pile. Where so shown in the Plans, cover the tops and ends of pile caps with 10 ounce, minimum weight, copper sheet meeting the requirements of ASTM B370.

470-7 Floors.

Attach the planks to each joist or nailing strip with at least two 8 inch nails for 3 inch planks, or two 10 inch nails for 4 inch planks. Use nails that are at least 1/4 inch in diameter. For treated timber floors where a bituminous wearing surface is to be applied, lay the planks with the best side up and with adjacent edges in contact. Grade the planks as to thickness before laying, and lay the planks so that no two adjacent planks vary in thickness more than 1/8 inch. Cut the floor to straight lines along the side of the roadway and walkway.

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470-8 Framing.

Cut and frame truss and bent timbers to a close fit in such manner that they will have even bearing over the entire contact surface of the joint. Do not perform blocking or shimming of any kind in making the joints. The Engineer will not accept open joints.

470-9 Holes for Bolts, Dowels, Rods, and Lag Screws.

Bore holes to the diameters shown in the following table:

Table 470-1	
Hole use	Hole diameter
Drift Bolts and Dowels	1/16 inch less in diameter than the bolt or dowel to be used
Machine Bolts	same diameter as the bolt
Rods	1/16 inch greater in diameter than the rod
Lag Screws	not larger than the body of the screw at the base of the thread

470-10 Stringers.

The Contractor may use butt joints for outside stringers, but shall frame interior stringers to bear over the full width of floor beam or cap at each end. Separate the ends at least 1/2 inch to allow circulation of air, and securely fasten the ends to the timber on which they rest.

470-11 Railings.

Construct railings of treated dressed lumber.

470-12 Hardware.

470-12.1 General: Use hardware, including bolts, drift pins, dowels, rods, nuts, washers, spikes, nails and all similar incidental metal items, necessary to complete the work in accordance with the details shown in the Plans. Use common wire nails as commercially manufactured. Use ogee washers of cast or malleable iron. The Contractor may use other hardware of steel, iron, or any similar material ordinarily used in the manufacture of such articles.

470-12.2 CCA, ACQ-D, and CA-C, Treated Timber Structures: Use the fasteners and connectors as described in the following table:

Table 470-2 Hardware Requirements for Treated Timber		
Environmental condition where structure will be located	Fasteners	Connectors
Permanent wood foundations and/or where salt spray if prevalent	304 or 316 Stainless Steel	304 or 316 Stainless Steel
Structures that will be exposed to standing water or rainwater	304 or 316 Stainless Steel	304 or 316 Stainless Steel
Structures that will be situated indoors and remain dry in service	304 or 316 Stainless Steel Hot-dipped galvanized fasteners meeting ASTM A-153 requirements	304 or 316 Stainless Steel Hot-dipped galvanized connectors meeting the requirements of ASTM A-653 Class G185 sheet or better
Do not use aluminum in direct contact with treated wood.		

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470-12.3 Bolts: Use bolts of the sizes shown in the Plans with square heads and nuts and with screw threads that make close fits in the nuts. Upon completion of the installation, check all nuts for tightness, and cut off protruding bolt ends so that not more than 1/4 inch extends beyond the nut.

470-12.4 Inspection: The Engineer will inspect the hardware for quality of manufacture and accuracy of size prior to use on wood structures.

470-13 Countersinking.

Perform countersinking wherever the heads of screws or bolts would otherwise interfere with the assembly of the work. Fill recesses formed by countersinking with hot asphalt.

470-14 Method of Measurement.

470-14.1 General: The quantity to be paid for will be the plan quantity, in feet board measure, of such timber actually incorporated in and forming a part of the completed structure.

470-14.2 Method of Calculation: For calculating the quantity of timber, the width and thickness will be taken as the actual sizes shown in the Plans or ordered by the Engineer. Where special sizing is required, the width and thickness to be used will be that of the smallest commercial size from which the special piece could be cut. Lengths to be used in the calculations will be the overall lengths of the pieces as shown in the Plans, except that, where the lengths actually incorporated in the structure are less than the lengths shown in the Plans, the lengths actually incorporated will be used in the calculations. Deductions will not be made for copes, scarfs, or crownings.

470-15 Basis of Payment.

Prices and payments will be full compensation for all the work specified in this Section, including all copper covering over pile heads, caps, etc., as shown in the Plans, all hardware except such plates, lag screws, and other metal parts as may be shown in the Plans to be paid for as structural steel and all paint materials and all excavation, painting, and incidentals necessary to complete the work.

Payment will be made under:

Item No. 470- 1- Treated Structural Timber - per Thousand Board Measure.

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SECTION 471
FIBER REINFORCED POLYMER FENDER SYSTEMS

471-1 Description.

Construct fiber reinforced polymer (FRP) fender systems using components in accordance with this Section and the Plans.

Submit design calculations, shop drawings, and test reports for the FRP fender system in accordance with the Plans, the FDOT Structures Manual noted in the Plans and this Specification.

471-2 Materials.

Meet the following requirements:

Fiber reinforced polymer composites (Piles, Wales, Spacer-blocks, Decking & Splice Plates) ..... Section 973
Concrete used to fill hollow piles ..... Section 347

Use only SAE Type 316 stainless steel metallic fastening and connection hardware.

471-3 Product Acceptance.

Obtain fender system components from a producer that is currently on the list of Producers with Accepted Quality Control Program for Fiber Reinforced Polymer Composites. Producers seeking inclusion on the list shall meet the requirements of 105-3.

Submit to the Engineer the manufacturer's certification in accordance with Section 6 that the FRP components meet the material requirements of Section 973.

471-4 Shop Drawings and Design Calculations.

471-4.1 Shop Drawings: Submit shop drawings in accordance with Section 5. Include the following, as a minimum, in the shop drawings:

1. General notes.
2. Energy absorption capacity (EAC) of the fender system (in units of kip-ft).
3. Fender system deflection (in units of feet).
4. Minimum pile tip elevation.
5. The name and address of the manufacturer for each component, including the physical address where the fabrication is performed.
6. Pile configuration and layout based on, and compatible with, the geometry shown in the Plans.
7. Pile and wale material properties including fill material used for hollow piles and required admixtures. If the material properties are defined in the Standard Specifications, a reference to the applicable Sections.
8. Pile and wale section properties used in the design.
9. Flexural and shear resistance of the pile and wale components.
10. Pile-to-wale and pile-to-pile connection details.
11. Sections, views, details, and dimensions required to successfully complete the construction of the fender system.
12. Any supplier required limitations regarding pile installation techniques or other typical construction practices permitted by Section 455 (e.g., full length pile driving versus jetting/driving combination).

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471-4.2 Design Calculations: Submit design calculations. Design fender system piles, wales, and connections in accordance with the Plans, this Specification, and the FDOT Structures Manual edition noted in the Plans.

471-5 Performance and Testing Requirements.

An independent laboratory must perform all testing and produce the test report. Submit a test report with the following information:

1. Written certification that the fender system components meet the requirements of this Section.
2. Verification of the flexural properties of the pilings and wales as derived from ASTM D6109 using characteristic values in accordance with ASTM D7290 with the following modifications:
    a. Supports shall be located to provide a minimum span-to-depth ratio of 16:1 and a maximum span to depth ratio of 20:1.
    b. Three-point bending tests are acceptable.
    c. Test a minimum of 5 of the same sample of the FRP piling(s) and FRP wale(s) shown on the Shop Drawings.
    d. Do not include adhesive bonding of individual components within a system during verification testing.
3. For hollow FRP sections, verification of shear properties as derived from ASTM D2344. Test a minimum of 5 of the same sample of the hollow FRP sections shown in the Shop Drawings.
4. Detailed material specifications showing material type, quality, certifications, acceptance and rejection criteria and placement procedures.
5. Other information pertinent to the design and performance of the fender system as necessary.

471-6 Design Criteria.

471-6.1 Wales: Wales must meet the following minimum design criteria:

1. Be structurally continuous across a minimum of two spans.
2. Recess all hardware a minimum of 1/2-inch from the front face of wales.
3. Provide fasteners and connection hardware that prevent loosening over time.
4. Provide adequate stiffness to distribute vessel impact loading to meet the minimum required energy absorption capacity (EAC) of the system.
5. Use wales that meet or exceed the flexural and shear demands of the minimum EAC. The minimum flexural resistance must not be less than 40 ft-kip.
6. Meet the following criteria for hollow wale sections:
    a. Provide a minimum of 1/4-inch wall thickness.
    b. Provide a minimum bolt pull-through and crushing resistance greater than or equal to the maximum connection reaction force. Pull-through and crushing resistance is defined at the point of first yield and/or the load at which an audible crack occurs.
    c. Must be capable of resisting crushing loads perpendicular to the axis of the member as required for the impact force applied to the fender in the analysis used to determine the associated EAC of the system. This impact force may be equally distributed between two lines of wales and over a longitudinal distance of five feet.
    d. The minimum shear resistance must not be less than 40 kip.
7. Provide black wales unless otherwise shown in the Plans.

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8. Wales, other than RTSS as defined in Section 973, must include minimum 1-1/2" thick UHMW-PE wearing surface.

471-6.2 Piles: Piles must meet the following minimum design criteria:

1. Provide fasteners and connection hardware that prevent loosening over time.

2. For hollow pile sections, provide a minimum bolt pull-through and crushing resistance greater than or equal to the maximum connection reaction force. Pull-through and crushing resistance is defined at the point of first yield and/or the load at which an audible crack occurs.

3. Provide black piles unless otherwise shown in the Plans.

471-7 Storage, Handling and Installation.

Unless otherwise shown in the manufacturer's approved field construction manual, use the following construction details.

Protect materials at all times against exposure to extreme heat or impact. Transport products in a manner that will minimize scratching or damage to the outer surfaces, stack on dunnage above ground so that it may be easily inspected and store in a manner that will avoid damage. Handle and lift products with nylon slings. Do not use sharp instruments in handling the product. Products damaged in shipping or handling will be rejected.

Products containing cracks in the reinforcing rods, or cracks or splits (partial or full depth) across the section will be rejected.

Cut, bevel, drill, countersink and otherwise install products in accordance with the manufacturer's recommendations. Set all material accurately to required levels and lines, with members plumb and true and accurately cut and fitted. Securely attach all materials to substrate by anchoring and fastening as shown in the shop drawings. Perform all cutting and drilling in a manner that allows for the collection of all debris and dispose of properly.

Field installation of grout or concrete inside of hollow wales is not allowed.

Install piles in accordance with Section 455.

471-8 Method of Measurement.

The quantity for the entire fender system to be paid will be lump sum.

471-9 Basis of Payment.

471-9.1 Price and payment for fender system will be full compensation for the work specified in this Section including all labor, equipment and materials required to furnish and install the piles to the pile cut-off elevations shown in the Plans, and all wales, dimensional lumber, material, storage costs, disposal of unused material and waste, transportation costs, fasteners and other necessary items required for completing the work.

Payment will be made under:

Item No. 471- 3- Fender System Polymeric - lump sum.

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SECTION 502
SHEAR CONNECTORS

502-1 Description.

Furnish and install welded shear connectors on steel beams and girders at locations shown in the Contract Documents. Field weld shear connectors located on the top flange only after the deck forms are in place. Installation of shear connectors in the fabrication plant is not permitted.

502-2 General Requirements.

502-2.1 Design: Provide shear connector studs of a design suitable for end-welding to steel beams and girders, with automatically timed stud welding equipment. Provide the type, size or diameter, and length of stud as specified by the Contract Documents, and as approved by the Engineer. Meet the allowable tolerances on dimensions as specified in 502-7.

502-2.2 Arc-Shield: Furnish an arc-shield (ferrule), of heat-resistant ceramic or other suitable material, with each stud. Use material that is not detrimental to the welds, does not cause excessive slag, and has sufficient strength not to crumble or break due to thermal or structure shock before the weld is completed.

502-2.3 Flux: Furnish flux for welding with each stud, either attached to the end of the stud or combined with the arc-shield for automatic application in the welding operation.

502-2.4 Coatings: Do not paint or galvanize studs.

502-2.5 Qualification: Use only qualified studs, passing the tests prescribed in 502-6. Use the same arc-shield in production as used in the qualification tests.

502-2.6 Data to be Submitted: Before placing orders for studs, submit to the Engineer for approval, the following information on the studs to be purchased:

1. The name of the manufacturer.
2. A detailed description of the stud and arc-shield to be furnished.
3. A certification from the manufacturer that the stud is qualified as specified in 502-2.5.
4. The qualification test report as certified by the testing laboratory.

502-2.7 Freedom from Defects: After welding, ensure that the studs are free from any defect or substance that would interfere with their function as shear connectors.

502-3 Materials.

502-3.1 Metal: For shear connector studs, meet the requirements of ASTM A108, cold-drawn bar, Grades 1015, 1017, or 1020, either semi-killed or fully-killed. If using flux-retaining caps, use caps of a low-carbon grade steel suitable for welding and meeting the requirements of ASTM A109.

502-3.2 Mechanical Properties: For tensile properties as determined by tests of bar stock after drawing, or of finished studs, meet the following requirements:

Tensile strength	60,000 psi (minimum)
Yield strength*	50,000 psi (minimum)
Elongation	20% in 2 inches (minimum)

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Reduction of area ..... 50% (minimum)
*As determined by 0.2% offset method.

Determine tensile properties in accordance with ASTM A370. Perform tensile tests of finished studs on studs welded to test plates. If fracture occurs outside of the middle half of the gage length, repeat the test.

502-3.3 Quality and Finish: Provide finished studs of uniform quality and condition, free from injurious laps, fins, seams, cracks, twists, bends, and other injurious defects. Produce a finish by cold drawing, cold rolling, or machining.

502-3.4 Certification: Ensure that the manufacturer certifies that the studs, as delivered, are in accordance with the materials requirements of this Subarticle. Submit certified in-plant quality control test reports to the Engineer upon request.

502-4 Construction Requirements.

502-4.1 Equipment: End weld stud shear connectors to steel beams or girders with automatically timed stud welding equipment connected to a suitable power source.

502-4.2 Interlocking: If two or more stud welding guns are to be operated from the same power source, interlock them so that only one gun at a time can operate and the operating gun finishes each weld before starting another weld.

502-4.3 Condition of Studs: At the time of welding, ensure that the studs are free from rust, rust pits, scale, oil, and other deleterious matter which would adversely affect the welding operation.

502-4.4 Weather Limitations: Do not weld when the base metal temperature is below 0ºF, or when the surface is wet or exposed to rain or snow.

502-4.5 Position of Welding Gun: While operating, hold the welding gun in position without movement until the weld metal has solidified.

502-4.6 Preparation of Areas: Prepare the surface where studs are to be welded by wire-brushing, peening, prick-punching, grinding, or other approved methods to remove paint, scale, rust, oils, or other deleterious matter which would adversely affect the welding operation.

502-4.7 Spacing: Ensure that longitudinal and lateral spacing of studs with respect to each other and to edges of beam or girder flanges does not vary more than 1/2 inch from the dimensions shown in the Plans. However, the Engineer will allow a variation of 1 inch where required to avoid interference with other attachments on the beam or where welding a new stud to replace a defective stud. Provide a minimum distance of 1 inch from the edge of a stud to the edge of a beam, but where possible provide at least 1-1/2 inches.

502-4.8 Testing: After allowing them to cool, bend the first two studs welded on each beam or girder, 45 degrees by striking the stud with a hammer. If failure occurs in the weld of either stud, correct the procedure, and weld and test two successive studs successfully before welding any more studs to the beam or girder. Inform the Engineer of any changes in the welding procedure at any time during construction. When the temperature of the base metal is below 32ºF, bend one stud in each 100 studs welded 45 degrees in addition to the first two bent as specified above.

502-4.9 Repair of Welds: The Contractor may repair studs, on which a full 360 degrees weld is not obtained, in accordance with the procedures of ANSI/AASHTO/AWS D1.5, Bridge Welding Code.

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502-4.10 Reduction in Height: If the reduction in the height of studs as they are welded becomes less than 1/16 inch, immediately stop welding and correct the cause. Do not resume welding until the cause has been corrected.

502-4.11 Replacing Studs: Before welding the replacement stud, remove the defective stud, grind the area smooth and flush or, in the case of a pullout of metal, fill the pocket with weld metal, using the shielded metal-arc process with low-hydrogen welding electrodes, and then grind flush. In compression areas of flanges, the Contractor may weld a new stud adjacent to the defective area in lieu of repair and replacement of the existing weld.

502-5 Inspection Requirements.

502-5.1 Bend Test: If visual inspection reveals any stud which does not show a full 360 degrees weld, any stud which has been repaired by welding, or any stud in which the reduction in height due to welding is less than normal, strike such stud with a hammer and bend 15 degrees off the vertical. For studs showing less than a 360 degrees weld, bend the stud in the direction opposite to the lack of weld. Replace studs that crack in either the weld or the shank. The Engineer may select additional studs to be subjected to the bend test specified above. The Contractor may leave the tested studs that show no sign of failure in the bent position.

502-5.2 Unsatisfactory Work: If, during the progress of the shear connectors work, inspection and testing indicate that the shear connectors being obtained are not satisfactory, make such changes in welding procedure, welding equipment, and type of shear connector as necessary to secure satisfactory results, at no expense to the Department.

502-5.3 Requalification: If the Engineer requests, require the manufacturer of the studs to submit sample studs for requalification in accordance with the procedures of 502-6, at no expense to the Department.

502-6 Qualification Procedure.

502-6.1 Purpose: The purpose of this procedure is to prescribe weldability tests which will qualify a shear connector stud for welding under shop or field conditions. The Contractor may have a university, independent laboratory, other testing authority, or agency perform the tests. Ensure that the agency performing the tests submits to the manufacturer of the stud a certified report giving procedures and results for all tests, including the information listed under 502-6.9.

502-6.2 Duration of Qualification: Once a type and size of stud with arc-shield has been qualified, the Engineer will consider the stud qualified until the manufacturer makes any change in the base of the stud, the flux, or the arc-shield, which affects the welding characteristics.

502-6.3 Preparation of Specimens: Prepare test specimens by welding representative studs to the center of square specimen plates, 1/2 to 3/4 inch thick, of structural steel, ASTM A36. The manufacturer may weld studs to a large plate and cut the specimen plates to a size suitable for test equipment used.

502-6.4 Welding Procedure: Weld studs with manufacturer recommended power source, welding gun, and control equipment. Measure welding voltage, current, and time by suitable instrumentation, and record these measurements for each specimen. Ensure that lift and plunge are at the manufacturer-recommended optimum setting.

502-6.5 Number of Test Specimens:

1. Weld 30 test specimens consecutively, with time held constant at optimum but with current 10% below optimum.

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2. Weld 30 test specimens consecutively, with time held constant at optimum but with current 10% above optimum.

502-6.6 Qualification Tests:

502-6.6.1 Tensile Tests: Subject 10 of the specimens welded in accordance with 502-6.5(1), 10 in accordance with 502-6.5(2) to a tensile test. The Engineer will consider a stud qualified if all test specimens have a tensile strength above the minimum specified in 502-3.2.

502-6.6.2 Bend Tests: Place 20 of the specimens welded in accordance with 502-6.5(1), 20 in accordance with 502-6.5(2) in a bend testing device, and bend alternately 30 degrees in opposite directions until failure occurs. The Engineer will consider a stud qualified if, on all test specimens, fracture occurs in the shank of the stud and not in the weld.

502-6.7 Retest: If weld failure occurs in any of the tensile or bend test groups, the Contractor may retest that group. If weld failure repeats, consider the stud as having failed to qualify.

502-6.8 Qualification: For a manufacturer's studs and arc-shields to be qualified, ensure that each group of 30 studs, by test or retest, meets the requirements prescribed in 502-6.6.

502-6.9 Report of Tests: Include the following in the laboratory report:

1. Drawings which show shapes and dimensions with tolerances of studs, arc-shields, and flux.

2. A complete description of materials used in the studs and arc-shields, including the quantity and analysis of the flux.

3. A certification that the studs and arc-shields described in the report are qualified in accordance with 502-6.8.

502-7 Dimensions and Tolerances.

Meet the following dimensions and tolerances:

Table 502-1

C	L*	H	T
3/4 - 1/64 inch	4 +0.062 inches 4 -0.125 inches	1-1/4 ± 1/64 inch	3/8 inch minimum
7/8 - 1/64 inch	4 +0.062 inches 4 -0.125 inches	1-3/8 ± 1/64 inch	3/8 inch minimum

*4 inches length is standard.
The Contractor may obtain other lengths by special order.

Where:

C = Shaft diameter
L = Total stud length measured from top of head to base of shaft
H = Diameter of head
T = Thickness of head

502-8 Method of Measurement.

For the purpose of payment, shear connectors will be classified as Structural Steel. The quantity to be paid for will be determined in accordance with Section 460.

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502-9 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including furnishing and installing shear connectors.

Payment will be made in accordance with Section 460.

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SECTION 504
STEEL GRID FLOORS

504-1 Description.

Furnish and erect open-type steel grid roadway and sidewalk floors, on the movable spans of bridges and at other locations shown in the Plans. Where specified in the Plans, completely fill the floor with concrete.

504-2 Materials and Construction Methods.

504-2.1 General: Meet the following requirements:

Portland Cement Concrete	Section 346
Structural Steel and Miscellaneous Metals	Section 460
Shop, Field, and Maintenance Painting of Structural Steel	Section 560

504-2.2 Roadway Floor: Construct the roadway floor as an open steel grid with rectangular openings. Place and weld the grid to the floor stringers as shown in the Plans. If the flooring requires secondary or supplemental stringers, the Department will consider these stringers and their fastenings a part of, and included in, the materials to be furnished and erected under this Section.

504-2.3 Sidewalk Floor: Erect sidewalk flooring consisting of a system of main bars and secondary bars, arranged in a system of rectangular, reticulum or U-shaped openings. Do not allow the clear distance in any opening to exceed 5/8 inch in one direction. Do not allow the longest dimension of any opening to exceed 3 inches. Place and weld the floor to the supporting members in accordance with the details shown in the Plans, or in accordance with the manufacturer's directions as approved by the Engineer.

504-2.4 Conformance with Manufacturer's Specifications: Meet the manufacturer's specifications for the material and construction methods, as approved by the Engineer, for any type of steel floor used.

504-2.5 Use of Trade Names: Where the Plans refer to the type of floor by manufacturer's designation or trade name, the Contractor may use a similar floor providing equivalent section modulus per unit width, and equivalent surface qualities, if approved by the Engineer.

504-3 Painting.

Apply to all exposed areas of steel grid floors the same number, type, and thicknesses of paint coatings as are specified for painting structural steel. Prepare the surface the same as required for painting structural steel. Although not required, the Contractor may apply paint on areas to be covered by concrete.

504-4 Method of Measurement.

The quantities to be paid for will be the plan quantity, in square feet, installed, complete and accepted. Proper deductions for open joints in the floor will be made in calculating plan quantity.

504-5 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section, including furnishing and installing the complete floor above the tops of the main floor members

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shown in the Plans, furnishing and installing any secondary joists which are required in addition to the main floor members, filling any specified portion with concrete, furnishing paint materials, painting, and welding.

Payment will be made under:

Item No. 504-	1-	Steel Roadway Floor - per square foot.
Item No. 504-	2-	Sidewalk Floor Steel - Rehab - per square foot.

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SECTION 506
BRIDGE DRAINAGE SYSTEM

506-1 Description.

Construct drainage facilities and accessories to collect and dispose of water from drains on the bridge structures, in accordance with the details shown in the Plans.

506-2 Materials.

Use materials as specified or required in the Plans. For aluminum materials, submit a certified mill analysis, along with a certificate from the producer stating that the materials used meet all requirements of these Specifications. Submit such reports to the Engineer.

506-3 Method of Measurement.

The quantity for bridge drainage system to be paid for will be at the Contract lump sum price.

If bridge drainage piping is included in the Contract, the quantity to be paid for will be at the length, in feet.

If bridge drains are included in the Contract, the quantity to be paid for will be at the Contract unit price for each.

506-4 Basis of Payment.

Prices and payments will be full compensation for all work, equipment, and materials specified in this Section or shown in the Plans, including the complete installation of the drainage system for the bridge structure.

Payment will be made under:

Item No. 506- 1-	Bridge Drainage System - lump sum.
Item No. 506- 2-	Bridge Drainage Piping - per foot.
Item No. 506- 3-	Bridge Drains - each.

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SECTION 510
NAVIGATION LIGHTS FOR FIXED BRIDGES

510-1 Description.

Furnish and install navigation lighting systems, including all wiring, conduit, wiring devices, transformers, enclosures, grounding system, controls, protective devices, lights, etc., as shown in the Plans and in compliance with Code of Federal Regulations (CFR), Title 33, Part 118, which is further clarified in U.S. Coast Guard (USCG) Publication "A Guide to Bridge Lighting". Navigation lights must operate from sunset to sunrise and during periods of low visibility.

510-2 Coordination of Electrical Work.

Use experienced personnel in the type of work required by the Contract Documents to provide a complete and satisfactory fitting and fully operational installation. Perform all electrical work either by, or under the immediate supervision of an electrical journeyman.

Schedule and arrange electrical work in a neat, well-organized manner without interference with the work scheduling of other trades.

510-3 Materials and Equipment.

Meet the equipment and material requirements as shown in the Contract Documents.

Furnish and install only materials and equipment of new stock meeting ANSI, NEC, NEMA, and UL requirements, and approved by the Engineer, except where the Contract Documents allow or specify the use of other than new equipment.

Furnish and install marine type products manufactured of corrosion resistant materials.

Furnish and install only fasteners manufactured from ASTM 316 stainless steel with yield strength 35,000 psi or higher.

Furnish and install ASTM 300 series stainless steel conduit straps or hangers held at not less than two points.

Furnish and install framework for supporting boxes, switches, and other externally mounted electrical devices fabricated from ASTM A709 Grade 36 hot-dip galvanized structural steel.

510-4 Navigation Lights and Aids.

510-4.1 Navigation Lights: Equip all navigation lights with a LED array with a minimum of 50,000 hour life and bright enough to meet the visibility requirements of CFR Title 33, Part 118. Mount LED arrays on an internal shock and vibration isolator. Provide, in the circuit, a lightning surge suppressor capable of absorbing multiple strikes without replacement. Provide special power supply to provide current limited DC voltage to the LED array.

Furnish and install fixtures with unpainted housings of heavy duty cast aluminum or bronze construction with a 1-1/2 to 2 inch threaded conduit opening on the bottom. Use only marine type mounting boxes with minimum 3/4 inch conduit opening. Furnish and install fixtures with lenses that are standard marine molded, single-piece fresnel type, rigid, heat resistant glass or U.V. resistant polycarbonate and inside diameter of 7 to 8 inch. Furnish all stainless steel closure bolts, lens tie rods, and attachment hardware for a complete and accepted installation.

Furnish and install pier/fender lights, center channel lights and channel margin lights with cast aluminum or bronze swivel assembly and mounting bracket, complete with

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stainless steel pivot, watertight "O" ring seal, bronze bearings, cable entrance fitting, and stainless steel service chain rated for a minimum 225 pounds load. Use a 1-1/2 or 2 inch galvanized pipe or stainless steel pipe as a hanger stem with automatic lock at service and operating positions. Furnish and install a 60% counterweight if stem exceeds 5 feet in length.

Ensure the pier/fender Light is equipped with a red 180 degree lens, the center channel light is equipped with a green 360 degree lens and the channel margin light is equipped with a red 180 degree lens.

510-4.2 Clearance Gauge Lights: Furnish and install one-piece die-cast aluminum fixture housing fitted with watertight gasket, stainless steel hinges and fasteners, and adjustable aiming capability, equipped with a 120 V_{AC} 50 watt, high-pressure sodium lamp. Use a heavy cast aluminum connection box body and cover with stainless steel swing bolts, watertight gasket and provisions for mounting to a platform with four stainless steel lag bolts or screws.

510-5 Disconnect Switches.

Furnish and install switches that are HP rated and meet Federal and NEMA Specifications with NEMA Type 4X (stainless steel) enclosures, and with metal factory nameplates that are front cover mounted and contain a permanent record of switch type, catalog number, and HP rating. Provide switch with visible blades, reinforced fuse clips, and non-teasible, positive, quick make-quick break mechanisms. Provide switch assembly plus operating handle as an integral part of the enclosure base.

Use switches with defeat able door interlocks that prevent the door from opening when the operating handle is in the ON position, and whose handle position is easily recognizable and is padlockable in the OFF position. Use heavy-duty switches with line terminal shields.

510-5.1 Fusible Switch Assemblies: Furnish and install NEMA KS 1 type; load interrupter enclosed knife switch. Provide fuse Clips that are designed to accommodate Class R fuses.

510-5.2 Non-fusible Switch Assemblies: Furnish and install NEMA KS 1; HD type, load interrupter enclosed knife switch.

510-5.3 Enclosures: Furnish and install NEMA KS 1 type enclosure as shown in the Contract Documents.

510-5.4 Installation: Install disconnect switches where indicated in the Contract Document or where required by the Engineer. Use separate conduits for line and load conductors. Install fuses in fusible disconnect switches.

510-6 Supporting and Mounting Devices.

Ensure the sizes, and types of anchors, fasteners and supports used are adequate to carry the load of the equipment and conduit, including the wire in the conduit.

Space conduit supports to avoid conflicts with reinforcing steel at 5 feet maximum. For concrete mounting, use anchor bolts and all matching parts and tools recommended by and provided by the same manufacturer, as well as suitable for dynamic loading caused by vibration due to traffic. To mount conduit supports and pull boxes, use 1/4 inch diameter anchor system. To mount channel lights use minimum 1/2 inch diameter anchor system with 3-1/2 inch embedment and 8 inch edge distance.

Use ASTM 300 series stainless steel conduit straps or hangers held at not less than two points.

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Do not use powder-actuated anchors. Do not drill or weld structural steel members. Do not use bolts smaller than 1/4 inch in diameter except as may be necessary to fit the mounting holes in small and light devices. Install surface-mounted boxes with minimum of three anchors.

510-7 Conduit.

510-7.1 General: Furnish and install conduit in the quantities and sizes required to complete the work as shown in the Plans and as required by NEC. Use products listed and classified by UL as suitable for purpose specified and shown. Do not use non-metallic flexible conduit, aluminum, or electrical metallic tubing (EMT).

510-7.2 Liquid-Tight Flexible Metal Conduit: Furnish and install, liquid-tight flexible metal conduit of interlocked steel construction with PVC jacket, and fittings meeting the requirements of ANSI/NEMA FB 1.

510-7.3 PVC Conduit: Furnish and install, schedule 80 PVC 3/4 inch minimum diameter conduit meeting the requirements of ASTM D1785 and NEMA TC 2 and fittings and conduit bodies meeting the requirements of ASTM D2467 and NEMA TC 3.

510-7.4 Fiberglass Reinforced Epoxy Conduit: Furnish and install rigid non-metallic fiberglass reinforced epoxy conduit and fittings manufactured in accordance with the applicable standards of ANSI and NEMA TC-14B.

Ensure the conduit has a bell and spigot type coupling and the coupling seal is made rigid by using an adhesive that will provide a water and vapor tight joint with a tensile strength equal to that listed for the conduit. An alternative type assembly may be used by applying a triple seal ribbed gasket of water resistant rubber material. Ensure the gasket is held firmly in place with a compatible adhesive.

Ensure that all fittings, adapters, and bends are manufactured from the same materials as the conduit and conform to the dimensional requirements of NEMA TC-14.

Use only fiberglass reinforced epoxy conduit and fittings made by the same manufacturer to insure proper fit and assembly, listed on the UL approved list and labeled for Type I service sizes 2 to 6 inches.

Ensure that each piece of conduit and fitting is clearly marked with durable contrasting ink, stenciled with the following:

1. Nominal size,
2. Bends to show the degree and radius of curvature,
3. Type: SW or HW,
4. Manufacturers' name or trademark.

510-7.5 Installation: Install conduit in accordance with National Electrical Contractors Association (NECA) "Standard of Installation" and manufacturer's instructions.

Arrange supports to prevent misalignment during wiring installation. Support conduit using straps, lay-in adjustable hangers, clevis hangers, and split hangers. Do not support conduit with wire or perforated pipe straps, plastic straps, or plastic hangers. Ensure that all wire used for temporary supports is removed upon completion of installation.

Install an expansion fitting for specified PVC conduit at all structure expansion joints or where movement between adjacent sections of conduit is expected. Submit certification to the Engineer from the manufacture that the expansion fitting meets the following minimum requirements: compatibility with the connected conduits, water proof, UV protected, and allows longitudinal movement equal to that of the expansion joint or movement expected.

Route exposed conduit parallel and perpendicular to walls and concrete barriers or route conduit in traffic railings. Install conduits to be continuous and watertight between boxes

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or equipment. Protect conduits at all times from the entrance of water and other foreign matter by being capped or well plugged overnight and when the work is temporarily suspended.

Cut conduit square using saw or pipe cutter; de-burr cut ends. Bring conduit to shoulder of fittings; fasten securely. Use conduit hubs to fasten conduit to metal boxes. Do not install more than the equivalent of three 90 degree bends (total 270 degrees) between boxes. Use conduit bodies to make sharp changes in direction such as around diaphragms.

Join PVC conduit using cement recommended by manufacturer. Wipe PVC conduit dry and clean before joining. Apply full even coat of cement to entire area inserted in fitting. Allow joint to cure for a minimum of 20 minutes before pulling conductors.

Do not use flexible conduit extensions greater than 24 inches in length. Ensure that all flexible conduit extensions are equipped with bonding jumpers.

Do not allow moisture traps; provide pull box with drain fitting at low points in exposed conduit system.

510-8 Wiring.

510-8.1 General: Do not use aluminum conductors. Use only SE or RHW on incoming service and use single conductor with XHHW insulation, unless otherwise noted in the Plans.

Do not use wire smaller than No. 12 AWG.

Furnish insulated conductors of seven or nineteen strand copper with a minimum 98% conductivity and connector accessories for copper in sufficient quantities for a complete installation.

510-8.2 Installation: Use pull boxes wherever necessary to facilitate the installation of the conductors. Do not use condulets for pulling more than ten conductors or for branching conductors.

Splice only in accessible boxes. Make lug connections with high pressure indent connector tools as recommended by the lug manufacturer. Make splices and taps to carry full ampacity of conductors without perceptible temperature rise. Tighten all connections to manufacturer's recommendations. Tape uninsulated conductors and connectors with electrical tape to 150% of the insulation value of conductor. Ensure all splices are waterproof.

Use solderless pressure connectors with insulating covers for No. 8 AWG and smaller wire splices and taps. Use split bolt connectors for No. 6 AWG and larger wire splices and taps.

Pull all conductors into a raceway at the same time. Use soap base wire pulling lubricant for pulling No. 4 AWG and larger wire.

510-8.3 Testing: Test each circuit for continuity and short-circuits for its complete length before being connected to its load.

Inspect wire and cable for physical damage and proper connection.

510-8 Method of Measurement.

The quantity to be paid for will be at the Contract lump sum price, completed and accepted.

510-9 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 510- 1- Navigation Lights - lump sum.

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SECTION 514
GEOSYNTHETIC FOR DRAINAGE APPLICATIONS

514-1 Description.

This Section specifies the construction requirements for geosynthetics used in drainage, slope protection, and material separation applications.

514-2 Material.

Use geosynthetic materials meeting the requirements of Section 985 and listed on the Approved Product List (APL). Ensure the geosynthetic materials received at the job site are in unopened shipping packages and the packages are clearly labeled with the manufacturer's name, product name, style number, roll dimension and LOT number, otherwise, the Engineer will reject the material. Store geosynthetic materials in accordance with the manufacturer's instructions ensuring to protect the geosynthetic material from physical damage, debris, and temperatures greater than 140° F. Prevent mud, fluid concrete, asphalt, or other deleterious materials from coming in contact with the geosynthetic materials that could impact the performance of the geosynthetic material. Replace geosynthetic materials with defects, tears, punctures, flaws, deterioration, or other damage at no additional cost to the Department.

514-3 Construction Methods.

514-3.1 Geosynthetic Materials for Drainage Applications: Select a geosynthetic material meeting the appropriate application as specified in 985-3. Place and install the geosynthetic material at the proper elevation, location and orientation as shown in the Contract Documents and in accordance with the manufacturer's instructions. Place the geosynthetic material on areas with a uniform slope that are reasonably smooth, free from mounds, windrows, and any debris or projections which might damage the geosynthetic material. When overlapping is necessary, the Contractor may sew the seams to reduce overlaps as specified in 985-2.6.

After placement of the geosynthetic material, do not exceed the manufacturer's recommendations for exposure to ultraviolet light or five days, whichever is less. If the exposure time is exceeded, remove and replace the geosynthetic material.

514-3.2 Subsurface Drainage Applications: When indicated in the Plans, place the geosynthetic material with the long dimension parallel to the trench. Place and install the geosynthetic material to provide a minimum 12-inch overlap for each joint or in accordance with the manufacturer's recommendation, whichever is greater. Do not drop coarse aggregate materials from heights greater than 3 feet.

514-3.3 Revetment System Applications: Overlap adjacent strips of geosynthetic material at a minimum of 24 inches and in accordance with the manufacturer's recommendations, whichever is greater. Anchor the geosynthetic materials with securing pins inserted through both strips of geosynthetic material along a line through the midpoint of the overlap and to the extent necessary to prevent movement of the geosynthetic material.

Place the geosynthetic material so that the upstream (upper) strip of geosynthetic material overlaps the downstream (lower) strip. Stagger vertical laps a minimum of 5 feet. Use full rolls of geosynthetic material whenever possible to reduce the number of vertical laps. Do not drop bedding stone or riprap from heights greater than 3 feet onto the geosynthetic material.

514-3.4 Repairs: Replace geosynthetic material damaged during or after installation at no cost to the Department. Repair geosynthetics damaged during or after installation only after

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the manufacturer establishes that the intended use and stability is not affected and after obtaining the Engineer's approval. Make such repairs as follows:

Remove materials placed within the damaged geosynthetic area plus an additional 4 feet in all directions beyond the limits of the damage. Place a patch consisting of the same material as the geosynthetic material over the damaged area in accordance with the manufacturer's recommendation. Overlap the undamaged geosynthetic material with the patch at a minimum of 3 feet in all directions. Place backfill material on the geosynthetic material in accordance with the Contract Documents after repairs have been completed.

For repairs of Geosynthetic material placed on slopes adjacent to water, place geosynthetic material so that the upstream (upper) strip of geosynthetic material overlaps the downstream (lower) strip.

514-4 Acceptance Criteria.

Submit to the Engineer the product label with the manufacturer's name, product name, style number, roll dimension and LOT number at least fourteen days prior to placement. In addition, provide two 8-inch by 10-inch samples of geosynthetic materials for product identification to the Engineer. The acceptance of the geosynthetic material is subject to the approval of the State Materials Office (SMO).

514-5 Basis of Payment.

No separate payment will be made for the work specified in this Section. The cost of furnishing, placing, and sewing or overlapping the fabric will be included in the Contract price for the items to which it is incidental.

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SECTION 515
METAL PEDESTRIAN/BICYCLE RAILINGS, GUIDERAILS, AND HANDRAILS

515-1 Description.

Furnish and install metal pedestrian/bicycle railings, including bullet rails, guiderails and handrails in accordance with the Plans and Standard Plans.

515-2 Materials.

Meet the following requirements:

Concrete	Section 346
Anchor Bolts, Rods, Nuts and Washers*	Section 962
Adhesive Anchors**	Section 937
Aluminum**	Section 965
Bearing Pads**	932-2.5
Epoxy Mortar**	Section 926
Steel**	Section 962

*Do not use expansion anchors.

**Use products listed on the Department's Approved Product List (APL).

515-3 Construction Requirements.

515-3.1 General: Space posts to clear obstacles without exceeding maximum post spacing and maintain a uniform spacing with reasonable consistency. Place splices in approximately the same place within a railing section.

Railings must be free of burrs and sharp edges and all plug welds ground smooth.

515-3.2 Welds: An American Welding Society certified welding inspector must visually inspect all welds for final approval. Nondestructive testing of welds is not required, unless otherwise shown in the Plans. Prior to installation of the railings, a certifying statement from the welding inspector must be provided. The document must identify the project information, date of inspection, welding inspector name, and inspector certification number.

515-3.2.1 Aluminum Railing: Welds must be in accordance with Section 965. Filler material for seal welds, plug welds and bend splices may be ER4303.

515-3.2.2 Steel Railing: Meet the requirements of Section 962, except weld connections must be in accordance with AWS D1.1, Structural Welding Code, using E70XX weld material, unless otherwise shown in the Plans.

515-3.3 Coatings:

515-3.3.1 Aluminum Railing: Coating is not required, unless otherwise shown in the Plans. Finished product must have a smooth uniform appearance.

When a colored coating is required, use a fluoropolymer based powder coating system complying with American Architectural Manufacturers Association (AAMA) Specification No. 2605.

515-3.3.2 Steel Railing: Components must be hot-dip galvanized after fabrication in accordance with Section 962, unless otherwise shown in the Plans. When a colored coating is required, meet the requirements of 649-4.

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515-4 Shop Drawings.

Submit shop drawings and obtain approval prior to fabrication in accordance with Section 5. Show project specific geometry (line and grade), post type and locations, expansion joint and splice locations.

Include other project specific details such as tapered end transitions, continuity or transition details post and panel infill type, and anchor bolt general details.

515-5 Installation.

515-5.1 General: Place a 1/8 inch thick bearing pad with dimensions matching the base plate between the base plate and concrete surface.

515-5.2 Bullet Railings: Install rail posts perpendicular to the profile grade longitudinally and plumb transversely.

515-5.3 Pedestrian /Bicycle Railings and Guiderails: For locations other than bridges, fabricate and install posts plumb. On bridges, fabricate and install posts perpendicular to the profile grade line longitudinally and plumb transversely. Use aluminum shim plates to make necessary adjustments. Bond stacked shim plates with adhesive bonding material and field trim shim plates to match the foundation contours. Beveled shim plates may be used in lieu of trimmed flat shim plates.

If shims greater than 1/2 inch total thickness are required, provide longer anchor bolts. Bolts must be long enough to secure washers and nuts and meet the minimum embedment length.

Post tolerance from plumb is plus or minus one inch, measured at 42 inches above the foundation. Rails must form a smooth continuous line without hills or dips greater than 1/2 inch between any three posts or side sway greater than 1/2 inch between post assemblies.

515-5.4 Anchoring:

515-5.4.1 General: Secure nuts to a snug tight condition. Tack weld nuts to stem or distort bolt threads to prevent nut loosening and removal. Coat damaged galvanizing on bolt stems, nuts, and tack welds in accordance with Section 562.

515-5.4.2 Adhesive Anchors: Install anchors in accordance with Section 416.

515-5.4.3 C-I-P and Thru-Bolt Anchors: Use galvanized hex head anchor bolts. When thru-bolting is used, coat cut reinforcing steel inside the drilled hole with a zinc galvanizing compound in accordance with Section 562 prior to installing bolts.

515-5.4.4 Embedded Guiderail Posts: Core holes into the foundation concrete, then clean holes, in accordance with the manufacturer's instructions. At a minimum, use oil free compressed air to remove loose particles, brush the inside surface to free loose particles, then use compressed air again to remove any remaining particles. Use a Type AB, or F epoxy compound to secure guiderail posts into the cored holes.

515-6 Method of Measurement.

The quantity of railing to be paid for will be the plan quantity, in linear feet, installed and accepted. The quantity will be measured along the centerline of the top rail.

515-7 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including all materials, hardware, labor, and incidentals required to complete the installation.

For relocation of existing railing, price and payment will be full compensation for the

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removal and reinstallation, including all materials, hardware, labor, and incidentals required to complete the installation.

Payment will be made under the following:

Item No. 515- 1- Pipe Handrail-Guiderail - per linear foot.
Item No. 515- 2- Pedestrian/Bicycle Railing - per linear foot.
Item No. 515- 3- Handrail - Retrofit to Existing Railing - per linear foot.
Item No. 515- 4- Aluminum Bullet Railings - per linear foot.

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SECTION 520
CONCRETE GUTTER, CURB ELEMENTS, AND TRAFFIC SEPARATOR

520-1 Description.

Construct portland cement concrete curb. Curb will include concrete curb and gutter, concrete traffic separator, valley gutter, special concrete gutter, curb for sidewalk curb ramps and driveways, and any other types of concrete curb not specified in other Sections.

520-2 Materials.

520-2.1 Concrete: Use concrete meeting the requirements of Section 347.

520-2.2 Reinforcement: For all steel reinforcement required by the Plans, meet the requirements of Section 415.

520-2.3 Joint Materials: Meet the requirements of Section 932.

520-2.4 Toll Header Curb Concrete: Use concrete meeting the requirements of Section 346, Class II.

520-3 Forms.

520-3.1 Form Materials: Construct forms for this work of either wood or metal. Provide forms that are straight, free from warp or bends, and of sufficient strength, when staked, to resist the pressure of the concrete without deviation from line and grade. For all items constructed on a radius, use flexible forms.

520-3.2 Depth of Forms: Ensure that forms have a depth equal to the plan dimensions for the depth of concrete being deposited against them.

520-3.3 Machine Placement: The Contractor may place these items by machine methods with the approval of the Engineer provided that the Contractor consistently produces an acceptable finished product, true to line, grade, and cross section.

520-4 Excavation.

Excavate to the required depth, and compact the foundation material upon which these items are to be placed as specified in 120-9.

520-5 Placing Concrete.

Place the concrete in the forms, and tamp and spade it to prevent honeycombing, and until the top of the structure can be floated smooth and the edges rounded to the radius shown in the Plans.

520-6 Joints.

520-6.1 Contraction Joints: Except for machine placed items, the Contractor may form joints by using dummy joints (either formed or sawed) or by using sheet metal templates. If using sheet metal templates, ensure that they are of the dimensions, and are set to the lines, shown in the Plans. Hold templates firmly while placing the concrete. Leave templates in place until the concrete has set sufficiently to hold its shape, but remove them while the forms are still in place.

Saw contraction joints, for machine placed items, unless the Engineer approves an alternate method. Saw the joints as soon as the concrete has hardened to the degree that excessive raveling will not occur and before uncontrolled shrinkage cracking begins.

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Space contraction joints at intervals of 10 feet except where closure requires a lesser interval, but do not allow any section to be less than 4 feet in length.

520-6.2 Expansion Joints: Construct expansion joints at all inlets, at all radius points, and at other locations indicated in the Plans. Locate them at intervals of 500 feet between other expansion joints or ends of a run. Ensure that the joint is 1/2 inch in width.

520-7 Finishing.

520-7.1 Repair of Minor Defects: Remove the forms within 24 hours after placing the concrete, and then fill minor defects with mortar composed of one part portland cement and two parts fine aggregate. The Engineer will not allow plastering on the face of the curb. Remove and replace any rejected curb, curb and gutter, or valley gutter without additional compensation.

520-7.2 Final Finish: Finish all exposed surfaces while the concrete is still green. In general, the Engineer will only require a brush finish. For any surface areas, however, which are too rough or where other surface defects make additional finishing necessary, the Engineer may require the Contractor to rub the curb to a smooth surface with a soft brick or wood block, using water liberally. Also, if necessary to provide a suitable surface, the Engineer may require the Contractor to rub further, using thin grout or mortar.

520-7.3 Imprinted Concrete: Install imprinted concrete as shown in the Plans.

520-8 Curing.

520-8.1 General: Continuously cure the concrete for a period of at least 72 hours. Commence curing after completely finishing and as soon as the concrete has hardened sufficiently to permit application of the curing material without marring the surface. Immediately replace any curing material removed or damaged during the 72 hour period.

After removing the forms, cure the surfaces exposed by placing a berm of moist earth against them or by any of the methods described below, for the remainder of the 72 hour curing period.

520-8.2 Wet Burlap Method: Place burlap, as specified in 925-1, over the entire exposed surface of the concrete, with sufficient extension beyond each side to ensure complete coverage. Overlap adjacent strips a minimum of 6 inches. Hold the burlap securely in place such that it will be in continuous contact with the concrete at all times, and do not allow any earth between the burlap surfaces at laps or between the burlap and the concrete. Saturate the burlap with water before placing it, and keep it thoroughly wet throughout the curing period.

520-8.3 Membrane Curing Compound Method: Apply clear membrane curing compound or white pigmented curing compound, as specified in 925-2, by a hand sprayer meeting the requirements of 350-3.10, in a single coat continuous film at a uniform coverage of at least one gallon per 200 square feet. Immediately recoat any cracks, checks, or other defects appearing in the coating. Thoroughly agitate the curing compound in the drum prior to application, and during application as necessary to prevent settlement of the pigment.

520-8.4 Polyethylene Sheeting Method: Place polyethylene sheeting, as specified in 925-3, over the entire exposed surface of the concrete, with sufficient extension beyond each side to ensure complete coverage. Overlap adjacent strips a minimum of 6 inches. Hold the sheeting securely in place and in continuous contact with the concrete at all times.

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520-9 Backfilling and Compaction.

After the concrete has set sufficiently, but not later than three days after pouring, refill the spaces in front and back of the curb to the required elevation with suitable material. Place and thoroughly compact the material in layers not thicker than 6 inches.

520-10 Surface Requirements.

520-10.1 Straightedge: Test the gutter section of curb and gutter with a 10 foot straightedge laid parallel to the centerline of the roadway and while the concrete is still plastic. Perform straightedging along the edge of the gutter adjacent to the pavement or along other lines on the gutter cross-section, as directed by the Engineer. Immediately correct irregularities in excess of 1/4 inch.

520-10.2 Elevation and Cross Slope: Place curb and gutter so the calculated actual roadway or shoulder cross slope to be placed within the curb and gutter is within +/- 0.2% of the calculated design cross slope for that location. Once per 500 feet, check the elevation of lip of curb and gutter and calculate actual cross slope between curb and gutter on each side of a lane or set of adjacent lanes. Perform these checks prior to placement of the curb and gutter and adjust to ensure cross slope tolerance is met. After placement and curing of curb and gutter, perform the above checks again. Correct any curb and gutter found to be outside the cross slope tolerance described above.

520-11 Method of Measurement.

For curb or curb and gutter, the quantity to be paid will be the plan quantity, in feet, measured along the face of the completed and accepted curb or curb and gutter. Curb for sidewalk curb ramps or driveways will be paid at the Contract unit price for the adjacent curb type.

For valley gutter or shoulder gutter, the quantity to be paid will be the plan quantity, in feet, measured along the gutter line of the completed and accepted valley gutter or shoulder gutter.

For concrete traffic separator of constant width, meeting the requirements of Standard Plans, Index 520-020, the quantity to be paid will be the plan quantity, in feet, measured along the center of its width, completed and accepted, including the length of the nose.

For concrete traffic separator of nonstandard or varying width, the quantity to be paid will be the plan quantity, in square yards, completed and accepted.

For curb of any type next to concrete pavement, the curb-pavement joint quantity to be paid will be the plan quantity, in feet, measured along the face of the completed and accepted curb.

520-12 Basis of Payment.

520-12.1 Concrete Gutter, Curb Elements, and Traffic Separator: Price and payment will be full compensation for all work specified in this Section, including reinforcement steel, dowels, asphalt pavement and base under traffic separator, joint materials and asphalt curb pad.

520-12.2 Excavation: Excavation for new installations will be paid for as roadway excavation in accordance with 120-13.2.

520-12.3 Payment Items: Payment will be made under:

Item No. 520-	1-	Concrete Curb and Gutter - per foot.
Item No. 520-	2-	Concrete Curb - per foot.
Item No. 520-	3-	Concrete Valley Gutter - per foot.

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Item No. 520- 4-	Curb-Concrete Pavement Joint - per foot.
Item No. 520- 5-	Concrete Traffic Separator - per foot.
Item No. 520- 6-	Concrete Shoulder Gutter - per foot.
Item No. 520- 70-	Concrete Traffic Separator - per square yard.

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SECTION 521
CONCRETE BARRIERS, TRAFFIC RAILINGS, AND PARAPETS

521-1 Description.

Construct precast or cast in place concrete barriers, traffic railings, opaque visual barriers, and parapets, herein referred to as rigid barrier, in accordance with the Standard Plans and the details shown in the Plans. Use stationary removable forms or sliding forms to construct the rigid barrier. Do not use permanent precast concrete rigid barrier on bridge or box culvert structures.

Submit written certification from the manufacturer of the precast rigid barrier that the barrier meets the requirements of this Section. Rigid barrier is produced using certification acceptance; therefore, assume responsibility for performance of quality control testing and inspections required by Sections 346 and 400. Perform all Quality Control Testing and inspections using CTQP qualified testing personnel. Perform compressive strength testing in a laboratory inspected by CCRL or CMEC.

Ensure that each shipment of products to the job site includes a list of products shipped and the required written certification statement for each product. Submit this list and certifications to the Engineer.

521-2 Materials.

Meet the following requirements:

Flowable Fill	Section 121
Concrete	Sections 346 and 347
Reinforcing Steel	Section 415
Joint Materials	932-1.1
Joint Materials*	932-1.2 and 932-1.3
Barrier Delineators *	Sections 705

*Use products listed on the Department's Approved Product List (APL).

521-3 Requirements.

521-3.1 Precast Temporary Concrete Barrier: Meet the requirements of 102-9.5.

521-3.2 Precast Noise Wall Barrier Requirements: Obtain precast concrete components from a plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list must meet the requirements of Section 105.

Do not accept products that are not permanently and clearly stamped on the tongue and groove portion of the panel and posted with the type, date cast, project number, and the manufacturer's name or symbol by the Producer.

521-3.2.1 Casting Tolerances: Maintain the following casting tolerances:

1. Overall Height and Width: +/- 1/4"
2. Thickness: +/- 1/4"
3. Out of Square: 1/8" per 6 ft., but not more than 3/8" total along any side
4. Warping: 1/16" per foot distance to nearest corner
5. Bowing: 1/240 segment dimension
6. Surface Smoothness: +/- 1/16"
7. Tongue and groove joint dimensions: +/- 1/4"

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521-3.2.2 Shop Drawing Submittal: Submit shop drawings for precast elements, when required, in accordance with Section 5, showing a plan and elevation with the following project specific information:

1. Begin and end wall stations with offsets
2. Horizontal and vertical alignments of the wall
3. Segment locations and lengths
4. Segment locations for:
    a. Graphic details for architectural inlays as required
    b. Special detailing for drainage requirements
5. Elevations of top of segments
6. Existing ground and finished grade elevations
7. Top panel to precast base grouted and dowelled joint dowel and sleeve locations
8. Non-standard precast component details
9. Lifting devices

521-4 Construction.

521-4.1 General: The Contractor may use stationary removable forms or slip form construction methods provided a completed rigid barrier with acceptable alignment and finish is obtained. Do not use forms which are damaged or are not in alignment. At no expense to the Department, remove and replace sections of rigid barrier having unconsolidated concrete, surface blemishes, deviations in alignment or profile which exceed tolerances, or other defects which cannot be repaired to the satisfaction of the Engineer.

521-4.2 Stationary Form Construction: Provide precast or cast in place concrete rigid barrier constructed using stationary forms in accordance with Section 400 and provide a general surface finish. Align and erect the stationary form so that all plane surfaces of the finished barrier will have no deviation greater than 3/8 inch measured as an ordinate between the concrete and a 10 foot straightedge. Correct all alignment deviations greater than 3/8 inch. Straightedge by half lapping the straightedge for the full length of all plane surfaces.

521-4.3 Slip Form Construction: When electing to use the slip form method in lieu of the stationary forming method, place the concrete with a slip form machine approved by the Engineer. The concrete cover tolerance is plus or minus 3/4 inches from the plan dimensions, except the minimum concrete cover, as constructed, must not be less than 1-3/4 inches.

Provide a finished texture to the slip formed rigid barrier by hand troweling, brushing, or both to eliminate pockmarks, blemishes and any other discontinuities in surface texture. Ensure that the final finish has a fine texture and is free of pinholes, pockmarks, and blemishes.

Remove and recast or repair sections of slip formed rigid barrier having areas of unconsolidated concrete, having surface blemishes, and/or having pockmarks greater than 1/2 inch in diameter after hand troweling and brushing. Repair areas of unsatisfactory surface finish by hand methods using mortar screened from the concrete used to construct the rigid barrier. Use the mortar screened from the rigid barrier concrete only to fill holes and surface blemishes below the slip formed surface of the concrete. Do not use mortar as a surface overlay coating on the rigid barrier concrete.

During the finishing operation, while the concrete remains plastic, straightedge all plane surfaces of the slip formed rigid barrier with a 10 foot straightedge. Straightedge by half lapping the straightedge for the full length of the plane surfaces. Correct any deviation found

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during straightedging, greater than 3/8 inch, measured as an ordinate between the concrete surface and the straightedge, in an approved manner at no expense to the Department. Do not use surface overlay coatings of mortar screened from the concrete, or surface overlay coatings of concrete to correct alignment deviations.

521-5 Curing.

Meet the requirements of Section 400.

521-6 Joints.

521-6.1 General: Place expansion and contraction joints in concrete rigid barrier either mounted on or adjoining rigid structures in a manner similar to the type and method of jointing used in the supporting or adjoining structure or as shown in the Contract Documents. Place expansion and contraction joints in concrete rigid barrier supported by soil or flexible foundation materials in the manner detailed in the Plans.

521-6.2 Contraction Joints in Rigid Barrier Supported by or Adjoining Rigid Structures: The Contractor may form or saw contraction joints. When sawing contraction joints, saw them as soon as the concrete has hardened sufficiently to permit sawing without raveling and before uncontrolled cracking occurs, but in no case later than 12 hours after casting. Match contraction joints to adjacent contraction joints in the structure. Space contraction joints at 15 to 30 foot intervals. For rigid barrier on bridge structures or approach slabs, space contraction joints as shown in the Contract Documents.

521-6.3 Expansion Joints in Rigid Barrier Supported by or Adjoining Rigid Structures: Construct expansion joints at right angles to the face, and extend them through the entire cross-section of the rigid barrier. Construct expansion joints at the same location and width as the expansion joints in the structure on which the rigid barrier rests and at other locations shown in the Contract Documents. Form expansion joints with an expansion filler material or removable forming materials and secure to the forms as required to provide proper position.

521-7 Repairs and Rejection.

For permanent precast concrete rigid barrier that has not been installed, evaluate cracks, spalls and other deficiencies in accordance with 450-12. Repair deficiencies in accordance with 450-13 or the plant's approved repair methods that are included as part of the Quality Control (QC) Plan. Ensure that the original performance and durability of the repaired rigid barrier is maintained. Use materials for concrete repair that will meet or exceed the strength requirement for the class of concrete used. Materials meeting the requirements of Section 930 may be substituted for non-shrink grout when required by 450-13. Concrete rigid barrier is subject to rejection if it fails to conform to any of the Specification requirements after repair. The disposition of concrete cracks in rigid barrier after installation shall be in accordance with 400-21.

521-8 Method of Measurement.

The quantity to be paid for under this Section will be the plan quantity, in feet, completed and accepted. The quantity will be measured along the centerline of the rigid barrier from begin to end station, including transitional and end sections, with no deduction for expansion joints, open joints, or leave-outs.

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521-9 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including all reinforcing, concrete, flowable fill, soil stabilization, miscellaneous materials, and incidentals necessary to complete the work.

Payment will be made under:

Item No. 521- 1-	Median Concrete Barrier - per foot.
Item No. 521- 5-	Concrete Traffic Railing - Bridge - per foot.
Item No. 521- 6-	Concrete Parapet - per foot.
Item No. 521- 8-	Concrete Barrier - with Junction Slab - per foot.
Item No. 521- 9-	Opaque Visual Barrier - per foot.
Item No. 521- 72-	Shoulder Concrete Barrier - per foot.

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SECTION 522
CONCRETE SIDEWALKS AND DRIVEWAYS

522-1 Description.

Construct concrete sidewalks and driveways in accordance with the Plans and the Standard Plans. Sidewalk will include curb ramps, landings, transition slopes, sidewalk curb, and edge beams.

522-2 Materials.

Meet the requirements specified in 520-2 and the embankment utilization requirements of Standard Plans Index 120-001.

522-3 Forms.

Provide forms as specified in 520-3.

522-4 Foundation.

Shape and compact the foundation materials with suitable equipment to a firm, uniform, smooth, even surface, true to grade and cross-slope that is free of debris and irregularities.

For the following conditions proof roll the graded areas with a vibratory roller or mini plate compactor in such manner that a firm and unyielding foundation is established within 1 foot beyond each side of the sidewalk or driveway, when right-of-way conditions allow:

1. For all fill areas not exceeding 6 inches.
2. All cut areas.
3. Existing sidewalk and driveways to be replaced in the same location, horizontal alignment, profile grade, and cross slope.

For fill areas 6 inches or greater, compact the foundation below the bottom of the concrete and 1 foot beyond each side of the sidewalk or driveway when right-of-way conditions allow, to a density not less than 95% of the maximum density as determined by FM 1-T099 for the following conditions:

1. For fill areas not exceeding 2 feet, take densities for the entire fill height.
2. For fill areas 2 feet or greater, take densities on the last (upper) 2 feet of fill height.

Meet the testing frequency and maximum lift thickness requirements of Section 120. Record density test results in the Earthwork Records System (ERS) section of the Department's database. Compact the material in the remaining fill areas to match the adjacent area density.

522-5 Joints.

Install expansion and contraction joints in accordance with the Plans and the Standard Plans.

522-6 Placing Concrete.

Place the concrete as specified in 520-5.

522-7 Finishing.

522-7.1 Screeding: Strike-off the concrete by means of a wood or metal screed, used perpendicular to the forms, to obtain the required grade and remove surplus water and laitance.

522-7.2 Surface Requirements: Imprint concrete as detailed in the Plans, otherwise provide a broom finish. Ensure that the surface variations are not more than 1/4 inch under a

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10-foot straightedge or more than 1/8 inch on a 5-foot transverse section. Finish the outer edges of the concrete with an edging tool having a radius of 1/2 inch.

522-7.3 Sidewalk Cross Slope Requirements: Construct sidewalk with cross slope as shown in the Plans and Standard Plans. Sidewalks must have some cross slope, but no more than 2.0%, in either the positive or negative direction after construction.

522-8 Curing.

Cure the concrete as specified in 520-8.

522-9 Opening Sidewalk to Pedestrian Traffic.

Install detectable warnings, when shown in the Plans, in accordance with Section 527 on completed sections of sidewalk before opening to pedestrian traffic.

522-10 Method of Measurement.

The quantity to be paid will be plan quantity, in square yards, completed and accepted.

522-11 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section. Excavation for new installations will be paid for under the items for the grading work on the project.

Payment will be made under:

Item No. 522-	Concrete Sidewalks and Driveways - per square yard.

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SECTION 523
PATTERNED PAVEMENT

523-1 Description.

Patterned pavement is defined as a post applied surface marking material to either the pavement surface or to an imprinted pavement surface.

523-2 Materials.

Use patterned pavement products listed on the Department's Approved Product List (APL) meeting the requirements of Section 974.

Prior to installation, submit pattern and color samples to the Engineer for confirmation that the product meets the pattern and color specified in the Plans. Do not begin installation until acceptance by the Engineer.

The Engineer will take random samples of all material in accordance with the Department's Sampling, Testing and Reporting Guide schedule.

523-3 Construction Requirements.

Install patterned pavement on asphalt or concrete locations with the color and pattern as specified in the Plans. Prepare the surface and install patterned pavement in accordance with the manufacturer's installation instructions, using materials and equipment recommended and approved by the manufacturer.

Install overlay products to a thickness not exceeding 180 mils.

Patterns and variations within the installation shall comply with ADA requirements.

Complete all utility, traffic loop detector, and other items requiring a cut and installation under the finished surface, prior to product installation.

Protect treated surfaces from traffic and environmental effects until the product is completely installed, including drying and curing according to the manufacturer's instructions.

For installation on new asphalt roadways, apply patterned pavement a minimum of 14 days after placement of the adjacent pavement.

Patterned pavements shall be weather resistant, friction resistant, and through normal wear, shall show no signs of failure due to tearing, stretching, rollback, blistering, excessive cracking, chipping, discoloration, poor adhesion to the pavement, pavement damage, or vehicular damage.

Upon completion of the installation, the Engineer will check the area at random locations for geometric accuracy. If any of the chosen areas are found to be deficient, correct the entire patterned area at no additional cost to the Department.

Submit certification to the engineer, including the APL number and that the patterned pavement was installed in accordance with the manufacturer's installation instructions and this Section.

523-4 Method of Measurement.

The quantity to be paid will be the plan quantity in square yards of patterned pavement, completed and accepted. No deduction will be made for areas occupied by landscaping, manholes, inlets, drainage structures, or by any public utility appurtenances within the area.

523-5 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 523- 3- Patterned Pavement - per square yard.

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SECTION 524
CONCRETE DITCH AND SLOPE PAVEMENT

524-1 Description.

Construct concrete pavement in the flow channel of drainage ditches and on slopes as shown on the Plans and in accordance with the Standard Plans.

524-2 Materials.

Concrete .....Section 347
Preformed Expansion Joint Material and Hot Poured Sealer .....
.....Section 932
Filter Fabric*.....Section 985
Reinforcing Steel .....Section 415
*Use products listed on the Department's Approved Product List (APL).

524-3 Forms.

Provide forms as specified in 520-3.

524-4 Foundation.

Shape and compact the foundation materials, upon which the pavement is to be constructed, to a firm, even surface, true to grade and cross slope.

Dispose of surplus material.

524-5 Joints and Weep Holes.

524-5.1 Joints:

524-5.1.1 Joints in Ditch Pavement: Construct formed (construction joint) or tooled contraction joints, spaced at 25 feet maximum intervals. Open joints are prohibited. Construct expansion joints with 1/2-inch preformed joint filler at all inlets, endwalls, and at intervals of not more than 200 feet.

524-5.1.2 Joints in Slope Pavement: Form open or tooled (dummy) type joints as shown in the Plans. Form open joints by staking a metal bulkhead in place and placing the concrete on both sides of it. When the concrete has set sufficiently to preserve the width and shape of the joints, remove the bulkhead. Upon finishing the pavement over the joint, open and edge the slot with a tool having a 1/4-inch radius.

524-5.2 Method of Placing Slope Pavement: Place slope pavement in vertical strips, 4 feet, plus or minus 1 inch, wide, except taper radii strips from the 4-foot width at the bottom to a minimum width of 1 foot at the top. Score the strips horizontally at intervals of 2 feet, plus or minus 1 inch, with a tool having a double 1/4-inch radius. Edge construction joints between strips with a tool having a 1/4-inch radius. The Engineer will allow construction joints at horizontal scorings.

524-5.3 Weep Holes: Locate and construct weep holes as shown in the Plans. Construct weep holes at the toe of slope for all slope pavements.

524-5.4 Filter Fabric: Place filter fabric directly beneath all concrete ditch pavement for the entire length and width of the pavement, regardless of the pavement thickness. Place filter fabric below weep hole aggregate to form a mat continuous with the pavement filter fabric or underlapping the pavement filter fabric, if present.

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524-6 Placing Concrete.

Place the concrete in the forms, tamp and spade it to prevent honeycombing, and until the top of the structure can be floated smooth and the edges rounded.

524-7 Finishing.

Roughen the surface of ditch pavement after screeding concrete, unless otherwise specified, to the approximate shape and grade by a rake or other suitable tool drawn perpendicular to the direction of flow. Ensure that the furrows are at least 1/4 inch deep.

Strike off slope pavement or smooth surfaced ditch pavement, when specified, true to line and cross slope and remove all surplus water and laitance from the surface. Lightly broom the finish.

524-8 Curing.

Cure the concrete as specified in 520-8.

524-9 Method of Measurement.

524-9.1 Concrete Ditch and Slope Pavement: The quantities to be paid for Concrete Ditch Pavement and Concrete Slope Pavement will be the plan quantity, in square yards, completed and accepted. Where the Plans show headers or cut-off walls at the end or edge of the pavement, the volume of the additional thickness of pavement that constitutes the headers, calculated in accordance with plan dimensions, will be converted into equivalent square yards of standard thickness pavement and included in the quantity to be paid for.

No deduction will be made for any areas occupied by manholes, inlets, or other drainage structures or by public utility appurtenances within the pavement area. The square yard quantity includes any ditch blocks with ditch or slope pavement on top. When steel reinforcement is called for in the Plans, payment will be included in the square yard item.

Sod will be measured and paid in accordance with Section 570.

524-9.2 Concrete Core Ditch Blocks: The quantity to be paid for Concrete Core Ditch Blocks will be the plan quantity of concrete, in cubic yards, completed and accepted. When steel reinforcement is called for in the Plans, payment will be included in the cubic yard pay item. The cubic yard pay item includes any ditch block within a grass or earth ditch, without other pavement on top.

524-10 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section, including all earthwork, skimmers, and incidental materials necessary to complete the work.

Payment will be made under:

Item No. 524-	1-	Concrete Ditch Pavement - per square yard.
Item No. 524-	2-	Concrete Slope Pavement - per square yard.
Item No. 524-	3-	Concrete Core Ditch Block - per cubic yard.

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SECTION 525
ASPHALT CONCRETE CURB

525-1 Description.

Construct an asphalt concrete curb on a previously laid pavement at the locations shown in the Plans.

525-2 Materials.

Meet the following requirements:

Superpave Type SP-12.5 (Traffic Level B or C) .....Section 334

525-3 Construction Methods.

Use a Type SP-12.5 (Traffic Level B or C) asphalt concrete mixture.

Sufficiently roughen the surface of the roadway pavement at the locations where the curb will be constructed to provide suitable bonding of the pavement and the curb.

Lay the curb by a machine or by other methods to provide the required cross-section. The Engineer may allow variation in the Plan cross-section for using the particular machine, provided the Contractor obtains the equivalent cross-sectional area and the specified height of curb. Provide appropriate compaction as directed by the Engineer.

525-4 Method of Measurement.

The quantity to be paid for will be the length plan quantity, in feet, completed and accepted. Any additions or deletions thereto as authorized by the Engineer will be determined by plan dimensions, station-to-station dimensions, final measurement, or any combination thereof, as measured along the face of the completed and accepted curb.

525-5 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including all materials and incidentals necessary to complete the work.

Payment will be made under:

Item No. 525- 1- Asphaltic Concrete Curb - per foot.

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SECTION 526
ARCHITECTURAL PAVERS

526-1 Description.

Furnish and install architectural pavers in accordance with this Section.

526-2 Materials.

526-2.1 General: Architectural pavers shall meet the following requirements:

Table 526-1
Architectural Paver Requirements

Proposed Use	ASTM C902 (Brick Paver)	ASTM C1272 (Brick Paver)	ASTM C936 (Concrete Paver)
Local Side Streets (≤ 35 mph Design Speed)	Do Not Use	X	X
Commercial Driveways	Do Not Use	X	X
Sidewalks and Medians	X	Do Not Use	X
Residential Driveways	X	Do Not Use	X

Ensure that the pavers are consistent in color, size, and appearance. Architectural paver type, pattern, shape and/or color will be in accordance with plan details, when specified.

526-2.2 Architectural Pavers - Roadway: For installations on roadways and commercial driveways, provide architectural pavers having a minimum thickness of 3-1/8 inch.

526-2.3 Architectural Pavers - Sidewalk: For installations on sidewalks, medians and residential driveways, provide architectural pavers having a minimum thickness of 2-3/8 inch.

526-2.4 Bedding and Joint Sands: Provide clean, non-plastic bedding and joint sand, free from deleterious or foreign matter, natural or manufactured from crushed rock.

Ensure the bedding sand meets the grading requirements of ASTM C33 Standard Specification for Concrete Aggregate.

Ensure the joint sand meets the grading requirements of ASTM C144 Standard Specification for Aggregate for Masonry Mortar.

Bedding sand may be used for joint sand. Do not use joint sand for bedding sand.

526-2.5 Bedding and Joint Grouts: A suitable grout, in thickness specified by the manufacturer and approved for use by the architectural paver manufacturer, may be substituted for either bedding sand, joint sand or both when specified in the Plans and approved by the Engineer.

526-3 Construction Methods.

526-3.1 General:

526-3.1.1 Submittals: For Architectural Pavers – Roadway, furnish full size samples to the Engineer for approval prior to beginning placement. For Architectural Pavers - Sidewalk, submit to the Engineer a certification that the architectural pavers meet the requirements of this Section. In addition, for all architectural pavers, submit a certified sieve analysis for gradation comparing results of the bedding sand and joint sand with the requirements of ASTM C33 or ASTM C144 as applicable.

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526-3.1.2 Mock-ups: Prior to beginning placement, install a 6 foot by 6 foot paver area following these specifications. This area will be used to determine surcharge of the bedding material layer, joint sizes, lines, laying patterns and colors of the job. This area will be adjacent to an edge treatment, incorporated into the work, and will be the standard from which the work will be judged.

526-3.1.3 Environmental Conditions: Cover stockpiled materials with waterproof covering to prevent exposure to rainfall. Do not install bedding materials or architectural pavers during heavy rains or over wet substrata.

526-3.2 Installation: Install the architectural pavers in the following manner:

1. Spread the bedding material evenly over the base course and screed to plan thickness, not to exceed a thickness of 1-1/2 inch. Do not disturb the screeded bedding material. Ensure placement of sufficient bedding material to stay ahead of the laid architectural pavers. Do not use the bedding material to fill depressions in the base course.
2. Lay architectural pavers in the pattern(s) shown in the Plans and maintain straight pattern lines.
3. Joints between the architectural pavers, on average, will be between 1/16 to 3/16 inch wide.
4. Fill gaps at the edges of the paved area with cut or edge architectural pavers.
5. When utilizing bedding and joint sand:
    a. Use a low amplitude vibrator capable of 5,000 foot-pounds with 7-100 Hz frequencies to vibrate and compact architectural pavers into bedding sand.
    b. Vibrate the architectural pavers, sweeping dry joint sand into the joints and vibrating, until the joints are full. Do not vibrate within 3 feet of the unrestrained edges of the architectural pavers.
    c. At the end of each day, all work within 3 feet of laying face must be left fully compacted, with sand-filled joints.
    d. Sweep off the excess sand.
6. Leave a final surface elevation of architectural pavers of 1/8 to 1/4 inch above adjacent drainage inlets, concrete collars or channels.
7. Do not permit the final surface elevations of the pavers to deviate more than 3/8 inch under a 10 foot long straightedge, or more than 1/8 inch between adjacent pavers.

526-4 Method of Measurement.

The quantity to be paid for will be the plan quantity, in square yards, for architectural pavers completed and accepted. No deduction will be made for the areas occupied by ornamental trees left within and any other areas occupied by manholes, inlets, drainage structures or by public utility appurtenances within the normal areas of the architectural pavers.

526-5 Basis of Payment.

Price and payment will be full compensation for all work, including all materials, equipment, labor, and incidentals necessary to complete the work.

Payment shall be made under:

Item No. 526- 1- - Pavers, Architectural - per square yard.

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SECTION 527
DETECTABLE WARNINGS

527-1 Description.

Detectable warnings are products used for the visually impaired and installed on newly constructed and/or existing concrete or asphalt walking surfaces (sidewalk curb ramps, sidewalks, shared use paths, etc.).

527-2 Materials.

Use detectable warnings as approved for use on uncured concrete, existing concrete, and asphalt surfaces. Use only products and materials appropriate for the surface on which they will be applied.

Use safety yellow, brick red, or black colored detectable warnings on concrete walking surfaces. Use safety yellow colored detectable warnings on asphalt walking surfaces.

Use detectable warnings listed on the Department's Approved Product List (APL) meeting the requirements of Section 974. Methods used to form detectable warnings in wet concrete will not be permitted.

527-3 Construction Requirements.

Prepare the surface and install detectable warnings in accordance with the manufacturer's installation instructions, using materials and equipment recommended and approved by the manufacturer. Construct in accordance with Standard Plans, Index 522-002.

Open the walking surface to pedestrian traffic within 72 hours for uncured concrete surfaces. Immediately open the walking surface to pedestrian traffic for asphalt and existing concrete surfaces.

Surface color and texture shall be complete and uniform. Detectable warnings will be securely installed as recommended by the manufacturer and free from lifting, cracking, missing or partial domes, and with no significant defects. Surfaces shall not deviate more than 0.10 inch from a true plane.

527-4 Method of Measurement.

Detectable warnings will be paid by plan quantity, per square foot, furnished, installed and accepted.

527-5 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including all labor, surface preparation, removal of existing removable or surface applied detectable warnings, materials, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Item No. 527- 2- Detectable Warnings - per square foot.

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SECTION 530
REVETMENT SYSTEMS

530-1 Description.

530-1.1 Riprap: Construct riprap composed of sand-cement or rubble (consisting of broken stone or broken concrete) as shown in the Standard Plans and in the Plans.

530-1.2 Articulating Concrete Block (ACB) Revetment Systems: Furnish and install an ACB revetment system in accordance with this Section and in conformance with the lines, grades, design, and dimensions shown in the Plans. Submit vendor drawings for review and approval by the Engineer. Submit signed and sealed calculations of the block and cable sizing design for approval. Comply with the National Concrete Masonry Association's Design Manual for Articulating Concrete Block Revetment Systems, Second Edition, or the National Highway Institute, Hydraulic Engineering Circular (HEC) No. 23, Publication No. FHWA NHI 09-110. Use a minimum Factor of Safety of 1.5 and 0.5 inch for the block projection.

Blocks must be open cell and non-tapered unless otherwise stated in the Plans. Revetment cabling must be bi-directional or, for mono-directional cabling, the block installation must include a permanent mechanism within the block matrix to prevent lateral displacement of the installed blocks. Cabling must be polyester and free to move within the block.

Use only ACB revetment systems currently listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6, and include certified test reports from an independent test laboratory certifying the ACB revetment system meets the requirements of this Section.

If the ACB revetment system is intended for use as bridge abutment protection, include the following drawings with the APL submittal:

1. At the corner transition between the front and side slopes.
2. For anchorages, geotextile fabric, treatment of voids between adjacent blocks, limits on void size between adjacent blocks and other special details required to successfully install the ACB.
3. For areas adjacent to bridge abutments, detail mat placement aroundopen in curves, connections, protection of mat ends, and splicing of mat.

530-1.3 Gabions: Furnish and install gabions, including gabion baskets and gabion mattresses, filled with rock in accordance with this Section and in conformance with the lines, grades, design, and dimensions shown in the Plans.

530-2 Materials.

530-2.1 Riprap:

530-2.1.1 Filter Fabric: Meet the following requirements:

Type D-2 Geotextile Fabric* .....Section 985

*Use products listed on the Department's APL.

Schedule work so that covering the fabric with the specified material does not exceed the manufacturer's recommendations for exposure to ultraviolet light or five days, whichever is less. If the Engineer determines the exposure time was exceeded, the Contractor shall replace the fabric at no expense to the Department.

Place the filter fabric (fabric) at locations as shown in the Plans, in accordance with the manufacturer's directions. Place the fabric on areas with a uniform slope that are

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reasonably smooth, free from mounds, windrows, and any debris or projections which might damage the fabric.

Loosely lay the material. Do not stretch the material. Replace or repair any fabric damaged or displaced before or during placement of overlying layers. Repair in accordance with the manufacturer's instructions.

The Contractor may sew the seams to reduce overlaps as specified in 985-3. Follow the manufacturer's instructions for all seams and overlaps.

530-2.1.2 Prepackaged Sand-Cement Bags: Provide prepackaged sand-cement bags that meet the following requirements:

1. Evenly proportioned sand and cement in the ratio of five cubic feet of sand to 94 pounds of cement. Material proportioned by mass shall use a sand density of 85 pounds per cubic foot.
2. Sealed package of 80 pounds of sand-cement in a bag.
3. Bag made of scrim-reinforced paper capable of holding the sand-cement without leakage.
4. Sand meets requirements of Section 902-3.3
5. Type I/II cement meets requirements of Section 921.

Prepackaged Sand-Cement Bags shall be one of the products listed on the Department's Approved Product List. Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6. Include with the submittal a product data sheet, safety data sheet, product label, and a self-certified statement the product meets the requirements of this Section.

530-2.1.3 Rubble:

530-2.1.3.1 Rubble (Bank and Shore Protection): Provide sound, hard, durable rubble, free of open or incipient cracks, soft seams, or other structural defects, consisting of broken stone with a bulk specific gravity of at least 2.20. Ensure that stones are rough and angular.

For this application, use broken stone meeting the following gradation and thickness requirements:

Weight Maximum Pounds	Weight 50% Pounds	Weight Minimum Pounds	Minimum Blanket Thickness in Feet
670	290	60	2.5
Ensure that at least 97% of the material by weight is smaller than Weight Maximum pounds]. Ensure that at least 50% of the material by weight is greater than Weight 50% pounds]. Ensure that at least 85% of the material by weight is greater than Weight Minimum pounds.			

530-2.1.3.2 Rubble (Ditch Lining): Use sound, hard, durable rubble, free of open or incipient cracks, soft seams, or other structural defects, consisting of broken stone or broken concrete with a bulk specific gravity of at least 1.90. Ensure that stones or broken concrete are rough and angular.

Use broken stone or broken concrete meeting the following gradation and thickness requirements:

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Weight Maximum Pounds	Weight 50% Pounds	Weight Minimum Pounds	Minimum Blanket Thickness in Feet
75	30	4	1.5
Ensure that at least 97% of the material by weight is smaller than Weight Maximum pounds. Ensure that at least 50% of the material by weight is greater than Weight 50% pounds]. Ensure that at least 90% of the material by weight is greater than Weight Minimum pounds].			

530-2.1.3.3 Physical Requirements of Broken Stone and Broken Concrete: Use broken stone and broken concrete meeting the following physical requirements:

Absorption (FM 1-T 85)	Maximum 5%
Los Angeles Abrasion (ASTM C535)	Maximum loss 45%*
Soundness (Sodium Sulphate) (AASHTO T 104)	Maximum loss 12%** (after five cycles)
Flat and elongated pieces	Materials with least dimension less than one third of greatest dimension not exceeding 10% by weight.
Dirt and Fines	Materials less than 1/2 inch in maximum dimension accumulated from interledge layers, blasting or handling operations not exceeding 5% by weight.
Drop Test***(EM 1110-2-2302)	No new cracks developed, or no existing crack widened additional 0.1 inch, or final largest dimension greater than or equal to 90% original largest dimension of dropped piece.
* Ensure that granite does not have a loss greater than 55% and that broken concrete does not have a loss greater than 45%. ** The Engineer may accept rubble exceeding the soundness loss limitation if performance history shows that the material will be acceptable for the intended use. The Engineer will waive the soundness specification for rubble riprap (broken stone) when project documents indicate it will be placed in or adjacent to water or soil with a sulfate content less than 150 parts per million and a pH greater than 5.0. Soundness is not required for broken concrete. *** The Engineer will waive the Drop Test unless required to ensure structural integrity. Provide all equipment, labor and testing at no expense to the Department. EM refers to the US Army Corps of Engineer's Specification Engineering Method.	

530-2.1.3.4 Source Approval and Project Control: The Engineer will approve construction aggregate sources in accordance with 6-2.3.

1. The Engineer may perform Independent Verification tests on all materials placed on the project.

2. The Engineer will check the gradation of the riprap by visual inspection at the project site. Resolve any difference of opinion with the Engineer in accordance with the method provided in FM 5-538. Provide all equipment, labor, and the sorting site at no expense to the Department.

3. The Engineer may test components in a blend of rubble processed from different geologic formations, members, groups, units, layers or seams. The Engineer may select components based on like color, surface texture, porosity, or hardness. The Engineer will reject any blend if a component that makes up at least five percent by volume of the blend does not meet these specifications.

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530-2.1.4 Bedding Stone: Use Bedding Stone of either a durable quality limestone or other quarry run stone, with a bulk specific gravity of not less than 1.90 and that is reasonably free from thin, flat and elongated pieces. Ensure that the bedding stone is also reasonably free from organic matter and soft, friable particles. Meet the following gradation limits:

Standard Sieve Sizes - Inches	Individual Percentage by Weight Passing
12 inches	100
10 inches	70 to 100
6 inches	60 to 80
3 inches	30 to 50
1 inch	0 to 15

The Engineer will conduct source approval and project control of bedding stone as specified in 530-2.1.3.4. In lieu of limestone or other quarry run stone, the Contractor may substitute non-reinforced concrete from existing pavement that is to be removed and which meets the above requirements for commercial bedding stone.

530-2.2 Articulating Concrete Block (ACB) Revetment Systems: Obtain all precast block, cabling, anchors, and necessary incidental materials from the same manufacturer. ACB revetment systems must meet the requirements of ASTM D6684, ASTM D7276 and ASTM D7277. Submit to the Engineer certification from the manufacturer that the ACB revetment system meets the requirements of this Section.

ACB system components must meet the following requirements:

Concrete .....Section 347, ASTM D6684
Cables and Fittings.....ASTM D6684
Type D-2 Geotextile Fabric * .....Section 985
Granular Underlay .....Section 901
*Use products listed on the Department's APL.

Cables must maintain at least 85% of original tensile strength (ASTM D638) after 1,000 hours exposure to a saturated solution of calcium hydroxide (pH greater than or equal to 11) at 73°F, plus or minus three degrees. Cables must not exceed a maximum of 0.5% moisture absorption at seven days, per ASTM D570. Cable crimps must be aluminum or stainless steel Type 304 or 316.

530-2.3 Gabions:

530-2.3.1 General: Provide gabions meeting the requirements of ASTM A974 and ASTM A975 as modified herein.

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Allowable Gabion Wire and Connector Material	Substructure Environmental Classification
Polymeric	Any
Metallic	Slightly Aggressive
Metallic – Galvanized and PVC coated	Slightly Aggressive Moderately Aggressive
Metallic – Type 304 Stainless Steel, Size W1.4 (MW10) or larger	Slightly Aggressive Moderately Aggressive Extremely Aggressive (< 2,000 ppm Chlorides)
Metallic – Type 316 Stainless Steel, Size W1.4 (MW10) or larger	Any

530-2.3.2 Metallic Gabions: The components of metallic gabions must meet the following requirements:

Wire Mesh and Fabric* .....ASTM A974 and A975
Spiral Binders, Lacing Wire, Stiffeners, and Ring Wire Fasteners .....ASTM A974 and A975
Stainless Steel Wire, Wire Fabric, and Lacing Wire .....ASTM A1022
*Wire mesh must be Style 1 or Style 3. Wire fabric must be Style 1 or Style 5.

530-2.3.3 Polymeric Gabions: Polymeric gabions must be constructed in general accordance with ASTM A974 using a single layer of structural geogrid instead of welded wire, and polymeric braid instead of ring wire fasteners. The structural geogrid must be Type R-1, 2, 3, 4, or 5 meeting the requirements of Section 985 and the following:

Tensile Strength @2% strain MD*.....575 lb/ft
Tensile Strength @ 2% strain XD** .....575 lb/ft
Junction Strength (% of Tensile Strength)..... 90%
Min UV Stability..... 85%
Min. Carbon Black Content (by Weight)..... 2%
*MD = machine direction
**XD = cross direction

Polymeric braid for seeming polymeric gabions or connecting metallic gabions must have a minimum tensile strength of 400 pounds for a 36 inch long specimen and contain at least 2% carbon black by weight.

530-2.3.4 Gabion Rock: Use rock meeting the requirements of ASTM D6711 to fill gabions. The rock must be reasonably free from thin, flat or elongated pieces. Rock size must be at least 1.25 times greater than the aperture size of the wire mesh or fabric. Each range of sizes may allow for a variation of 5% oversize rock by weight, 5% undersize rock by weight, or both.

Physical Property Requirements	Acceptable Range
Los Angeles Abrasion and ASTM C535	Maximum loss 40%
Bulk Specific Gravity	Minimum 2.20
Absorption, ASTM C127 and ASTM C128	Maximum 3%

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530-2.3.5 Miscellaneous Components: Miscellaneous components for gabion installations must meet the following requirements:

Type D-2 Geotextile Fabric* .....Section 985
Granular Underlay .....Section 901
Anchors ....Section 451 or manufacturer's recommendations
*Use products listed on the Department's APL.

530-3 Construction and Installation.

530-3.1 Geotextile Fabric: Overlap adjacent strips of fabric a minimum of 24 inches, and anchor them with securing pins (as recommended by the manufacturer) inserted through both strips of fabric along a line through the midpoint of the overlap and to the extent necessary to prevent displacement of the fabric.

Place the fabric so that the upstream (upper) strip of fabric overlaps the downstream (lower) strip.

Stagger vertical laps a minimum of 5 feet. Use full rolls of fabric whenever possible in order to reduce the number of vertical laps.

Do not drop bedding stone or riprap from heights greater than 3 feet onto the fabric.

530-3.2 Sand-Cement Bags:

530-3.2.1 Placing: Place the bags with their ends all in the same direction. Lay the bags with broken joints, in a regular pattern. Ram or pack the bags against each other so as to form a close and molded contact. Remove and replace bags ripped or torn in placing with sound, unbroken bags. Then, thoroughly saturate all bags with water.

530-3.2.2 Grouting: Immediately after watering, fill all openings between bags with dry grout composed of one-part Portland cement and five parts sand.

530-3.2.3 Toe Walls: Use sand-cement bags for the toe walls if required. Fill the entire trench excavated for the toe walls with sand-cement bags.

530-3.3 Rubble: Dump rubble in place forming a compact layer conforming to the neat lines and thickness specified in the Plans. Ensure that rubble does not segregate so that smaller pieces evenly fill the voids between the larger pieces.

530-3.4 Bedding Stone: Place a minimum one foot thick layer of bedding stone under all rubble riprap without puncturing or tearing the geotextile fabric. The Engineer will allow an in place thickness tolerance of plus or minus one inch.

Remove and replace geotextile fabric damaged as a result of operations at no expense to the Department.

530-3.5 Articulating Concrete Block (ACB) Revetment System: Install the ACB revetment system in accordance with ASTM D6884 and the manufacturer's recommendations, unless directed otherwise by the Engineer.

Prior to installation, construct the area to be stabilized to an elevation such that, upon completion of stabilizing operations, the completed stabilized subgrade will conform to the lines, grades and cross slope shown in the Plans. Bring the subgrade surface to a plane approximately parallel to the plane of the proposed finished surface, such that, upon placement of the mat, no individual block within the ACB mat will protrude more than one-half inch from any adjacent block. Uniformly compact each subgrade layer to achieve the density required in the Plans. If the Plans do not provide for stabilizing, compact the subgrade in both cuts and fills, to the density specified in ASTM D6884.

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Embed anchors at least six feet into the subgrade at a 45 degree angle into the bank with a minimum pullout resistance of 875 pounds. In the presence of the Engineer, perform on-site anchor strength testing to verify the required pull out resistance is achieved. Anchor strength testing must be performed on the first two and final two installed anchors, and randomly throughout the installation operation such that 5% of all installed anchors are tested for pullout resistance. If any anchor fails to meet the pullout resistance requirement, test every subsequent installed anchor until a revised installation plan is proposed and approved by the Engineer. Anchor spacing cannot exceed four feet.

Immediately prior to placing the geotextile fabric and ACB system, inspect the prepared subgrade to ensure it is free of loose material and the surface is smoothly compacted. Place the geotextile fabric directly on the prepared area, in intimate contact with the subgrade and free of folds or wrinkles. Do not glue or physically bond the geotextile fabric to the ACB mat. Install a six inch thick layer of bedding stone under the geotextile fabric, when called for in the Plans.

When installing ACB systems around curves, the mats shall be matched up to the greatest extent possible. Gaps greater than one block size shall be filled with a block and grouted the depth of the block with non-structural grout.

Do not install blocks with chips that result in any block weighing less than 95% of the manufacture specified weight.

530-3.6 Gabions: Install double-twisted wire mesh gabions in accordance with ASTM D7014. Install welded wire fabric gabions and polymeric gabions in accordance with the manufacturer's recommendations.

Prior to installation, complete any required excavation and preparation of the foundation as shown in the Plans or as directed.

Install soil anchors as specified in the Plans.

All adjoining gabion units shall be connected along the perimeter of their contact surfaces to obtain a monolithic structure. If more than one tier, stagger the vertical joints of subsequent rows by one half cell length and adjoin the empty gabions to the top of the lower tier along the front and back edges of the contact surface.

Fill gabions in a manner that minimizes voids, protects against local deformation of the basket or mattress and prevents damage to PVC coating. At no point in the filling process may rock be mechanically placed from a height of over 36 inches from machine to fill area. Uniformly overfill gabions by 1 to 2 inches to compensate for future rock settlements.

Any damage to the basket, mattress, or coatings during assembly, placement, or filling shall be repaired promptly in accordance with the manufacturer's recommendations or replaced with undamaged gabion baskets.

530-4 Method of Measurement.

530-4.1 Sand-Cement Bags: The quantity to be paid for will be the volume, in cubic yards, calculated from the minimum dimensions shown in the Plans or Standard Plans, satisfactorily placed and accepted.

530-4.2 Rubble and Bedding Stone: The quantities to be paid for will be the weight, in tons, in surface dry natural state, by railroad scales, truck scales, or barge displacement. The Contractor shall determine the weights as follows:

1. Railroad Weights: The Contractor shall weigh railroad cars on railroad scales, before and after loading or before and after unloading. If weighed by other than the Engineer, a

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certified statement of weights will be required. Certificates of weight, furnished by the railroad company, will be acceptable without further certification.

2. Truck Weights: The Contractor shall weigh trucks on certified scales, loaded and empty, as prescribed above for railroad weights. The Contractor shall weigh trucks in the presence of the Engineer, or submit certificates of weights.

3. Barge Displacement: The Engineer will measure each barge. The Contractor shall fit each barge with gauges graduated in 0.10 foot increments. The Contractor shall locate a gauge at each corner of the barge near the lower end of the rake. The Contractor shall furnish additional gauges amidships if the Engineer deems necessary. The Engineer will compute all weights.

530-4.3 Articulating Concrete Block (ACB) Revetment System: The quantity to be paid for will be the plan quantity, in square yards, completed and accepted, subject to the provisions of 9-3.2. No allowance will be made for ACB placed outside the Plan dimensions, unless the additional placement is ordered by the Engineer.

530-4.4 Gabions: For mattress type applications, the quantity to be paid for will be the plan quantity, in square yards, placed in the final locations.

For stacked basket applications, the quantity to be paid for will be the plan quantity, in cubic yards, placed in the final locations.

530-5 Basis of Payment.

530-5.1 Sand-Cement: Price and payment will be full compensation for all work specified in this Section, including all materials, labor, hauling, excavation, and backfill.

Include the cost of dressing and shaping the existing fills (or subgrade) for placing riprap in the Contract unit price for riprap (sand-cement).

530-5.2 Rubble: Price and payment will be full compensation for all work specified in this Section, including all materials, hauling, excavation, and backfill.

Include the cost of dressing and shaping the existing fills (or subgrade) for placing riprap in the Contract unit price for riprap (rubble).

As an exception to the above, concrete that is shown to be removed from an existing structure and subsequently disposed of by being used in the embankment as riprap will not be paid for under this Section. Include the cost of such work under removal of existing structures.

530-5.3 Bedding Stone: Price and payment will be full compensation for all work specified in this Section, including all materials and hauling.

Include the cost of dressing and shaping the existing fills (or subgrade) for placing bedding stone in the Contract unit price for riprap (rubble).

530-5.4 Geotextile Fabric: Include the cost of materials and installation of the geotextile fabric, including any repairs or replacement, in the Contract unit price for riprap or ACB revetment system.

530-5.5 Articulating Concrete Block (ACB) Revetment System: Price and payment will be full compensation for all work specified in this Section, including all materials, labor, hauling, excavation and backfill.

530-5.6 Gabions: Price and payment will be full compensation for all work specified in this Section, including all materials, labor, hauling, excavation and backfill.

530-5.7 Payment Items. Payment will be made under:

Item No. 530-	1-	Riprap Sand-Cement Bags - per cubic yard.
Item No. 530-	3-	Riprap (Rubble) - per ton.

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Item No. 530- 4-	Articulating Concrete Block Revetment System - per square yard.
Item No. 530- 5-	Gabion
Item No. 530- 74-	Bedding Stone - per ton.

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SECTION 534
NOISE AND PERIMETER WALLS

534-1 Description.

534-1.1 Precast Concrete Noise Walls:

Furnish and install concrete noise walls with piles, posts and panels constructed in accordance with Standard Plans, Index 534-200, unless the Plans indicate otherwise. Secure joints and connections in a structurally sound manner without openings in the system that would allow transmission of sound.

534-1.2 Perimeter Walls:

Furnish and install perimeter walls and foundations in accordance with Standard Plans, Index 534-250 for either the precast concrete or the masonry option.

534-2 Materials.

Meet the following requirements:

Portland Cement Concrete .....Section 346
Reinforcing Steel .....Section 415
Welded Wire Reinforcement (WWR) .....Section 415
Concrete Masonry Units (CMU) .....ASTM C90
Mortar .....ASTM C270
Grout .....ASTM C476
Horizontal Joint Reinforcing.....
..... ASTM A951* or ASTM A580
Control Joints.....ACI 530.1 Article 2.5 A or B
* Galvanized in accordance with ASTM A153

534-3 Requirements.

Construct concrete components in accordance with Section 400.

534-3.1 Precast Concrete Requirements:

Obtain precast concrete components from a plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list must meet the requirements of Section 105.

Do not accept products that are not permanently and clearly stamped on the tongue and groove portion of the panel and posted with the type, date cast, project number, and the manufacturer's name or symbol by the Producer.

534-3.2 Masonry Requirements:

Conform to the requirements of Specification for Masonry Structures (TMS 602/ACI 530.1/ASCE6), except as modified by the Plans or this Specification. Submit to the Engineer a certification that materials provided meet the requirements of this Section.

534-4 Shop Drawing Submittal.

Submit shop drawings for precast elements, when required, in accordance with Section 5, showing a plan and elevation with the following project specific information:

1. Begin and end wall stations with offsets
2. Horizontal and vertical alignments of the wall
3. Panel locations
    a. Graphic details and graphic panel locations (noise walls only)

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b. Drainage panel locations and Type
c. Location and length of side installed panels (when required)

4. Post locations and lengths
5. Elevations of top of panel, bottom of panel, and panel joints
6. Existing ground and finished grade elevations
7. Non-standard precast component details
8. Non-standard post and pile connection details
9. Lifting devices

534-5 Construction.

Keep to minimum the clearing and grubbing; trim trees and shrubs only to the extent necessary to construct the walls, unless otherwise shown in the Plans. Keep right-of-way fence that is scheduled to be salvaged in place until completing the wall or as otherwise directed by the Engineer.

Prior to beginning earthwork on the project, stake the wall location in the field and establish the finished graded surface elevations at the base of the walls. Use these elevations to develop the shop drawings. Protect the finish graded surface elevations established in the field for the duration of the project, and do not adjust without prior approval of the Engineer. When constructing earthen berms to raise the base elevation of walls, construct the berms of fill material compacted to 95% of the maximum density as determined by AASHTO T99. After erecting the wall, return the disturbed area to preconstruction condition unless otherwise indicated in the Plans.

534-5.1 Precast Construction.

Shimming of wall panels between the pile collar and the bearing pads is permitted, up to a maximum of 1-1/2 inches. Shims must be either stainless steel or engineered copolymer plastic. Copolymer plastic shims must have a minimum compressive strength of 8,000 psi, without any fractures. Stacked shim plates must be bonded together with a compatible epoxy adhesive. Stacking of shims is permitted as follows:

1. For heights of one inch or less, provide up to four 1/4 inch shims.
2. For heights greater than one inch, use a minimum of one 3/4 inch shim.

Erection Tolerances:

1. Variation from plumb: plus or minus 1/4 inch per 10 feet
2. Panel alignment: plus or minus 1/4 inch
3. Top of panel elevation: plus or minus 3/4 inch
4. Elevation difference of adjacent panels: plus or minus 1/2 inch
5. Joint taper over panel length: plus or minus 1/2 inch
6. Top of collar elevation: plus or minus 3/4 inch
7. Post placement:
   a. variation from specified location plus or minus 1 inch
   b. variation from specified elevation plus or minus 1/4 inch
8. Continuity of graphics, fracture fins, etc across joints: 1/4 inch

534-5.2 Concrete Masonry Construction.

Grout all cells that contain horizontal or vertical reinforcing bars.

534-6 Test Wall.

Erect a test wall section not less than 50 feet in length before starting general wall construction at the project site. The Engineer will use the erection of the test wall to verify the

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Contractor's methods and equipment are sufficient to produce a wall that meets the requirements of the Contract Documents. Build the test wall at a permanent wall location, as agreed to by the Engineer. If the test wall does not meet construction tolerances, remove and dispose of it at no expense to the Department. Include the cost of the test wall in the cost of the wall.

534-7 Repairs or Rejection.

For precast concrete components that have not been installed, evaluate cracks, spalls and other deficiencies in accordance with 450-12. Repair deficiencies in accordance with 450-13 or with the plant's approved repair methods that are included as part of the Producer Quality Control (QC) Plan. Ensure that the original performance and durability of repaired components are maintained. Use materials for concrete repair that will meet or exceed the strength requirement for the class of concrete used. Materials meeting the requirements of Section 930 may be substituted for non-shrink grout when required by 450-13. Precast concrete components are subject to rejection if they fail to conform to any of the requirements after repair. For precast components that have been installed, the disposition of concrete cracks shall be in accordance with 400-21.

534-8 Method of Measurement.

The quantity to be paid for will be the plan quantity, in square feet, measured in place, completed and accepted, of the area bounded by the top of the wall (including wall cap) and the bottom of the wall elements without deductions for openings from the beginning to end limits shown in the control drawings.

534-9 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including but not limited to, furnishing all materials and labor required to construct the wall including caps and foundations.

Payment will be made under:

Item No. 534- 72-	Concrete Noise Wall - per square foot.
Item No. 534- 73-	Perimeter Wall - per square foot.

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SECTION 536
GUARDRAIL

536-1 Description.

Construct guardrail, including end treatments, transition connections to rigid barrier, and other associated hardware, as specified in the Plans and in accordance with the Standard Plans, Index 536 series.

Remove existing guardrail as specified in the Plans.

536-2 Materials.

Use components for guardrail, including posts, offset blocks, steel panels, panel components, bolts, foundations, barrier delineators, end delineators, rub rail, pipe rail, and approach terminals, in accordance with Section 967. Prior to installation, submit a list of the APL numbers of all approach terminals, barrier delineators, and composite offset blocks to be used on the project.

536-3 Construction.

536-3.1 Height Tolerance: Install guardrail panels at the height shown in the Standard Plans with a tolerance of 1 inch above and 1/2 inch below the nominal height specified. Where unavoidable surface irregularities, including but not limited to across shoulder gutters, inlets, and roadway surface break lines, are encountered, a tolerance of 3 inches above and 1 inch below the nominal height is permissible.

536-3.2 Station Location Tolerance: Where guardrail feature stationing is called out in the Plans, the longitudinal stationing tolerance is plus or minus 3 feet and 1-1/2 inch, unless otherwise restricted by field conditions as determined by the Engineer.

For transition connections to rigid barrier, install the thrie-beam terminal connector at a 1/4 inch tolerance relative to the end of the rigid barrier as defined in the Plans and Standard Plans.

536-3.3 Setting Posts: Set posts plumb and to the soil depth shown in the Standard Plans. Use the deep post option only where specified in the Plans. Place posts in excavations, backfill the space around the posts, and thoroughly tamp the backfilled soil. As an alternate method, use a post-driving machine meeting the approval of the Engineer.

For guardrail post replacement, backfill and tamp the existing soil hole prior to setting the replacement post.

If driving timber posts, either block out holes in the asphalt pavement during the asphalt paving operation or cut holes through the asphalt mat prior to the post installation. Blocked out or cut holes in the asphalt pavement must be at least 50% larger than the cross-sectional area of the timber post. After driving the posts, patch the area of asphalt around each post with hot bituminous mixture in accordance with Section 339.

If driving steel posts, drive the post directly through the asphalt mat. Fill asphalt depressions or cracks with hot bituminous mixture in a manner meeting the approval of the Engineer.

For post locations where subsurface miscellaneous rock or other solid material is obstructing the post placement, remove such material as follows:

1. If any part of an obstruction is located within 0 and 18 inches in depth, excavate a minimum 24 inch diameter hole around the post location for the full depth of the post,

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with the back edge of the excavated hole placed a minimum of 15 inches behind the back face of the post.

2. If an obstruction is only located below 18 inches in depth, excavate a minimum 12 inch diameter hole around the post location, for the full depth of the post, with the back edge of the excavated hole placed a minimum of 3 inches behind the back face of the post.

3. Backfill the holes with soil and thoroughly tamp.

536-3.4 Post Location Conflicts: When the construction of guardrail at the required post spacing results in post(s) conflicting with sidewalks, gutter, underground utilities, or other permanent obstacles which cannot be removed as determined by the Engineer, the following options are permitted with the approval of the Engineer:

1. Additional Offset Blocks – Up to two additional offset blocks (3 total) may be used where the resulting post placement, moved farther behind the face of guardrail, will avoid a post conflict.

Use button-head bolts of added length as needed to secure the panel system with the rear nut and washer. Where bolts greater than 25 inches are required, a 5/8 inch threaded rod meeting the same material requirements may be substituted and secured with steel hex nuts of over 1-1/8 inches in diameter. Use a steel washer against the post and not the panel. The rod is not permitted to extend beyond 3/4 inch from the face of the tightened nut on the panel side; trim the rod as needed and galvanize in accordance with Section 562.

Over a distance of one post spacing, linearly widen the miscellaneous asphalt pavement where required to maintain a minimum of 10 inches of material behind the post.

2. Special Steel Posts – Where post placement atop a concrete structure cannot be avoided, use special steel posts as defined in the Standard Plans and 536-3.6.

3. Encased Posts – Where post placement results in a conflict with an underground utility or obstacle, use the shallower encased post option as defined in the Standard Plans where the concrete encasement will not damage a utility.

4. Frangible Leave-Out – Where post placement results in a conflict with a concrete slab, use the frangible leave-out as defined in the Standard Plans. Do not use posts through concrete slabs deeper than 8 inches.

536-3.5 Deep Post: Mark deep posts on the back face, centered 4 inches below the top edge, with a legible black letter ‘D’ approximately 2 inches vertical by 1 inch horizontal in size. Use a permanent black ink stamp or paint stencil.

536-3.6 Special Steel Post: Mount to concrete structures using the following systems.

536-3.6.1 Adhesive Bonded Anchors: For concrete structures 9 inches deep and greater, mount the base plate to the concrete using steel adhesive-bonded anchor bolts with a minimum tensile strength of 60 ksi and galvanized in accordance with ASTM A153. Stainless steel components may be substituted, but components plated in accordance with ASTM B633 are not acceptable. Use adhesive-bonded anchors in accordance with Section 937 and 416 (Type HSHV) and in accordance with the manufacturer’s specification.

Drill holes in concrete, through reinforcing steel if encountered. Thoroughly clean and dry the holes immediately prior to setting anchors.

At a minimum, meet the following strength capacities in Table 536-1:

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Table 536-1 Anchor Strength Capacities		
	Approach Slabs	Other Structures
Min. Tensile Load (Each Anchor)	14,000 lbs	8,000 lbs
Min. Shear Load (Each Anchor)	15,000 lbs	7,800 lbs

536-3.6.2 Hex-Head Bolt: For concrete structures less than 9 inches deep, use a 3/4 inch Hex-Head bolt passing through a 7/8 inch drilled hole in the concrete structure and secured from underneath with a washer and nut. The threaded bolt must not protrude more than 3/4 inches beyond the tightened nut; trim the threaded portion as needed and galvanize in accordance with Section 562.

536-3.7 Steel Panels: Use straight panels to construct radii of 125 feet or greater. Use fabricated shop-bent panels to accommodate radii of less than 125 feet.

536-3.8 Panel Slots and Holes: Use the panel's unaltered, prefabricated slots and holes as shown in the Standard Plans. Do not drill, punch, ream, or otherwise alter the prefabricated slots and holes, except when creating new post bolt slots for reduced post spacing (quarter spacing) and adjusting post spacing to avoid structure edge conflicts as shown in the Standard Plans. Where required, punch new post bolt slots to the dimensions given in the Standard Plans, spaced no closer than 4 inches measured edge to edge from an existing slot. Galvanize new punched slots per Section 562.

536-3.9 Barrier Delineators: Mount barrier delineators on top of the guardrail post by adhesive or mechanical means per the manufacturer's recommendations.

536-3.10 End Delineators: Install the retroreflective sheeting on the approach face (nose) of approach terminals, trailing anchorages, and controlled release terminal (CRT) end treatments where indicated in the Standard Plans. Mount the retroreflective sheeting vertically centered on the approach face by adhesive or mechanical means per the manufacturer's recommendations. Retroreflective sheeting must be a minimum 8 inches in height with a minimum area of 160 square inches for approach terminals and trailing anchorages and 240 square inches for CRT end treatments.

536-3.11 Rub Rail: Treat field drilled holes in accordance with Section 562.

Rub rail must terminate at the nearest post outside of the rub rail stationing range indicated in the Plans.

536-3.12 Pipe Rail: Treat field drilled holes in accordance with Section 562.

Pipe rail must terminate at the nearest post outside of the pipe rail stationing range indicated in the Plans.

536-3.13 Existing Guardrail: Stockpile guardrail, if specified, within the right-of-way at a location approved by the Engineer. Dispose of all remaining guardrail not specified for stockpiling.

536-3.14 Approach Terminal Assemblies: Install approach terminal assemblies as specified in the Plans and APL drawings and in accordance with the geometry and adjacent grading of the Standard Plans. The APL number must be permanently marked on each assembly at a readily visible location using legible lettering at least 3/4 inch in height.

If the Plans call for an approach terminal assembly and do not identify the specific system to be used, the contractor has the option to construct any Department-approved approach terminal assembly identified on the APL that meets the applicable test criteria, subject to the conditions identified in the Plans or the APL drawings.

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536-4 Acceptance.

Acceptance of materials and installation of guardrail will be based on conformance with the requirements of this Section and visual inspection by the Engineer.

536-5 Method of Measurement.

536-5.1 Guardrail: The quantity paid for will be the plan quantity, in linear feet, constructed, in place and accepted.

The length of guardrail is measured end-to-end following the centerline of the panels, between the begin/end guardrail stations as defined in the Standard Plans and the Plans, including the full lengths of the adjoining end treatments and transition connections to rigid barrier.

536-5.2 Rub Rail: The quantity paid for will be the plan length, in linear feet, constructed, in place and accepted.

536-5.3 Pipe Rail: The quantity paid for will be the plan length, in linear feet, constructed, in place and accepted.

536-5.4 Special Guardrail Post: The quantity paid for will be the number of each, constructed, in place and accepted. Special guardrail posts include deep posts, special steel posts, encased posts, and frangible leave-outs as defined in the Standard Plans and indicated in the Plans.

536-5.5 Transition Connection to Rigid Barrier: The quantity paid for will be the number of each, constructed, in place and accepted.

536-5.6 Guardrail Post Replacement: The quantity paid for will be the number of each, replaced.

536-5.7 Guardrail End Treatment: The quantity paid for will be the number of each type as designated, constructed, in place, and accepted. Guardrail end treatment types may include approach terminals, trailing anchorages, CRT end treatments, and double faced approach terminals as defined in the Standard Plans.

536-6 Basis of Payment.

536-6.1 Guardrail: Price and payment will be full compensation for all work specified under this Section, except those items specified in 536-6.2 through 536-6.7. Price and payment include furnishing and installing posts, panels, barrier delineators, offset blocks, and all other materials as defined in the Plans and the Standard Plans. The price and payment will include any reduced post spacing, nested panels, shop-bent panels, end unit panels, and CRT posts as required in the Plans.

The type of guardrail specified will be that which comprises the guardrail run between end treatments and transition connections to rigid barrier (including, but not limited to, w-beam general, w-beam double face, w-beam low-speed, modified thrie-beam). For guardrail systems with direct connections between end treatments and transition connections to rigid barrier, the type of guardrail specified will be w-beam for single face guardrail applications or double faced for double face guardrail applications.

536-6.2 Rub Rail: Price and payment will include all components specified in the Plans and Standard Plans.

536-6.3 Pipe Rail: Price and payment will include all components specified in the Plans and Standard Plans. Pipe rail will be shown and tabulated in the Plans for the condition that steel posts are installed at the indicated pipe rail location, however the pipe rail is not required if the timber post option is selected and installed at the indicated pipe rail location.

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536-6.4 Special Guardrail Post: Price and payment will include all costs for furnishing and installing special guardrail posts that are in addition to the cost of items included in 536-6.1, where special guardrail posts are installed instead of standard posts.

536-6.5 Transition Connection to Rigid Barrier: Price and payment will include all costs for furnishing and installing all hardware for approach or trailing transition connections to rigid barrier per the Standard Plans that are in addition to the cost of items included in 536-6.1. This includes costs for the concrete transition block or alignment curb where shown in the Standard Plans and barrier delineators for existing post and beam bridge railings. This item applies for connections to concrete barrier, concrete pier protection barrier, and concrete or metal bridge traffic railing, including thrie-beam retrofits.

536-6.6 Removal of Existing Guardrail: Price and payment will include all labor and equipment required for removal and disposition of the existing guardrail as specified in the Plans. No additional payment will be made for the removal of transition connections, double faced guardrail, thrie-beam guardrail, nested panels, pipe rail, rub rail, or end terminals.

536-6.7 Guardrail End Treatment: Price and payment will include all costs for furnishing and installing all guardrail end treatment assemblies specified in the Plans that are in addition to the cost of items included in 536-6.1.

536-6.8 Payment Items: Payment will be made under:

Item No. 536- 1-	Guardrail - per foot.
Item No. 536- 5-	Rub Rail - per foot.
Item No. 536- 6-	Pipe Rail - per foot.
Item No. 536- 7-	Special Guardrail Post - each.
Item No. 536- 8-	Transition Connection to Rigid Barrier - each.
Item No. 536- 73-	Removal of Existing Guardrail - per foot.
Item No. 536- 85-	Guardrail End Treatment - each.

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SECTION 538
RESETTING GUARDRAIL

538-1 Description.

Remove the existing guardrail system and reinstall using new and reusable components, at the locations shown in the Plans. Construct the reset guardrail in accordance with the Standard Plans using new and reusable components, excluding components defined as non-reusable in this Section.

Furnish and install end treatment assemblies, approach transition connections to rigid barrier, trailing end transition connections to rigid barrier, and bridge anchorage assemblies as required by the Plans.

538-2 Materials.

538-2.1 Planned Non-reusable Components: The following items are considered planned non-reusable components and must be replaced with new components:

1. Timber posts
2. Timber offset blocks
3. End treatment assemblies
4. Approach transition connections to rigid barrier, including but not limited to panels, posts, hardware, offset blocks, etc.
5. Trailing end transition connections to rigid barrier
6. Bridge anchorage assemblies, including but not limited to panels, posts, hardware, offset blocks, etc.
7. Mounting hardware, including but not limited to nuts, bolts, washers, etc.
8. Any other items specified as non-reusable in the Plans

538-2.2 Unforeseen Non-reusable Components: During construction operations, the Engineer may deem other existing components, excluding planned non-reusable components, as unacceptable for re-use. Such components are considered unforeseen non-reusable components and require replacement with new components. Unforeseen non-reusable components will be compensated in accordance with 4-4.

Components damaged during construction operations are not considered unforeseen non-reusable components and must be replaced with new components at no cost to the Department.

538-3 Construction Methods.

Construct the reset guardrail in accordance with Section 536.

If the reset guardrail is to be placed in the same location as the previous installation, do not use the previous installation's in-ground post holes. Place the reset posts at the approximate midspan location of the previous installation. Backfill and thoroughly tamp the unused, in-ground holes at the previous post locations.

To accommodate the new post locations, field punch new post bolt slots in the reusable guardrail panels where needed. Meet the dimension and treatment requirements of the Standard Plans and Section 536.

538-4 Method of Measurement.

The quantities paid for will be the plan length quantity, in linear feet, constructed, in place and accepted.

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The plan length of a run of guardrail is measured end-to-end following the centerline of the panels, from the begin/end guardrail stations as defined in the Standard Plans and specified in the Plans, including the end treatments and transition connections to rigid barrier lengths.

538-5 Basis of Payment.

Price and payment for resetting guardrail will be full compensation for all work specified in this Section, including the furnishing replacements for planned non-reusable components (excluding end treatment assemblies, approach transition connections to rigid barriers, and bridge anchorage assemblies) and installation of all required components as defined in the Standard Plans. The price and payment will include any reduced post spacing, trailing end transition connections, shop-bent panels, and CRT post segments as defined in the Standard Plans and shown in the Plans.

Price and payment for end treatment assemblies, approach transition connections to rigid barriers, and bridge anchorage assemblies will be as specified in Section 536.

Payment will be made under:

Item No. 538- 1- Guardrail - Reset - per foot.

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SECTION 544
CRASH CUSHIONS

544-1 Description.

Install redirective crash cushions as shown in the Plans. Redirective crash cushions are safety devices with capabilities to redirect the impacting vehicle along the full length of the device.

544-2 Approved Product List (APL).

Use crash cushions listed on the APL. Manufacturers seeking evaluation of crash cushions for inclusion on the APL must submit the following:

1. Product drawings, which at a minimum include:
    a. Anchorage details for the crash cushion
    b. Tables showing the relevant system information and lengths for all options
    c. Length of need location
    d. Transition details
    e. List of all components
2. Installation manuals
3. Crash testing reports demonstrating that the system meets the requirements of MASH
4. All relevant FHWA Eligibility Letters

544-3 Installation.

Handle and install manufactured materials or articles in accordance with the manufacturer's instructions and the Standard Plans. Transition crash cushions in accordance with the Plans, Standard Plans, Index 544-001 and the APL drawings.

Delineate crash cushion ends with Type IV or better retroreflective sheeting meeting the requirements of Section 994. Install retroreflective sheeting with a minimum surface area of 360 square inches and a minimum height of 15 inches. As an alternative, a Type 1 object marker meeting the requirements of Section 705 may be used to delineate the crash cushion end. Center the object marker 3 feet in front of the crash cushion end.

Perform repairs necessary due to defective material, work, or operations without additional cost to the Department.

Restore crash cushions damaged by the traveling public after the installation is completed, accepted and serving its intended purpose on an open section of bridge or roadway within 24 hours.

544-4 Method of Measurement.

The quantity paid for will be the number of each type as designated, constructed, in place, and accepted. Crash cushion types are designated by Test Level (TL) and include either narrow or wide systems.

544-5 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including delineation and system transitions to guardrail or rigid barriers.

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Relocation of an existing crash cushion to a permanent location called for in the Plans will be paid for at the Contract unit price for relocating existing systems. Price and payment will be full compensation for relocating and reinstalling the system in accordance with the manufacturer's instructions and the Standard Plans.

Payment will be made under:

Item No. 544- 2-	Crash Cushion TL-2
Item No. 544- 3-	Crash Cushion TL-3
Item No. 544- 74-	Relocate Crash Cushion - each

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SECTION 546
RUMBLE STRIPS

546-1 Description.

Construct rumble strips in accordance with the details shown in the Plans and Standard Plans, Indexes 546-001, 546-010, and 546-020.

546-2 Materials for Raised Rumble Strips.

546-2.1 Permanent Raised Rumble Strips: Construct permanent raised rumble strips using one of the following:

546-2.1.1 Preformed Thermoplastic: Use only materials listed on the Department's Approved Product List (APL), meeting the following requirements:

Preformed Thermoplastic..... 971-1 and 971-6

Ensure that the material used can be restored to its original dimensions by using a self bonding overlay meeting these requirements. Submit a certified test report to the Engineer indicating that the materials meet all requirements specified.

546-2.1.2 Asphalt: Any plant-mixed hot bituminous asphalt mixture meeting the requirements of a job-mix formula issued by the Department, except open-graded friction course.

546-2.2 Short-Term Raised Rumble Strips: Construct short-term raised rumble strips meeting the requirements of 546-2.1, or by using removable polymer striping tape meeting the requirements of 990-9.

546-3 Application.

546-3.1 Permanent Raised Rumble Strips: Notify the Engineer before the placement of raised rumble strips. Apply raised rumble strips having well defined edges. Remove and replace any raised rumble strips not meeting the requirements of the Contract Documents at no additional cost to the Department.

Before applying raised rumble strips, remove any material that would adversely affect the bond of the raised rumble strips by a method approved by the Engineer.

Apply raised rumble strips only to dry surfaces, and only when the ambient air and surface temperature is at least 55ºF and rising.

Before applying thermoplastic materials on portland cement concrete surfaces, apply a primer sealer recommended by the manufacturer.

Prior to the application of any plant-mixed hot bituminous material, apply a tack coat meeting the requirements of 300-2.3.

The mixture will be accepted on the basis of visual inspection by the Engineer with no further testing required.

546-3.2 Short-Term Raised Rumble Strips: Install short-term raised rumble strips before opening to traffic, and in accordance with 546-3.1. Maintain and remove short-term raised rumble strips until permanent raised rumble strips are installed.

546-3.3 Ground-In Rumble Strip:

546-3.3.1 General: Grind rumble strips that have well-defined edges and smooth interiors without tearing the finished pavement.

On a daily basis, before opening the adjacent lane to traffic, ensure that all debris generated by the grinding process is removed and disposed of by vacuum or a method

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approved by the Engineer. Do not dispose of the debris within the right of way. Do not use the debris generated by the grinding process in recycled asphalt (RAP).

Restore any pavement to the satisfaction of the Engineer, at no additional cost to the Department, when ground-in rumble strips do not meet the requirements of the Contract Documents.

546-3.3.2 Inspection: For limited access roadways, measure depth every one mile during the grinding operation to monitor tolerances specified in Standard Plans, Index 546-010. For arterial and collector roadways, measure depth every 500 feet during the grinding operation to monitor tolerances specified in Standard Plans Index 546-020.

If measurements are outside tolerances, immediately stop grinding operations and adjust grinding machine to meet tolerances before continuing the grinding. Measure depth along the rumble strip centerline at the high and low point of the grinding pattern. Measure depth from top of pavement grade to top of ground-in surface. Measure, record and certify on a Department approved form and submit to the Engineer.

546-4 Method of Measurement.

The quantity of raised rumble strip sets to be paid for under this Section will be the Plan quantity per each set per lane, constructed and accepted.

The quantity of ground-in rumble strips to be paid for under this Section will be the plan quantity in gross miles, constructed and accepted. No deduction will be made when the skip array is used.

546-5 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including all surface cleaning and preparation, all debris disposal, furnishing of all materials, application, curing and protection of all items, protection of traffic, furnishing of all tools, machines, labor, and equipment, and all incidentals necessary to complete the work. Final payment will be withheld until all deficiencies are corrected.

Payment will be made under:

Item No. 546- 71-	Raised Rumble Strip Sets - each.
Item No. 546- 72-	Ground-In Rumble Strips - per gross mile.

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SECTION 548
RETAINING WALL SYSTEMS

548-1 Description.

Construct permanent and temporary retaining wall systems in accordance with this Section and in conformance with the lines, grades, design, and dimensions shown in the Contract or established by the Engineer. Sheet pile walls and cast-in-place walls are not included in this Section. Construct all walls of a specific type (mechanically stabilized earth (MSE), counterfort, etc.), using the same wall system and supplier. If different types of wall systems must be used in such a manner that causes one wall to interact with or influence another wall, coordinate the detailing of these areas of interaction/influence with the assistance of the Contractor's Engineer of Record.

Obtain each reinforced concrete precast concrete retaining wall system from a plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.

Ensure that each wall system component is marked in accordance with 548-5.3.

Ensure that each shipment of products to the job site includes a signed or stamped delivery ticket in accordance with the Materials Manual, Section 8.2 Volume II, and the required written certification statement for each product shipped. Submit these tickets and certifications to the Engineer.

When shown in the Plans or approved by the Engineer, a segmental block MSE retaining wall (SBW) system may be provided as a substitute for a reinforced concrete panel MSE wall system. All SBW systems must comprise:

1. Unreinforced dry-cast masonry facing blocks in a running bond pattern meeting the requirements of 548-5.
2. Structural backfill reinforcement:
    a. Type R-3 geosynthetic backfill reinforcement placed in sheets full length without splices normal to the facing blocks and laterally without horizontal gaps, and with a vertical spacing of not more than every other course of blocks or 30 inches, whichever is less.
    b. Metallic reinforcement placed full length without splices normal to the facing blocks and spaced laterally and vertically not more than every other block or 30 inches, whichever is less, with a positive mechanical or shear connection to the facing blocks.
3. A mechanical shear connection to lock adjacent blocks together horizontally or vertically.

548-2 Materials.

Provide a wall system listed on the Department's Approved Product List (APL) based on the wall type shown in the Plans. Purchase components, soil reinforcement, attachment devices, joint filler, filter fabric, and all necessary incidentals for each wall from the same wall supplier.

548-2.1 Concrete: Ensure that concrete utilized for all wall components is consistent with the concrete class, environmental classification and admixture requirements for durability as stated in the Contract Documents. Produce and supply concrete for all reinforced concrete wall components meeting the requirements of Section 346.

Produce and supply concrete for the leveling pad meeting the requirements of Section 347. Use Department approved mix designs.

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548-2.2 Reinforcing Steel: Meet the requirements of Section 931 for steel reinforcing and Section 932 for FRP reinforcing, as identified in the Contract Documents and APL drawings.

548-2.3 Backfill Reinforcement: For walls utilizing backfill reinforcement, use reinforcement consisting of steel wire mesh, metal strips or structural geosynthetics as required for the wall system chosen. Use backfill reinforcement of the same length from top to bottom of wall at any section. For tiered walls, use backfill reinforcement of the same length within the height of each tier at any section.

Use plain steel wire mesh and embedded loops shop fabricated from cold drawn steel wire and weld into the finished mesh fabric meeting the requirements of ASTM A1064. Use longitudinal and transverse wires of equal and constant diameter within a given piece of mesh reinforcement. Use steel strips hot rolled from bars to the required shape and dimensions with physical and mechanical properties meeting ASTM A572 Grade 65 or as shown in the Contract. Use shop-fabricated hot rolled steel tie straps meeting the minimum requirements of ASTM A1011/A1011 M, Grade 50, or as shown in the Contract.

Ensure that steel reinforcing strips, tie strips, reinforcing mesh and connectors used in permanent walls are galvanized in accordance with ASTM A123 or ASTM A153, as applicable. For typical applications, punch or drill holes in metal items before galvanizing. Field drilled holes for bin walls are permitted. Repair field drilled holes; field cut ends and other damage to galvanized surfaces in accordance with Section 562.

Use Type R-3 structural geosynthetics made of polypropylene, select high density polyethylene or high-tenacity polyester fibers having cross-sections sufficient to permit significant mechanical interlock with the backfill. Use geosynthetics having a high tensile modulus in relation to the backfill. Use geosynthetics having high resistance to deformation under sustained long term design load while in service and resistant to ultraviolet degradation, to damage under normal construction practices and to all forms of biological or chemical degradation normally encountered in the material being reinforced. Do not use uncoated polyester (PET) reinforcements or reinforcements weakened or damaged by high pH environments within any portion of the flowable fill, or within coarse aggregate backfill below the design high water elevation (DHW) shown in the Plans.

Store the geosynthetics in conditions above 20ºF and not greater than 140ºF. Prevent mud, wet cement, epoxy, and like materials from coming into contact with and affixing to the geosynthetic material. Rolled geosynthetic may be laid flat or stood on end for storage. Cover the geosynthetic and protect from sunlight prior to placement in the wall system.

Carefully inspect all reinforcement, steel and geosynthetics to ensure they are the proper size and free from defects that may impair their strength and durability.

548-2.4 Attachment Devices: Use backfill reinforcement attachment devices as required by the wall system chosen.

548-2.5 Joint Materials and Filter Fabrics:

548-2.5.1 Horizontal Joint Pads: Use elastomeric or polymeric pads in all horizontal joints between precast components as recommended by the wall manufacturer. Ensure that the pads are of sufficient size and hardness to limit vertical stresses on the pad and concrete surface and to prevent concrete to concrete contact at the joints.

548-2.5.2 Joint Covers for Non-SBW Walls: For walls supporting bridge abutments on spread footings, cover joints and other wall openings within a horizontal distance equal to the larger of:

1. the length of the reinforcement under the footing plus 25 feet, or

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2. twice the maximum height of the footing above the leveling pad, measured from the nearest edge of the footing, surrounding the reinforced backfill for the abutment with Type D-2 geotextile fabric meeting the requirements of Section 985.

Cover all joints and wall openings in portions of the wall backfilled with coarse aggregate with Type D-2 geotextile fabric meeting the requirements of Section 985. Cover all other joints and wall openings with Type D-2 or D-3 geotextile fabric with a maximum apparent opening size (AOS) equal to US Sieve No. 70 meeting the requirements of Section 985. Apply an adhesive approved by the Engineer to the back of the precast component for attachment of the fabric material.

548-2.5.3 Alignment Pins: Ensure that pins used to align the precast components during construction are of the size, shape and material required for the wall system chosen.

548-2.5.4 Separation Geotextile: Provide a Type D-2, D-3, or D-5 separation geotextile meeting the requirements of Section 985 between the coarse aggregate and the select backfill/embankment at the bottom, top and sides of the coarse aggregate.

548-2.6 Backfill Material:

548-2.6.1 General: Provide compacted select backfill or coarse aggregate backfill within the retaining wall volume as shown in the Plans. For permanent walls, provide coarse aggregate backfill in lieu of compacted select backfill to an elevation at least one foot above the DHW shown in the Plans when the DHW is above the lowest adjacent ground surface. Provide flowable fill within the retaining wall volume in lieu of compacted select backfill or coarse aggregate backfill only when the option for flowable fill is shown in the Plans. The retaining wall volume is defined to extend from the top of the leveling pad or footing, or bottom of walls which do not have footing or leveling pads, to the finish grade line and from the face of the wall to a vertical plane passing through the end of the extreme wall component (straps, counterforts, etc.) plus one foot.

548-2.6.2 Compacted Select Backfill: Meet the requirements of Sections 105 and 120 except as noted within this Section. Have the backfill material tested for every soil type for pH, resistivity, sulfate and chloride content by a Department approved independent testing laboratory prior to placement. Submit a certification, signed and sealed by a Professional Engineer registered in the State of Florida, that the results have met the requirements of this Section.

Use backfill material with a pH between 5.0 and 10.0 as determined by FM 5-550. For polyester geosynthetic reinforcement, use backfill material with a pH between 5.0 and 9.0. Sources of select backfill material having a pH low as 4.5 and 5.0 for walls utilizing metallic reinforcement and pH low as 3.0 for walls utilizing geosynthetic reinforcement, may be used provided the interior face of the MSE wall panels have three inches of concrete cover over the reinforcement, the concrete used in the panels contain either an highly reactive pozzolan or the ternary mix design meets the requirements of Table 346-2 with a surface resistivity equal or greater than 29 kOhm-cm and there are no steel piles and metallic elements/pipes other than metallic reinforcement placed within the backfill.

In addition, for permanent walls utilizing metallic soil reinforcement, use backfill that meets the following electro-chemical test criteria for determining corrosiveness:

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Table 548-1 Electro-Chemical Test Criteria	
Criteria	Test Method
Resistivity: > 3,000 ohm -·cm	FM 5-551
Soluble chloride content < 100 PPM	FM 5-552
Soluble sulfate content: < 200 PPM	FM 5-553

For constructing the retaining wall volume, do not use backfill material containing more than 2.0% by weight of organic material, as determined by FM 1-T267 and by averaging the test results for three randomly selected samples from each stratum or stockpile of a particular material. If an individual test value of the three samples exceeds 3%, the stratum or stockpile will not be suitable for constructing the retaining wall volume.

Ensure that the material is non-plastic as determined by AASHTO T 90 and the liquid limit as determined by AASHTO T 89 is less than 15.

For walls using soil reinforcement, use backfill that meets the following gradation limits determined in accordance with AASHTO T 27 and FM 1-T011:

Table 548-2 Gradation Limits	
Sieve Size	Percent Passing
3-1/2 inches	100
3/4 inch	70-100
No. 4	30-100
No. 40	15-100
No. 100	0-65
No. 200	0-12

For walls not using soil reinforcement, use backfill that meets the following gradation limits determined in accordance with AASHTO T 27 and FM 1-T 011:

Table 548-3 Gradation Limits Not Using Soil Reinforcement	
Sieve Size	Percent Passing
3-1/2 inches	100
No. 200	0-12

548-2.6.3 Flowable Fill: Meet the requirements of Section 121 except as noted within this Section and the Plans.

548-2.6.4 Coarse Aggregate Backfill and Drainage Aggregate: Provide coarse aggregate comprised of natural stones meeting the requirements of Section 901 with a size distribution of any of the listed aggregate gradations from Size No 57 through Size No 89, inclusive, except as noted on the Plans. Have all coarse aggregate backfill materials tested for pH, resistivity, sulfate and chloride content by a Department approved independent testing laboratory prior to placement. Submit a certification, signed and sealed by a Professional Engineer registered in the State of Florida, that the results of these tests meet the requirements of 548-2.6.2.

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For SBW systems, provide drainage aggregate comprised of coarse aggregate backfill and a drainage geotextile to separate the drainage aggregate from the reinforced backfill as specified for each approved wall system.

548-3 Approved Product List (APL).

All proprietary retaining wall systems shall be listed on the APL. Manufacturers seeking evaluation of products for inclusion on the APL shall submit an application in accordance with Section 6, independently certified test reports, and calculations and drawings in accordance with the latest edition of the AASHTO LRFD Bridge Design Specifications and the Department's Structures Design Guidelines (SDG) signed and sealed by a Professional Engineer registered in the State of Florida. Submit calculations and drawings showing details, notes, materials, dimensions, sizes, and other information as described below for a complete description of the retaining wall system.

1. Soil reinforcement durability and/or corrosion data;
2. Differential settlement the wall system can tolerate without exceeding normal stress range of the soil reinforcement and wall facing, or the construction tolerances in this Section;
3. The effects of water flow;
4. Applicable environmental classifications as outlined in the SDG;
5. Signed and sealed design calculations. Design calculations may be either by hand or by a wall company program with hand calculations verifying the program output. It is only necessary to include sample hand calculations for a 20 foot height for each soil condition.
6. Corrosion and durability design procedures for soil reinforcement elements;
7. Provide 11 inch x17 inch drawings showing:
    a. Notes specific to the wall system;
    b. Panel sizes and reinforcing;
    c. Soil reinforcement connection to wall facings;
    d. Wall panel abutment interfacing;
    e. Slip joints;
    f. Steps in leveling pad;
    g. Soil reinforcing details around all vertical obstructions;
    h. Filter fabric placement at panel joints and around all obstructions;
    i. Details for skewing soil reinforcement (15 degrees maximum) without cutting;
    j. Corner elements (required at all angle breaks greater than 5 degrees);
    k. Bin wall details for acute corners (required at all acute corners where interior corner angle is less than 70 degrees);
    l. Details showing how to accommodate long term (post construction) wall settlement in excess of four inches without attaching soil reinforcement to the abutment; and,
    m. Details of how to ground the wall system.
8. Pull-out test data for the proposed wall/reinforcement connection, and size and type of soil reinforcement for wall system. Testing shall be done by an independent soil testing laboratory or testing agency certified by the Department. Ensure test data includes all sizes and types of soil reinforcement to be utilized on Department projects. Default AASHTO values may be used for conventional soil reinforcement. For soil reinforcement grids, include all various configurations and combinations of longitudinal and transverse wires.

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9. Other information pertinent to the design and performance of the wall system as necessary.

10. A field construction manual describing construction requirements and sequencing for the wall system. Submit manual in 8-1/2 inch x 11 inch format in either pdf or MS Word format.

548-4 Shop Drawings.

Submit shop drawings and calculations in accordance with Section 5. Provide calculations and drawings showing details, notes, materials, dimensions, sizes and other information necessary for the complete fabrication and erection of the retaining wall system. As a minimum, provide the following:

1. Elevation view showing the finished graded surface and elevations of the top and bottom of wall at the begin and end of wall, all breaks in vertical alignment and all whole stations and 25 foot station increments.

2. Sections showing the length, size and designation of soil reinforcement.

3. Plan view showing the horizontal alignment and offsets from the horizontal control line to the exterior face of the wall; the location of utilities, drainage structures and other items that impact the wall; the limits of the reinforced soil volume; and, the location of piles within the reinforced earth volume.

4. Details for construction around utilities, drainage structures and other items that impact the wall; for placement of soil reinforcement at acute corners; for addressing conflicts between soil reinforcement and obstructions in the reinforced soil volume; for addressing different wall types intersecting and impacting each other.

5. General notes and design parameters including design soil characteristics; factored bearing resistance and factored bearing pressure for each wall height increment and other notes required for construction of the walls.

6. Design calculations for each wall height increment detailed in the shop drawings.

7. When the friction angle depicted in the shop drawings exceeds 30 degrees for sand backfill or 34 degrees for limerock backfill, provide laboratory test results in accordance with 548-9.5 verifying the backfill to be used for the wall meets the design soil characteristics for the shop drawings.

8. For SBW systems, include details for the placement of drainage aggregate, drainage pipes and separation geotextile. Drawings should be similar to details for Type II or Type III underdrains in Standard Plans, Index 440-001. Do not directly cover perforated drainage pipes with a geotextile filter fabric (such as a filter sock).

9. When SBW systems use friction or semi-friction connections between geosynthetic reinforcement and the facing blocks, include the results of connection capacity testing. Tests must be performed using the materials to be used on the project and tested in accordance with ASTM D6638 to justify the short-term ultimate connection strength reduction factor (CR_u) used to determine the long-term connection strength reduction factor (CR_{cr}) value in the design calculations for each wall height increment detailed in the shop drawings.

548-5 Concrete Component Construction.

Construct reinforced concrete components in accordance with Section 400. Precast wall components are produced using certification acceptance; therefore, assume responsibility for performance of all quality control testing and inspections required by Sections 346 and 400 for

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the precast component construction. Perform all quality control (QC) inspection and testing using Construction Training and Qualification Program (CTQP) qualified personnel. Perform compressive strength testing in a laboratory meeting and maintaining at all times the qualification requirements listed in Section 105. The minimum time for form removal is 12 hours. Unless otherwise indicated in the Contract, apply a Class 3 finish to the concrete surface for the front face, and roughly screed the rear face to eliminate open pockets of aggregate and surface distortions in excess of 1/4 inch.

Construct unreinforced concrete SBW components (facing blocks) with a minimum compressive strength of 4,000 psi at 28 days and a maximum absorption of 6.5% in accordance with ASTM C140. Units must have a normal weight density classification meeting the requirements of ASTM C1372, except as modified in this Section.

548-5.1 Curing: Cure reinforced concrete components in accordance with Section 400.

548-5.2 Tolerances: Meet the following manufactured tolerances:

548-5.2.1 Reinforced Concrete Components:

1. Precast component dimensions: lateral position of soil reinforcement attachment devices - within 1 inch. All other dimensions - within 3/16 inch.

2. Precast component squareness: angular distortion of the component must not exceed 0.2 inches in 5 feet.

3. Precast component surface finish: surface defects on smooth formed surfaces measured on a length of 5 feet must not exceed more than 0.1 inches. Surface defects on textured finished surfaces measured on a length of 5 feet must not exceed 5/16 inch.

548-5.2.2 Unreinforced Concrete SBW Components:

1. Length, width and height of each individual block must be within 1/16 inch of the specified dimension. Hollow units must have a minimum wall thickness of 1-1/4 inches.

2. All units must be free of defects that would interfere with proper placing of the unit or impair the integrity of the wall construction. Minor cracks with a width less than 1/32 inch and a length less than 25% of the unit height may be acceptable.

3. Exposed facing blocks must be split face texture with a uniform wheat or tan color, unless shown otherwise in the Plans.

548-5.3 Marking of Precast Components:

548-5.3.1 Reinforced Concrete Components: Permanently and legibly mark the following information on the back of each reinforced precast wall panel by etching: the panel number or type, piece mark, project number (if applicable), date cast and precast manufacturer's name or symbol with the approved producer's QC stamp affixed.

548-5.3.2 Unreinforced Concrete SBW Components: Label each pallet of dry-cast unreinforced concrete SBW facing blocks with the component identification number or type, project number (if applicable), LOT number, date cast, and the manufacturer's name or symbol. Labels must be clearly legible until the component is installed.

548-6 Repairs or Rejection of Precast Components.

548-6.1 Reinforced Concrete Components: For precast concrete wall components that have not been installed, evaluate cracks, spalls and other deficiencies in accordance with 450-12. Repair deficiencies in accordance with 450-13 or the plant's approved repair methods that are included as part of the Producer Quality Control Plan. The original performance and durability of repaired wall components must be maintained. Use materials for concrete repair that meet or

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exceed the strength requirement for the class of concrete used. Materials meeting the requirements of Section 930 may be substituted for non shrink grout when required by 450-13.

For precast concrete wall components that have been installed, the disposition of concrete cracks will be determined in accordance with 400-21.

The Department will reject all precast concrete wall components not meeting the quality standard of this Section and referenced Specifications. In addition, any of the following defects will be sufficient cause for rejection by the Department:

1. Defects that indicate unsatisfactory molding.
2. Defects indicating honeycombed or open texture concrete.
3. Defects in the physical characteristics such as:
    a. Signs of aggregate segregation
    b. Broken or cracked corners
    c. Soil reinforcement attachment devices improperly installed/damaged
    d. Lifting inserts not useable
    e. Exposed reinforcing steel
    f. Insufficient cover over reinforcing steel
    g. Cracks at the alignment pipe or pin
    h. Insufficient concrete compressive strength
    i. Precast component thickness in excess of plus or minus 3/16 inch from that shown in the Contract Documents
    j. Stained front face, due to excess form oil or other reasons. If the face of the precast component is stained or discolored to the point of rejection, the stain or discoloration may be removed, or a Department approved stain or a Class 5 finish may be applied to attain a uniform appearance for the entire structure, to the satisfaction of the Engineer.

548-6.2 Unreinforced Concrete SBW Components: The Department will reject all segmental retaining wall blocks not meeting the requirements of this Section and the Contract Documents. In addition, any of the following defects will be sufficient cause for rejection of SBW facing blocks by the Department:

1. Defects that indicate unsatisfactory molding.
2. Defects indicating honeycombed or open texture concrete.
3. Defects in the physical characteristics such as:
    a. Signs of aggregate segregation
    b. Broken or cracked corners
    c. Insufficient concrete compressive strength
    d, Excessive concrete absorption
    e. Exceeding dimensional tolerances, or
    f. Discoloration.

Correct cracks or spalls occurring after installation in accordance with 400-21.

548-7 Handling Storage and Shipping.

Handle, store and ship all components in a manner that prevents chipping, cracks, fractures, excessive bending stresses, mud, dirt and debris. Support precast panel wall and counterfort components in storage on firm blocking located immediately adjacent to the attachment device.

Do not ship precast concrete wall components to the project site prior to the completion of the 72 hour curing period and attainment of the required 28 day strength.

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The Contractor is permitted to verify the shipping strength test, before 28 days, by testing compressive strength cylinders that are cured under the conditions similar to the product or by testing temperature match cured cylinders. The shipping strength test is the average compressive strength of two test cylinders. Do not ship reinforced concrete products until accepted and stamped by the QC Manager or the inspectors under the direct observation of the QC Manager.

548-8 Construction Requirements.

548-8.1 General: Due to the unique nature of the structure and concept, procure from the wall supplier fully detailed shop drawings, technical instructions, guidance in preconstruction activities and on-site technical assistance during construction. Closely follow any instructions from the wall supplier, unless otherwise directed by the Engineer. Submit any instructions from the wall supplier to the Engineer. Verify all pertinent retaining wall information (soil parameters, wall alignment, utility locations, conflicting structures) prior to the wall supplier finalizing shop drawings. Bring any conflicts not shown in the Contract to the Engineer's attention.

548-8.2 Wall Excavation: Excavate to the limits shown in the Contract and in conformance with Section 125.

548-8.3 Foundation Preparation: Grade the foundation for the structure level for a width equal to or exceeding the limits of the retaining wall volume or as shown in the Contract. Prepare the foundation in conformance with Section 125.

In addition to the compaction requirements of Section 125, compact the graded area with an appropriate vibratory roller weighing a minimum of eight tons for at least five passes or as directed by the Department's District Geotechnical Engineer. Remove and replace any soft or loose foundation subsoils incapable of sustaining the required compaction to the Engineer's satisfaction.

For permanent MSE wall systems, provide an unreinforced concrete leveling pad as shown in the Contract Documents. Cure the leveling pad a minimum of 12 hours before placement of precast wall components.

For SBW MSE wall systems, a geogrid reinforced, geotextile wrapped, compacted aggregate leveling pad may be used in lieu of the unreinforced concrete leveling pad. The compacted aggregate leveling pad must be at least 24 inches wide and at least 8 inches thick after compacting, and the geogrid must be at least 6 inches below the top of the leveling pad. Wrap the aggregate leveling pad with a D-2, D-3, or D-5 separation geotextile. The geotextile may run up the front and back of the first block course or between the aggregate leveling pad and the first block course.

548-8.4 Wall Erection: Assemble, connect and support wall components as recommended by the wall supplier. As backfill material is placed behind the wall face of MSE wall systems utilizing reinforced concrete panels, maintain the wall in the vertical position or slightly battered into the backfill to provide a final vertical alignment (by means of bracing, temporary wooden wedges placed in the joint at the junction of the two adjacent precast components on the external side of the wall or other alignment aids). Remove wooden wedges as soon as the precast component above the wedged precast component is completely erected and backfilled. External bracing is required for the initial lift of MSE systems.

For SBW systems, carefully place the first course of concrete block units on the leveling pad. Up to 1/2 inch of sand may be placed between the concrete leveling pad and the buried first course of blocks to provide a level and stable base. A one inch gap between the first course of facing units is allowed, provided a suitable filter fabric is placed behind the foundation units as specified for each approved wall system. Each unit must be in full contact with the base

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and checked for level and horizontal alignment. Voids must be kept to a minimum to prevent point loading and cracking, unless otherwise indicated in the shop drawings. Place units side by side for the full length of wall alignment. Fill the hollow cores or cells and the space within blocks with drainage aggregate. Sweep away excess material from top of units and install the next course.

Place soil reinforcement normal to the face of the wall, unless otherwise shown in the Contract or as directed by the Engineer. Do not cut or kink soil reinforcement. Do not connect soil reinforcement to piles or allow soil reinforcement to bear against piles. Field cut soil reinforcement only at locations as shown in the approved shop drawings. Prior to placement of the reinforcement, compact the backfill in accordance with 548-8.5.

For SBW systems, shims made of non-degradable materials may be used as specified for each approved wall system. The shim thickness per course of block must not exceed 1/8 inch and must not be installed on reinforcement elevations when the reinforcement connection relies on any friction.

548-8.4.1 Tolerances for Permanent Walls: Walls that do not meet the following tolerances will not be accepted by the Department and must be removed and reconstructed at no cost to the Department.

548-8.4.1.1 Reinforced Concrete MSE Wall Systems: Vertical tolerances (plumbness) and horizontal alignment tolerances must not exceed 3/4 inch when measured with a 10 foot straightedge. The maximum allowable offset in the joint between precast components is 3/4 inch. The final overall vertical tolerance of the completed wall (plumbness from top to bottom) must not exceed 1/2 inch per 10 feet of wall height. Horizontal and vertical joints between precast components must not be less than 1/2 inch or more than 1-1/4 inches.

548-8.4.1.2 SBW Systems: Horizontal alignment tolerances must not exceed 3/4 inch per10 feet of wall length. The maximum allowable gap between segmental retaining wall blocks above the first course must not exceed 1/16 inch. The final overall vertical tolerance of the completed wall (deviation from plumbness from top to bottom or batter shown in the Plans) must not exceed 1/2 inch per 10 feet of wall height.

548-8.4.2 Tolerances for Temporary Walls: Vertical tolerances (plumbness) and horizontal alignment tolerances must not exceed three inches when measured with a 10 foot straightedge. The final overall vertical tolerance of the completed wall (plumbness from top to bottom) must not exceed one inch per three feet of wall height, not to exceed a total of six inches.

548-8.5 Backfill Placement:

548-8.5.1 Compacted Select and Coarse Aggregate Backfill: A LOT is defined as a single lift of finished embankment not to exceed 500 feet in length of continuous or interconnected walls. Backfill within 3 feet from the panels and backfill beyond 3 feet from the panels are separate LOTs. Overlapping retaining wall volumes may be considered one LOT, excluding the 3-foot width behind the panels. Strips up to 8 feet wide between two retaining wall volumes constructed with the same material in a single operation may be considered as one LOT with the retaining wall volumes. Isolated compaction operations will be considered as separate LOTs. For multiple phase construction, a LOT will not extend beyond the limits of the phase. When bridge abutments on spread footings are shown in the Plans, the material within 3 feet behind the wall face and within the limits defined in 548-9.4.2 are considered as separate LOTs.

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Remove wrinkles in geosynthetic reinforcement prior to covering with backfill. Place the backfill closely following the erection of each course of precast components or soil reinforcement layers and spread by moving the machinery parallel to the wall face. Do not allow equipment heavier than eight tons closer than three feet behind the wall face. Place backfill in a manner to avoid any damage or disturbance to the wall materials or misalignment of the facing materials. Remove and replace any wall materials which become damaged or disturbed during backfill placement at no cost to the Department, or correct as directed by the Engineer. Remove and reconstruct any misalignment or distortion of the wall facing due to placement of backfill outside the limits of this specification at no cost to the Department.

Compact coarse aggregate backfill with a minimum of three passes of a vibratory compactor weighing between 600 and 1,000 pounds or two passes of vibratory compactor weighing over 1,000 pounds. Use the highest vibration level that does not cause excessive fracture of the aggregate in the opinion of the Engineer. Continue compaction until there is no additional movement. Sheepsfoot, grid rollers or other types of equipment employing a foot are not allowed for any backfill type. Achieve compaction of all backfill types within three feet of the back of the wall face using a power operated roller or plate weighing less than 1,000 pounds. At a distance greater than three feet from the back of the wall, a vibratory roller may be used, provided that the frequency and amplitude combined with bulk weight of the roller has performed satisfactorily at a trial section of the same type of wall. For select backfill, a smooth wheel or rubber tire roller is considered adequate. For walls employing geosynthetic reinforcement, limit the weight of compaction equipment to 25,000 pounds. Ensure that the maximum lift thickness after compaction does not exceed six inches. Decrease the lift thickness if necessary, to obtain specified density.

All transitions from coarse aggregate backfill to select backfill must occur at least six inches above and below any layers of backfill reinforcement. Place a separation geotextile in accordance with 548-2.5.4 between the coarse aggregate backfill and select backfill and embankment.

Perform backfill compaction in a way that the compactor moves in a direction parallel to the wall face and proceeds from a distance not less than three feet behind the wall face toward the end of the soil reinforcement element.

When placing select backfill, the moisture content of the backfill material prior to and during compaction must be uniformly distributed throughout each layer of material. Use backfill material having a placement moisture content at the dry side of the optimum moisture content. To achieve the required compaction moisture content, use water that meets the requirements of Section 923. Do not transport excessively moist backfill materials to the site for any reason. Determine the optimum moisture content in accordance with the test method used to determine maximum density in 548-9.

At the end of each day's operation, shape the last level of backfill to permit runoff of rainwater away from the wall face or provide a positive means of controlling run off away from the wall such as temporary pipe.

548-8.5.2 Thick Lift Option for Compacted Select Backfill: If through field tests, the Contractor can demonstrate that the compaction equipment can achieve density for the full depth of a thicker lift, the backfill may be constructed in successive courses of not more than 10 inches compacted thickness.

Based on the results of a full-height test wall constructed by each Contractor or MSE wall sub-contractor, the Engineer will approve each Contractor's or MSE

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wall sub-contractor's specified compaction procedures. The length of the test wall shall be the length required to produce one LOT of 500 feet at the top of the wall. When all individual walls using this option are less than 500-feet long, the test wall may be broken into two segments comprising separate LOTs. Both segments must be accepted to determine the required percent compaction for the remaining walls. For each Contractor or MSE wall sub-contractor, the height of the test wall shall be 20 feet or the highest wall using this option, whichever is less. Lower height walls may be constructed using these procedures until a full height test wall is constructed. Notify the Engineer prior to beginning construction of a test wall.

Perform one set of QC density tests per thick lift of the test wall on the backfill within three feet behind the wall face and one set of QC density tests per thick lift of the test wall on the backfill placed beyond three feet behind the wall face, at random locations within each LOT. At each QC density test, the set will include testing the entire lift thickness and a dig down test of the bottom 6 inches. Excavate materials as needed to allow testing of the bottom 6 inches, at no cost to the Department. Maintain the exposed surface as close to undisturbed as possible; no further compaction will be permitted during the test preparation. The Department will perform verification testing of density for the bottom 6 inches and the entire lift thickness at the frequency indicated in 548-9.6. All QC tests and a Department Verification test must meet the density required by 548-9.4.

Identify the test wall with the required percent compaction effort and thickness in the Earthwork Records System (ERS) portion of the Department's database. For the material within three feet behind the wall face, the minimum density required on the thick lift will be the average of all the passing QC results obtained on the thick lifts of the test wall within the three feet behind the wall face. For the material placed beyond three feet behind the wall face, the minimum density required will be the average of all the passing QC results obtained on the thick lifts of the test wall beyond three feet behind the wall face. If the thick lift density does not meet or exceed the thick lift density results during the test wall, perform dig-down density tests to verify the density of the bottom 6 inches of the lift. The Contractor may elect to place material in 6 inches compacted thickness at any time. Once approved, a change in the source of backfill material will require the construction of a new test wall. Do not change the compaction effort once the test wall is approved. The Engineer will periodically verify the density of the bottom 6 inches during thick lift operations. If unable to achieve the required density, remove and replace or repair the test wall to comply with the specifications at no additional expense to the Department. The Engineer may terminate the use of thick lift construction and instruct the Contractor to revert to the 6 inches maximum lift thickness if the Contractor fails to achieve satisfactory results or meet the requirements of this Section.

548-8.5.3 Flowable Fill: Metallic wall components (including metallic soil reinforcements) must not be in partial contact with the flowable fill. If the metallic components contact the flowable fill, the metallic components must be completely encapsulated by the flowable fill.

548-8.6 Compressible Free Draining Seal: Seal all joints between panels of reinforced concrete panel MSE walls with compressible free draining material (open cell) to prevent plant growth from seeds or spores that may be in the joints or transported to the joints by wind or rain. Install the seal at least 1-1/2-inches from both the front and rear faces of the panel. Protect the free draining seal during the application of coatings and sealants. Should the seal become coated or clogged, remove and replace the coated or clogged free draining seal. The installation must be

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secure and free draining to keep the seal securely in place until uninstalled and to prevent hydrostatic forces from building up behind the panel.

548-9 Acceptance Program.

548-9.1 General Requirements: Meet the requirements of 120-10 except delete the requirements of 120-10.1.4.1, 120-10.1.4.3, 120-10.1.6, 120-10.2 and 120-10.3.

548-9.2 Maximum Density Determination: For select backfill, determine the maximum QC density in accordance with FM 1-T180. When compacting A-3 or A-2-4 materials to meet the alternate acceptance criteria in 548-9.4.1, determine the maximum density in accordance with FM 1-T099.

Perform gradation tests on the sample collected in accordance with AASHTO T 27 and FM 1-T011. Classify soils in accordance with AASHTO M 145 to determine compliance with embankment utilization requirements.

548-9.3 Density Testing Requirements: Meet the requirements of 120-10.1.4.2 except as modified herein. Perform these tests at a minimum frequency of one set of tests per LOT.

Determine test locations including stations and offsets, using the random number generator provided by the Engineer. Do not use notepads or worksheets to record data for later transfer to the ERS section of the Department's database. Notify the Engineer upon successful completion of QC testing on each LOT.

548-9.4 Acceptance Criteria: For select backfill, obtain a minimum density of 90% of the maximum dry density as determined by FM 1-T180 within three feet behind the wall face and obtain a minimum density of 95% of the maximum dry density as determined by FM 1-T180 from beyond three feet behind the wall face.

For flowable fill, meet the requirements of 121-6. For coarse aggregate backfill, compact with a minimum of three passes of a vibratory compactor weighing between 600 and 1,000 pounds or two passes of a vibratory compactor weighing over 1,000 pounds. Use the highest vibration level that does not cause excessive fracture of the aggregate in the opinion of the Engineer. Continue compaction until there is no additional movement.

548-9.4.1 Optional Acceptance Criteria for A-3 and A-2-4 Materials: Obtain a minimum density of 95% of the maximum dry density as determined by FM 1-T099 within 3 feet behind the wall face and obtain a minimum density of 100% of the maximum dry density as determined by FM 1-T099 beyond 3 feet behind the wall face.

The combined width from both MSE wall backfill (excluding the 3-foot zone from the panels) and embankment material may be considered the same LOT if the same material is used; the material in both wall backfill and embankment is compacted with the same procedure, equipment and compacting effort; and the maximum lift thickness after compaction in both wall backfill and embankment is 6-inches.

548-9.4.2 Acceptance Criteria for Wall Backfill Supporting Spread Footings: When spread footings at bridge abutments are shown in the Plans, obtain a minimum of 95% of the maximum dry density as determined by FM 1-T180 on the material within 3 feet behind the wall face, and underneath the footing as defined by the following limits:

1. All lifts below the bottom of the footing for a depth equal to at least the footing width
2. A minimum distance of 3 feet beyond the edges of the footing width

If the optional criteria specified in 548-9.4.1 is used, compact the backfill material within the limits specified above to obtain a minimum density of 100% of the maximum dry density as determined by FM 1-T099. Compact the remainder of the backfill in accordance

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with 548-9.4 or 548-9.4.1 as applicable. Do not use compaction equipment larger than permitted in 548-8.5 within 3 feet behind the wall face; decrease the lift thickness if necessary.

548-9.5 Friction Angle: When the friction angle depicted in the shop drawings exceeds 30 degrees for sand backfill or 34 degrees for limerock backfill, ensure the friction angle of the backfill material tested in accordance with FM 3-D3080 equals or exceeds the backfill friction angle depicted in the shop drawings.

548-9.6 Frequency: Conduct sampling and testing at a minimum frequency listed in the table below. The Engineer will perform verification sampling and tests at a minimum frequency listed in Table 548-4 below.

Table 548-4
Minimum Frequency Testing

Test Name	Quality Control (QC)	Verification
Maximum Density	One per soil type	One per soil type
Density	One per LOT	One per four LOTs for each type of QC test
Gradation	One per Maximum Density	One per Maximum Density
LL&PI	One per Maximum Density	One per Maximum Density
Soil Classification	One per Maximum Density	One per Maximum Density
Organic Content	One per soil type	One per soil type
pH	One per soil type	One per soil type
Direct Shear	Three per soil type when required by 548-9.5	One per soil type

In addition, for permanent walls utilizing metallic soil reinforcement, test for corrosiveness at a minimum frequency of one test per soil type at point of placement according to the electro-chemical table in 548-2.6. The Engineer will collect enough material to split and create two separate samples and retain one for resolution at point of placement until LOTs represented by the samples are accepted. The Engineer will perform verification tests for corrosiveness at a minimum frequency of one test per soil type.

548-9.7 Verification Comparison Criteria and Resolution Procedures:

548-9.7.1 Maximum Density Determination: The Engineer will collect enough material to split and create two separate samples and retain one for resolution until LOTs represented by the samples are accepted.

The Engineer will meet the requirements of 120-10.4.1 except replace FM 1-T099 with FM 1-T180. If the Contractor selects the Optional Acceptance Criteria, the Engineer will verify the QC results of FM 1-T099 in accordance with 120-10.4.1.

548-9.7.2 Density Testing: Meet the requirements of 120-10.4.2.

548-9.7.3 Soil Classification: The Engineer will meet the requirements of 120-10.4.3 except test the sample retained in 548-9.7.1 instead of taking the additional one.

548-9.7.4 Gradation: The Engineer will verify the QC results if the verification result meets the gradation limits set forth in the gradation table of 548-2.6. Otherwise, the Engineer will test the sample retained in 548-9.7.1. The State Materials Office (SMO) or an

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AASHTO accredited laboratory designated by the SMO will perform resolution testing. The material will be sampled and tested in accordance with AASHTO T 27 and FM 1-T011.

If the resolution test result satisfies the required gradation limits, the LOTs will be verified. If the resolution test results do not meet the required gradation limits, reconstruct the LOTs with acceptable material. The Engineer will perform new verification testing.

548-9.7.5 Liquid Limit and Plasticity Index (LL&PI): The Engineer will verify the QC results if the verification result satisfies the plasticity index and liquid limit criteria set forth in 548-2.6. Otherwise, the Engineer will test the sample retained in 548-9.7.1. The SMO or an AASHTO accredited laboratory designated by the SMO will perform resolution testing. The material will be sampled and tested in accordance with AASHTO T 90 and AASHTO T 89, respectively.

If the resolution test result satisfies the required criteria, LOTs of that soil type will be verified. If the resolution test results do not meet the required criteria, reconstruct the corresponding LOTs with acceptable material. The Engineer will perform new verification testing.

548-9.7.6 Corrosiveness: The Engineer will verify the QC results if the verification result satisfies the electro-chemical and pH test criteria set forth in 548-2.6. Otherwise, the Engineer will test the sample retained in 548-9.7.1. The SMO or an AASHTO accredited laboratory designated by the SMO will perform resolution testing. The material will be sampled and tested in accordance with FM 5-550, FM 5-551, FM 5-552 and FM 5-553.

If the resolution test result satisfies the required criteria, material of that soil type will be verified and accepted. If the resolution test results do not meet the required criteria, reject the material and reconstruct with acceptable material.

548-9.7.7 Organic Content: The Engineer will verify the QC results if the verification result satisfies the organic content test criteria set forth in 548-2.6. Otherwise, the Engineer will collect three additional samples. The material will be sampled and tested in accordance with FM 1-T267 and by averaging the test results for three randomly selected samples from at least one lift per soil type. The SMO or an AASHTO accredited laboratory designated by the SMO will perform resolution testing.

If the resolution test result satisfies the required criteria, material of that soil type will be verified and accepted. If the resolution test results do not meet the required criteria, reject the material and reconstruct with acceptable material.

548-9.7.8 Friction Angle: When the friction angle depicted in the shop drawings exceeds 30 degrees for sand backfill or 34 degrees for limerock backfill, the Engineer will take a verification sample at the point of placement to perform a direct shear verification test in accordance with FM 3-D3080. The SMO or a consultant qualified to perform geotechnical specialty lab testing (Type of Work 9.5), per Rule 14-75 of the Florida Administrative Code will perform the verification testing. If the test verifies the material has a friction angle greater than or equal to the friction angle depicted in the shop drawings, the material in the LOTs will be verified. If the verification test does not meet the required friction angle, reconstruct the LOTs with acceptable material.

The Contractor may request to redesign the wall and resubmit the shop drawings with the lower friction angle indicated by the verification test. Employ a Professional Engineer to redesign and submit signed and sealed drawings and computations. Do not begin any

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reconstruction until the proposed redesign has been reviewed and approved by the Engineer. The Contractor shall bear the costs of the redesign and any work resulting from the design changes.

548-10 Certification.

Submit all test reports to the Engineer necessary to document compliance with the Specifications, at least ten days prior to wall construction.

Also submit a certificate of compliance certifying that the retaining wall materials, backfill and construction practices comply with this Section.

For SBW systems, the Engineer will randomly select samples of each type of block used in the segmental block retaining wall system and review a copy of the certified test report corresponding the sample at a frequency of one sample per type of block for each wall.

Acceptance of furnished material will be based on the certificate of compliance, accompanying test reports, and visual inspection by the Engineer.

548-11 Method of Measurement.

The quantity to be paid for will be the plan quantity, in square feet, completed and accepted, of the area bounded by the following:

For permanent retaining wall systems: the top of the coping, the top of the leveling pad or top of structural footings and the begin and end wall limits as shown on the wall control drawings.

For temporary retaining wall systems: the top of wall, the ground line and the begin and end wall limits as shown on the wall control drawings.

548-12 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including the design of the wall system, excavation required specifically for wall construction below the finished graded surface, backfill reinforcement, leveling pad, footings, copings, light pole pedestals, fabric material, horizontal joint materials, alignment pins, repairs, labor, equipment, and other materials necessary to complete the wall in an acceptable manner as shown in the Contract. The cost of backfill for the finished graded surface will be included in the cost of embankment or borrow excavation, as applicable.

Payment will be made under:

Item No. 548- 12-	Retaining Wall System (Permanent) - per square foot.
Item No. 548- 13-	Retaining Wall System (Temporary) - per square foot.

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SECTION 550
FENCING

550-1 Description.

Furnish, erect and reset metal fence of the type and at the locations shown in the Plans.

550-2 Types of Fence.

The types of fence are designated as follows:

Type A (Farm Fence).
Type B (Chain-Link Fence).
Type R (Chain-Link Fence for Pedestrian Overpass).

550-3 Materials.

550-3.1 Type A Fence (Farm Fence): Meet the requirements of Section 954 for timber posts and braces. For metal posts and braces, and for recycled plastic fence posts, meet the requirements of the Standard Plans.

For the fabric and all other accessories, meet the requirements of the Standard Plans.

550-3.2 Type B Fence (Chain-Link): For the posts, braces, fabric and all accessories other than the concrete for bases, meet the requirements of the Standard Plans.

Use concrete as specified in Section 347, or a premix approved by the Engineer for bases. The requirements contained in 347-2.2, and 347-3 will not apply.

550-3.3 Type R Fence (Chain-Link for Pedestrian Overpass): Use the fabric and accessories specified in the Plans.

550-3.4 Resetting Fence: Use material from the existing fence. For any additional materials required, provide the same type of material as in the existing fence and as specified herein, including gates when applicable.

550-3.5 Optional Use of Materials: For Type A Fence, a combination of steel, aluminum, timber, recycled plastic or concrete posts may be used. Unless otherwise called for in the Plans, line posts of one material may be used with corner, pull and end post assemblies of a different material. The Engineer will permit the use of line posts of only one optional material and pull posts assemblies of only one optional material between corner and end post assemblies. Within individual corner and end post assemblies, the Engineer will allow the use of only one optional material.

For Type B Fence, a combination of zinc-coated steel fence members, aluminum coated fence members and aluminum alloy fence members may be used. Unless otherwise indicated in the Plans, the Engineer will allow the use of only one type of fabric material, one type of line post material and one type of pull assembly material between corner and end post assemblies.

550-3.6 Certification: Provide the Engineer with certified test reports from the manufacturer confirming that all materials (posts, braces, fabric and all other accessories) conform to the requirements of this Section, Section 6 and the Standard Plans. Provide the Engineer a copy of the certification at least ten days prior to fence construction.

Also furnish the Engineer a Certificate of Compliance certifying that the fencing system, materials and construction practices comply with the applicable Standard Plans and Specifications.

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Acceptance of furnished material will be based on the Certificate of Compliance, accompanying test reports and visual inspection by the Engineer.

550-4 Construction Methods.

550-4.1 General: Install the fence in accordance with the specific requirements of this Article and with the details shown on the Standard Plans for the particular type of fence called for, except for Type R Fence which shall be detailed in the Plans. Construct the fence in close proximity to the right of way line except as otherwise detailed in the Plans. Assume responsibility for obtaining satisfactory permits or permission from property owners for any encroachments required to perform the work, and for proper scheduling of the fence installation with the removal of existing fence where it is necessary to provide continuous security to adjacent areas already fenced. In order to meet this requirement, where necessary for maintaining security of livestock on adjacent property during construction of the new fence, the Engineer may require the erection and subsequent removal of temporary fencing.

550-4.2 Spacing of Posts: Space posts as shown in the Standard Plans, within a tolerance of 12 inches, except where definite spotting of corner posts is required. Ensure that in any line of fence, the over-spacings and the under-spacings shall approximately compensate. Set additional line posts at abrupt changes in grade.

550-4.3 Clearing: Where the clearing and grubbing for the project includes the area occupied by the fence, clear the area to the limits shown in the Plans. If the limits are not shown in the Plans, clear the area at least 2 feet wide on each side of the fence line. The Engineer may direct that desirable trees be left in place and may restrict clearing where permission from the property owners cannot be obtained.

550-4.4 Construction Over Irregular Terrain and Other Obstructions:

550-4.4.1 Clearance of Bottom of Fence: Install the fence such that the bottom of the fence, in general, follows the contour of the ground. The fence is detailed in the Plans at approximately 3 inches above finished graded surface. Over irregular ground, however, the Engineer will permit a minimum clearance of 1 inch and a maximum of 6 inches for a length not to exceed 8 feet, and, for Type A fence, with the barbed wire spaced midway between ground and bottom of fabric.

550-4.4.2 Grading: Where necessary to secure proper vertical alignment and to meet the clearance requirements, fill depressions (except where filling would obstruct proper drainage) and cut down knolls and ridges. Provide a substantial and permanent foundation for the fence.

550-4.4.3 Use of Extra-Length Posts. At locations where it is impracticable to adjust the ground level, the Engineer may require that posts of additional length be set and that the opening at the bottom be closed by additional barbed wire, stretched taut between poles, with no vertical distance between wires greater than 3 inches. For all such posts requiring a concrete base, extend the concrete downward to the bottom of the extra-length post.

550-4.5 Setting Posts: If rock occurs within the required depth of the post hole, or pavement which is to remain in place exists at the location of a post, drill a hole of a diameter slightly larger than the greatest dimension of the post or footing and grout in the post or footing. Set timber posts either by digging or by driving. Set recycled plastic fence posts in accordance with the Standard Plans.

550-4.6 Placing Fabric: Do not place fabric and barbed wire until the posts have been permanently positioned and concrete foundations have attained adequate strength. Place the fabric by securing one end and applying sufficient tension to remove all slack before making

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permanent attachments at intermediate points. Fasten the fabric to all end, corner and pull posts by approved means. Fasten the fabric using tools designed for the purpose, in accordance with the manufacturer's recommendations. Apply the tension for stretching by mechanical fence stretchers or with single-wire stretchers designed for the purpose.

550-4.7 Electrical Grounds:

550-4.7.1 Grounding for Overhead Lines: Wherever an overhead power line crosses over the fence, install a ground rod directly below the point of crossing. Where an overhead power line runs parallel to, and within 100 feet of the fence, install a ground rod at each end of the fence and at intervals of no greater than 1,500 feet. Use copper-clad steel ground rods that are a minimum of 8 feet in length and 1/2 inch in diameter. Drive the rod vertically until the top of the rod is approximately 6 inches below the ground surface. Connect a conductor of No. 6 AWG solid copper wire to the ground rod and each metal fence element directly adjacent to the ground rod using non-corrosive ground rod clamps.

550-4.7.2 Fences with Non-Metal Posts: For all fences using non-metal posts, substitute a metal post for a non-metal post at intervals of no greater than 300 feet with at least one metal post in any length of fence. Tightly fasten a galvanized steel wire to the barbed wire, fence fabric, and metal post.

550-5 Method of Measurement.

550-5.1 General: The quantities to be paid for will be plan quantity for the number of gates and the length of each type of fence constructed and accepted. In addition, extra payment will be made, in accordance with 550-6.2, for additional lengths of post approved by the Engineer for the crossing of depressions in accordance with 550-4.4.3, muck areas, or other areas of inadequate support for a post of standard length.

550-5.2 Measurement of Fence Length, and Payment: The length of fence to be paid for will be plan quantity completed and accepted. Measurement for resetting fence will be the actual length of existing fence reset, including gates when applicable.

550-6 Basis of Payment.

550-6.1 Basic Items of Fencing: The Contract unit price per foot for the item of fencing, will be full compensation for all work and materials necessary for the complete installation, including line posts, corner, end, and pull posts. Such price and payment will include, but not be limited to, the following specific incidental work.

1. Any work required to level and prepare the terrain along the line of the fence.
2. Any additional clearing incidental to construction of the fence.
3. All preparation for post holes, in whatever type of material, as specified herein.
4. Any furnishing and installing of electrical grounds.
5. Any additional work or materials required for special construction over irregular terrain, or terrain of inadequate support for the posts, including the additional barbed wire, but not including the extra lengths of posts ordered by the Engineer.
6. Any cost of erection and removal of any temporary fencing, which may be necessary for maintaining security of livestock, etc., on adjacent property during construction of the new fence.

550-6.2 Payment Rates for Extra-Length Posts: Any extra length posts added to complete installation of the fence will require an invoice. The Contractor will be compensated for invoice price plus 10% as payment for any extra length posts.

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The standard length of steel, recycled plastic and aluminum posts will be the required length as indicated in the Plans or Standard Plans for each type and case.

The payment for additional length of post will include the cost of additional concrete to extend concrete bases, as applicable.

550-6.3 Gate Payment: The quantities to be paid for will be full compensation for all labor, materials, posts, and associated hardware for the complete installation of the type gate specified in the Plans, and accepted by the Engineer.

550-6.4 Payment Items: Payment shall be made under:

Item No. 550- 10- Fencing - per foot.

Item No. 550- 60- Gates - each.

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SECTION 555
DIRECTIONAL BORE

555-1 Description.

555-1.1 Scope of Work: The work specified in this Section documents the approved construction methods and procedures for directional boring, also commonly called horizontal directional drilling (HDD).

555-1.2 General: HDD is a trenchless method for installing a product that serves as a carrier pipe for transporting solids, liquids or gasses (under pressure or gravity flow), or serves as a conduit, casing, or duct for a carrier pipe, cable, or wire line products. It is a multi-stage process consisting of site preparation and restoration, equipment setup, and drilling a pilot bore along a predetermined path and then pulling the product back through the drilled space. When necessary, enlargement of the pilot bore hole may be necessary to accommodate a product larger than the pilot bore hole size. This process is referred to as back reaming and is done at the same time the product is being pulled back through the pilot bore hole.

Accomplish alignment of the bore by proper orientation of the drill bit head as it is being pushed into the ground by a hydraulic jack and determine orientation and tracking of the drill bit. In order to minimize friction and prevent collapse of the bore hole, introduce a soil stabilizing agent (drilling fluid) into the annular bore space from the trailing end of the drill bit.

Select or design drilling fluids for the site specific soil and ground water conditions. Confine free flowing (escaping) slurry or drilling fluids at the ground surface during pull back or drilling. Remove all residual slurry from the surface and restore the site to preconstruction conditions.

555-2 Construction Site Requirements.

555-2.1 Pedestrian Traffic: When and where installations temporarily disrupt use of a pedestrian way, provide a safe alternate route in accordance with Standard Plans, Indexes 102-600 and 102-660.

555-2.2 Site Conditions:

1. Carry out excavation for entry, exit, recovery pits, slurry sump pits, or any other excavation as specified in Section 120. Sump pits are required to contain drilling fluids if vacuum devices are not operated throughout the drilling operation, unless approved by the Engineer.

2. Within 48 hours of completing installation of the product, clean the work site of all excess slurry or spoils. Take responsibility for the removal and final disposition of excess slurry or spoils. Ensure that the work site is restored to pre-construction conditions or as identified on the plans.

3. Provide MOT in accordance with the Standard Plans and the MUTCD when and where the former is silent.

4. Exposure of product shall be limited to 3 feet and 14 consecutive days unless approved by the Engineer.

555-2.3 Damage Restoration: Take responsibility for restoration for any damage caused by heaving, settlement, separation of pavement, escaping drilling fluid (frac-out), or the directional drilling operation, at no cost to the Department.

555-2.3.1 Remediation Plans: When required by the Engineer, provide detailed plans which show how damage to any roadway facility will be remedied. These details will

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become part of the As-Built Plans Package. Remediation plans must follow the same guidelines for development and presentation of the as-built plans. When remediation plans are required, they must be approved by the Engineer before any work proceeds.

555-3 Quality Control.

555-3.1 General: Take control of the operation at all times. Have a representative who is thoroughly knowledgeable of the equipment, boring and Department procedures, present at the job site during the entire installation and available to address immediate concerns and emergency operations. Notify the Engineer 48 hours in advance of starting work. Do not begin installation until the Engineer is present at the job site and agrees that proper preparations have been made.

555-3.1.1 Product Testing: When there is any indication that the installed product has sustained damage and may leak, stop all work, notify the Engineer and investigate the damage. The Engineer may require a pressure test and reserves the right to be present during the test. Perform pressure test within 24 hours, unless otherwise approved by the Engineer. Submit the test results to the Engineer for review and approval. The Engineer is allowed up to 72 hours to approve or determine if the product installation is not in compliance with the specifications. The Engineer may require non-compliant installations to be filled with excavatable flowable fill.

555-3.1.2 Testing Methods: Testing may consist of one of the following methods and must always meet or exceed the Department's testing requirements:

1. Follow the product manufacturer's pressure testing recommendations.
2. Ensure carrier pipes installed without a casing meet the pressure requirements set by the owner. If the owner does not require pressure testing, the Engineer may require at least one test.
3. A water tight pipe and joint configuration where the product is installed beneath any pavement (including sidewalk) and front shoulders is required. The Engineer will determine when and where water tight joint requirements will be applied to the ultimate roadway section for future widening. When a product is located elsewhere, the pipe and joint configuration must meet or exceed soil tight joint requirements. Conduct tests for joint integrity for one hour. The test for a soil tight joint allows up to 0.1 gallon of water leakage at a sustained pressure of 2 psi. The water tight joint criteria allows no leakage at all for a sustained pressure of 5 psi.

555-3.1.3 Failed Bore Path: If conditions warrant removal of any materials installed in a failed bore path, as determined by the Engineer, it will be at no cost to the Department. Promptly fill all voids with excavatable flowable fill.

555-3.2 Product Locating and Tracking: The method of locating and tracking the drill head during the pilot bore will be shown in the Plans. The Department recognizes walkover, wire line, and wire line with surface grid verification, or any other system as approved by the Engineer, as the accepted methods of tracking directional bores. Use a locating and tracking system capable of ensuring the proposed installation is installed as intended. If an area of radio signal interference is expected to exceed 5 feet, the Engineer may specify the use of a suitable tracking system. The locating and tracking system must provide information on:

1. Clock and pitch information
2. Depth
3. Transmitter temperature
4. Battery status
5. Position (x,y)

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6. Azimuth, where direct overhead readings (walkover) are not possible (i.e. subaqueous or limited access transportation facility)

7. Ensure proper calibration of all equipment before commencing directional drilling operation.

8. Take and record alignment readings or plot points such that elevations on top of and offset dimensions from the center of the product to a permanent fixed feature are provided. Such permanent fixed feature must have prior approval of the Engineer. Provide elevations and dimensions at all bore alignment corrections (vertical and horizontal) with a minimum distance between points of 100 feet. Provide a sufficient number of elevations and offset distances to accurately plot the vertical and horizontal alignment of the installed product. A minimum of three elevation and plot points are required.

555-3.3 Product Bore Hole Diameter: Minimize potential damage from soil displacement/settlement by limiting the ratio of the bore hole to the product size. The size of the back reamer bit or pilot bit, if no back reaming is required, will be limited relative to the product diameter to be installed as follows:

Table 555-1
Maximum Pilot or Back-Reamer Bit Diameter When Rotated 360 Degrees

Outside Pipe Diameter Inches*	Maximum Bit Diameter Inches
<8	Diameter + 4
8 to 24	1.5 x Diameter
>24	Diameter + 12

*Use manufacturer's recommendation for pipe with restrained joints.

555-3.4 Drilling Fluids: Use a mixture of bentonite clay or other approved stabilizing agent mixed with potable water with a minimum pH of 6.0 to create the drilling fluid for lubrication and soil stabilization. Do not use any other chemicals or polymer surfactants in the drilling fluid without written consent from the Engineer. Certify to the Engineer in writing that any chemicals to be added are environmentally safe and not harmful or corrosive to the facility. Identify the source of water for mixing the drilling fluid. Any water source used other than a potable water source may require a pH test.

555-4 Drilling Operations:

555-4.1 Installation Process: Ensure adequate removal of soil cuttings and stability of the bore hole by monitoring the drilling fluids such as the pumping rate, pressures, viscosity and density during the pilot bore, back reaming and pipe installation. Relief holes can be used as necessary to relieve excess pressure down hole. Obtain the Engineer's approval of the location and all conditions necessary to construct relief holes to ensure the proper disposition of drilling fluids is maintained and unnecessary inconvenience is minimized to other facility users.

To minimize heaving during pull back, the pull back rate is determined in order to maximize the removal of soil cuttings without building excess down hole pressure. Contain excess drilling fluids at entry and exit points until they are recycled or removed from the site or vacuumed during drilling operations. Ensure that entry and exit pits are of sufficient size to contain the expected return of drilling fluids and soil cuttings.

Ensure that all drilling fluids are disposed of or recycled in a manner acceptable to the appropriate local, state, or federal regulatory agencies. When drilling in suspected

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contaminated ground, test the drilling fluid for contamination and appropriately dispose of it. Remove any excess material upon completion of the bore. If in the drilling process it becomes evident that the soil is contaminated, contact the Engineer immediately. Do not continue drilling without the Engineer's approval.

When conditions warrant, as determined by the Engineer, back reaming for enlarging the bore diameter shall be accomplished by connecting the reamer to trailing drill stems at the exit pit of the pilot bore. The drill pipe shall remain in the bore hole until the final product is pulled into place. After the pilot bore is established, do not push anything from the entry pit to the exit pit.

The timing of all boring processes is critical. Install a product into a bore hole within the same day that the pre-bore is completed to ensure necessary support exists.

555-4.2 Boring Failure: If an obstruction is encountered during boring which prevents completion of the installation in accordance with the design location and specification, the pipe may be taken out of service and left in place at the discretion of the Engineer. Immediately fill the product left in place with excavatable flowable fill. Submit a new installation procedure and revised plans to the Engineer for approval before resuming work at another location. If, during construction, damage is observed to the FDOT facility, cease all work until resolution to minimize further damage and a plan of action for restoration is obtained and approved by the Engineer.

555-5 Documentation Requirements.

555-5.1 Boring Path Report: Submit a Bore Path Report to the Engineer within seven days of the completion of each bore path. Include the following in the report:

1. Location of project and financial project number including the Permit Number when assigned
2. Name of person collecting data, including title, position and company name
3. Investigation site location (Plans station number or reference to a permanent structure within the project right of way)
4. Identification of the detection method used
5. Elevations and offset dimensions as required in 555-3.2

555-5.2 As-Built Plans: Provide the Engineer a complete set of as-built plans showing all bores (successful and failed) within 30 calendar days of completing the work. As-built plans must be PDF files, in the same scale as the Plans. Ensure that the plans are dimensionally correct copies of the Plans and include roadway plan and profile, cross-section views, boring location and subsurface conditions as directed by the Engineer. The plans must show appropriate elevations referenced to a permanent FDOT feature (mast arm foundation, manhole inlet cover, head wall, etc). Specific plans content requirements include but may not be limited to the following:

1. The Contract plan view shows the center line location of each facility installed, or installed and placed out of service, to an accuracy of 1 inch at the ends and other points physically observed in accordance with the bore path report.
2. As directed by the Engineer, provide either a profile plan for each bore path, or a cross-section of the roadway at a station specified by the Engineer, or a roadway centerline profile. Show the ground or pavement surface and crown elevation of each facility installed, or installed and placed out of service, to an accuracy of within 1 inch at the ends and other exposed locations. On profile plans for bore paths crossing the roadway, show stationing of the crossing on the Plans. On the profile plans for the bore paths paralleling the roadway, show the Plans

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stationing. If the profile plan for the bore path is not made on one of the Plans, use a 10 to 1 vertical exaggeration.

3. If, during boring, an obstruction is encountered which prevents completion of the installation in accordance with the design location and specification, and the product is left in place and taken out of service, show the failed bore path along with the final bore path on the plans. Note the failed bore path as “Failed Bore Path - Taken Out of Service”. Also show the name of the utility owner, location and length of the drill head and any drill stems not removed from the bore path.

4. Show the top elevation, diameter and material type of all utilities encountered and physically observed during the subsoil investigation. For all other obstructions encountered during a subsoil investigation or the installation, show the type of material, horizontal and vertical location, top and lowest elevation observed, and note if the obstruction continues below the lowest point observed.

5. Include bore notes on each plan stating the final bore path diameter, product diameter, drilling fluid composition, composition of any other materials used to fill the annular void between the bore path and the product, or facility placed out of service. Note if the product is a casing as well as the size and type of carrier pipes placed within the casing as part of the Contract work.

555-6 Compensation.

No direct payment will be made for directional bore. Include the cost to perform this operation in the Contract price for the item being installed.

No compensation will be made for failed bore paths, injection of flowable fill, products taken out of service, or incomplete installations.

No compensation will be made for the pay item associated with the directional bore until a Bore Path Report has been submitted and accepted by the Engineer.

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SECTION 556
JACK AND BORE

556-1 Description.

556-1.1 Scope of Work: The work specified in this Section documents the approved construction methods, procedures and materials for Jack and Bore (J&B), also known as auger boring. Micro tunneling (MT) is also included in the category of J&B for purposes of the Specifications.

556-1.2 General: J&B is a method for installing a product (often called a casing) that may serve as a direct conduit for liquids or gases, or as a duct for carrier (Pipe, cable, or wire line products). It is a multi-stage process consisting of constructing a temporary horizontal jacking platform and a starting alignment track in an entrance pit at a desired elevation. The product is then jacked by manual control along the starting alignment track with simultaneous excavation of the soil being accomplished by a rotating cutting head in the leading edge of the product's annular space. The ground up soil (spoil) is transported back to the entrance pit by helical wound auger flights rotating inside the product. J&B typically provides limited tracking and steering as well as limited support to the excavation face.

MT is conducted similar to J&B with the exception that it is remotely controlled, guided pipe jacking process that provides continuous support to the excavation face. The guidance system usually consists of a laser mounted in the tunneling drive shaft which communicates a reference line to a target mounted inside the MT machine's articulated steering head. The MT process provides the ability to control the excavation face stability by applying mechanical or fluid pressure to counterbalance the earth and hydrostatic pressures.

Removal and disposition of excess material varies, is the responsibility of the boring contractor and is not covered under this Specification. However, the cost of removal or final disposition is included in the cost of the J&B operation.

No J&B conduit may be left open ended without approval of the Engineer.

556-2 Materials.

Select materials approved for installation within the right-of-way based on their suitability for the construction method as defined in Table 556-1. After determining product suitability, individual material standards as contained in Table 556-2 apply.

Table 556-1
Product Suitability by Construction Method

Type	Pipe/Casing Installation Mode	Suitable Pipe/Casing
Jack and Bore	Jacking	Steel, Plastic
Micro tunneling	Jacking	DI, FRPM, PC, PCCP, RCCP, RCP, Steel

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Table 556-2 Material Standards Acceptable for J&B and MT Installations		
Material Type	Non-Pressure	Pressure
Ductile Iron (DI)	AWWA C150/C151 ASTM A716	AWWA C150/C151
Fiberglass Reinforced Polymer Mortar (FRPM)	ASTM D3262	ASTM D3517 AWWA C950
Polymer Concrete (PC)	DIN 54815-1 & 2	N/A
Prestressed Concrete Cylinder Pipe (PCCP)	N/A	AWWA C301
Reinforced Concrete Cylinder Pipe (RCCP)	N/A	ASTM C361
Reinforced Concrete Pipe (RCP)	ASTM C76	ASTM C361 AWWA C300/C302
Steel	ASTM A139 Grade B(1) API 2B(2)	AWWA C200 API 2B(2)
Polyvinyl Chloride (PVC)	ASTM D1785	ASTM D1785
Reinforced Thermosetting Resin Pipe (RTRP)	ASTM D2996 or ASTM D2997	ASTM D2996 or ASTM D2997
(1) No hydrostatic test required (2) Dimensional tolerances only		

Unless otherwise tested and approved by the Department, only use encasement pipe or uncased carrier pipe material that is new and has smooth interior and exterior walls.

When the Plans show that the casing is to be used as a drainage carrier pipe, extend the casing the entire length from drainage structure to drainage structure. When using uncased carrier pipe, use pipe meeting the requirements in 556-4.3. Maintain a uniform diameter, wall thickness and material type for the entire length of the casing.

556-2.1 Steel Pipe Casing and Welds: In addition to meeting or exceeding the conditions contained in Table 556-1 and Table 556-2, meet the following requirements:

1. The size of the steel casing must be at least 6 inches larger than the largest outside diameter of the carrier. Casing size must accommodate pressure pipe or carrier pipe joint restraints.

2. The casing pipe must be straight seam pipe, spiral seam pipe, or seamless pipe.

3. All steel pipe may be bare inside and out, with the manufacturer's recommended minimum nominal wall thicknesses to meet the greater of either installation, loading or carrier requirements.

4. All steel casing pipe must be square cut and have dead-even lengths which are compatible with the J&B equipment.

Use steel pipe casings and welds meeting or exceeding the thickness requirements to achieve the service life requirements noted in the Department Drainage Manual Chapter 6. For purposes of determining service life, ensure that casings installed under roadways meet or exceed cross drain requirements and casings under driveways meet or exceed side drain pipe requirements. For pipe used in drainage applications, use pipe meeting the requirements in 556-4.3. For purposes of material classification, consider steel pipe casing structural plate steel

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pipe. Ensure that steel pipe casing of insufficient length achieves the required length through fully welded joints. Ensure that joints are air-tight and continuous over the entire circumference of the pipe with a bead equal to or exceeding the minimum of either that required to meet the thickness criteria of the pipe wall for jacking and loading or service life. All welding shall be done in accordance with the American Welding Society Structural Welding Code- Steel D1.1.

556-2.2 Reinforced Concrete Pipe Casing: In addition to meeting or exceeding the conditions contained in Tables 556-1 and Table 556-2, meet the following requirements:

Ensure that concrete pipe complies with the following minimum requirements:

1. 5,000 psi concrete compressive strength
2. Class III, IV, or V as required by load calculations, with a C-wall
3. Full circular inner and/or outer reinforcing cage
4. Multiple layers of steel reinforcing cages, wire splices, laps and spacers are permanently secured together by welding in place
5. Straight outside pipe wall with no bell modification
6. No elliptical reinforcing steel is allowed
7. Single cage reinforcement with a 1 inch minimum cover from the inside wall
8. Double cage reinforcement with a 1 inch minimum cover from each wall
9. Joints are gasket type
10. Additional joint reinforcement
11. For drainage applications, use pipe meeting the requirements in 556 4.3.

Upon installation, the Engineer may, at his discretion, require the Contractor to perform concrete wiping or injection of the joints if it is believed the joints have not maintained their water tightness during the jacking operation. No additional payment will be made for this operation.

556-2.3 Plastic Pipe Casing: Plastic pipe may be jacked and bored if its physical properties meet or exceed the conditions contained in Tables 556-1 and 556-2, and has a sufficient wall thickness to maintain proper alignment without exceeding the deflection requirements in Section 430-9.3. If plastic pipe is Jacked and Bored it may not be used as a pressurized carrier. Plastic pipe casing installed by the jack and bore method requires the use of an auger. Open end jacking without the use of an auger for continuous cleanout of the bore as the pipe is advanced is not permitted. Closed end jacking is not permitted.

For drainage applications, use pipe meeting the requirements in 556-4.3.

556-2.4 Pipe Couplings and Joints: In addition to meeting or exceeding the conditions contained in Tables 556-1 and 556-2, to minimize potential for bore failure, couplings must not project at right angles from the casing diameter by more than 3/4 inch.

1. Steel Pipe Coupling and Joints:
   a. Welds must comply with 556-2.1(4) when couplings are not used or when the coupling thickness is less than the casing thickness.
   b. When couplings are used the casing joint needs only to be tack welded. Couplings must have a full bead weld such that the thickness, when measured at an angle of 45 degrees to the casing and coupling interface, must be no less than the casing thickness.
2. Plastic Pipe Couplings and Joints:

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a. Must meet or exceed all ASTM strength and composition standards established for the casing material to which they are being attached.

b. Joints must be made sufficiently strong to withstand the pressures of jacking. All chemical welds must be completely set and cured before any jacking is attempted.

556-3 Construction Site Requirements.

556-3.1 Site Conditions:

1. Carry out excavation for entry, exit, recovery pits, auger slurry sump pits, or any other excavation as specified in Section 120. When using auger fluids, the sump pits must contain auger fluids if vacuum devices are not operated throughout the boring operation.

2. Within 48 hours of completing installation of the boring product, ensure that the work site is cleaned of all excess auger fluids or spoils. Removal and final disposition of excess fluids or spoils is the responsibility of the boring contractor and ensure that the work site is restored to pre-construction conditions or as identified in the Plans.

3. Restore excavated areas in accordance with the Specifications and Standard Plans.

4. Provide MOT in accordance with the Department Standard Plans and the MUTCD when and where the former is silent.

5. Ensure that equipment does not impede visibility of the roadway user without taking the necessary precautions of proper signing and Maintenance of Traffic Operations.

556-3.2 Ground Water Control: Investigate all sites for possibility of having to manage groundwater problems that may occur due to seasonal changes or natural conditions.

When ground water level must be controlled, use a system and equipment that is compatible with the properties, characteristics, and behavior of the soils as indicated by the soil investigation report.

556-3.3 Damage Restoration: Take responsibility for restoring any damage caused by heaving, settlement, separation of pavement, escaping boring fluid (frac-out) of the J&B or MT operation at no cost to the Department.

556-3.3.1 Remediation Plans: When required by the Engineer, submit detailed plans which show how damage to any roadway facility will be remedied. These details will become part of the As-Built Plans Package. Remediation plans must follow the same guidelines for development and presentation of the As-Built Plans. When remediation plans are required, they must be approved by the Engineer before any work proceeds.

556-4 Quality Control.

556-4.1 General: Take control of the operation at all times. Have a representative who is thoroughly knowledgeable of the equipment, boring, and Department procedures present at the job site during the entire installation and available to address immediate concerns and emergency operations. Notify the Engineer 48 hours in advance of starting work. Do not begin the installation until the Engineer is present at the job site and agrees that proper preparations have been made.

556-4.2 Construction Process and Approval: For all installations, submit sufficient information to establish the proposed strategy for providing the following:

1. An indication of where the leading edge of the casing is located with respect to line and grade and the intervals for checking line and grade. Indication may be provided by using a water gauge (Dutch level) or electronic transmitting and receiving devices. Other methods must have prior approval. Maintain a record of the progress at the job site.

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2. Equipment of adequate size and capability to install the product and including the equipment manufacturer's information for all power equipment used in the installation.

3. A means for controlling line and grade.

4. A means for centering the cutting head inside the borehole.

5. Provide a means for preventing voids by assuring:

a. The rear of the cutting head from advancing in front of the leading edge of the casing by more than 1/3 times the casing diameter and in stable cohesive conditions not to exceed 8 inches.

b. In unstable conditions, such as granular soil, loose or flowable materials, the cutting head is retracted into the casing a distance that permits a balance between pushing pressure, pipe advancement and soil conditions.

c. Development of and maintaining a log of the volume of spoil material removal relative to the advancement of the casing.

6. Adequate casing lubrication with a bentonite slurry or other approved technique.

7. An adequate band around the leading edge of the casing to provide extra strength in loose unstable materials when the cutting head has been retracted into the casing to reduce skin friction as well as provides a method for the slurry lubricant to coat the outside of the casing.

8. At least 20 feet of full diameter auger at the leading end of the casing. Subsequent auger size may be reduced, but the reduced auger diameter must be at least 75% of the full auger diameter.

9. Water to be injected inside the casing to facilitate spoil removal. The point of injection shall be no closer than 2 feet from the leading edge of the casing.

556-4.3 Testing:

556-4.3.1 Testing Requirements: Ensure all casing joints meet the Department's watertight pressure requirements in accordance with Section 430. Testing may consist of one of the following methods but must always meet or exceed Department testing requirements.

1. Follow the product manufacturer's pressure testing recommendations.

2. Carrier pipes installed without a casing must meet the pressure requirements set by the owner. If the owner does not require pressure testing, the Engineer may require at least one test.

556-4.3.2 Drainage Application Testing (Under Pavement): When under pavement (including sidewalk) and shoulders, all J&B pipe installations must meet or exceed the Department's watertight pipe and joint configuration in accordance with Section 430. The Engineer will determine when and where watertight joint requirements shall be applied to the ultimate roadway section for future widening. For all J&B carrier pipes installed without casing under pavement, perform air pressure testing at 5 psi in the presence of the Engineer as follows.

1. Pressurize pipe to 5 psi (positive and negative) and lock-off outside air source. Record pressure loss for 6 hours. A pressure loss equal to or less than 0.5 psi is acceptable. or,

2. A dragnet type leak detector or equivalent device capable of detecting pressure drops of 1/2 psi for a time period recommended by the manufacturer.

If the pressure loss exceeds 0.5 psi, repair leaks using methods approved by the Engineer and retest.

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556-4.3.3 Drainage Application Testing (Not Under Pavement): When J&B pipe installations are not located under the pavement, the pipe and joint configuration must meet or exceed soil tight joint requirements. The test for a soil tight joint allows up to 0.1 gallon of water leakage at a sustained pressure of 2 psi. Conduct test for joint integrity for one hour.

556-4.3.4 Damaged Product Testing: When there is any indication that the installed product has sustained damage and may leak, stop the work, notify the Engineer and investigate damage. The Engineer may require a pressure test in accordance with 556-4.3.2. Perform pressure test within 24 hours unless otherwise approved by the Engineer. Submit the test results to the Engineer for review and approval. The Engineer shall be allowed up to 72 hours to approve or determine if the product installation is not in compliance with Specifications. The Engineer may require non-compliant installations to be filled with excavatable flowable fill at no cost to the Department.

556-4.4 Product Locating and Tracking: Install all facilities such that their location can be readily determined by electronic designation after installation. For non-conductive installations, attach a minimum of two separate and continuous conductive tracking (tone wire) materials, either externally, internally, or integral with the product. Use either a continuous green sheathed solid conductor copper wire line (minimum No. 12 AWG for external placement or minimum No. 14 AWG for internal placement in the conduit/casing) or a coated conductive tape. Ensure that conductors are located on opposite sides when installed externally. Connect any break in the conductor line before construction with an electrical clamp or solder, and coat the connection with a rubber or plastic insulator to maintain the integrity of the connection from corrosion. Clamp connections must be made of brass or copper and of the butt end type with wires secured by compression. Soldered connections must be made by tight spiral winding of each wire around the other with a finished length minimum of 3 inches overlap. Tracking conductors must extend 2 feet beyond bore termini. Conductors must be tested for continuity. Identify each conductor that passes by removing the last 6 inches of the sheath. No deductions are allowed for failed tracking conductors. Failed conductor ends must be wound into a small coil and left attached for future use.

556-4.5 Augering Fluids: Use a mixture of bentonite clay or other approved stabilizing agent mixed with potable water with a minimum pH of 6.0 to create the drilling fluid for lubrication and soil stabilization. Vary the fluid viscosity to best fit the soil conditions encountered. Do not use other chemicals or polymer surfactant in the drilling fluid without written consent of the Engineer. Certify in writing to the Engineer that any chemicals to be added are environmentally safe and not harmful or corrosive to the facility. Identify the source of water for mixing the drilling fluid. Approvals and permits are required for obtaining water from such sources as streams, rivers, ponds or fire hydrants. Any water source used other than potable water may require a pH Test.

556-4.6 Micro-Tunneling (MT) and Micro Tunnel Boring Machine (MTBM) Requirements:

556-4.6.1 Performance Requirements: The MTBM must meet the following minimum performance requirements:

1. Capable of providing positive face support regardless of the MTBM type.
2. Articulated to enable controlled steering in both the vertical and horizontal direction to a tolerance of plus or minus 1 inch from design alignment.
3. All functions are controlled remotely from a surface control unit.

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4. Capable of controlling rotation, using a bi-directional drive on the cutter head or by using anti-roll fins or grippers. The Engineer must approve other methods.

5. Capable of injecting lubricant around the exterior of the pipe being jacked.

6. Indication of steering direction.

For slurry systems, the following is also required:

7. The volume of slurry flow in both the supply and return side of the slurry loop.

8. Indication of slurry bypass valve position.

9. Indication of pressure of the slurry in the slurry chamber.

556-4.7 Failed Bore Path: If conditions warrant removal of any materials installed in a failed bore path, as determined by the Engineer, it will be at no cost to the Department. Promptly fill all voids by injecting all taken out of service products that have any annular space with excavatable flowable fill.

556-5 Jack and Bore and Micro-Tunneling Operations.

556-5.1 Installation Process: Provide continuous pressure to the face of the excavation to balance groundwater and earth pressures. Ensure that shafts are of sufficient size to accommodate equipment, the pipe selected and to allow for safe working practices. Provide entry and exit seals at shaft walls to prevent inflows of groundwater, soil, slurry and lubricants. Use thrust blocks designed to distribute loads in a uniform manner so that any deflection of the thrust block is uniform and does not impart excessive loads on the shaft itself or cause the jacking frame to become misaligned.

The jacking system must have the capability of pushing the pipe in J&B operations or MTBM and pipe for MT operations through the ground in a controlled manner and be compatible with the anticipated jacking loads and pipe capacity. Monitor the jacking force applied to the pipe and do not exceed the pipe manufacturer's recommendations.

Ensure that the pipe lubrication system is functional at all times and sufficient to reduce jacking loads. Use pipe lubrication systems that include a mixing tank, holding tank and pumps to convey lubricant from the holding tank to application points at the rear of the MTBM. Maintain sufficient fluids on site to avoid loss of lubrication.

Power Distribution System must be identified in the Plans package or permit provisions as well as any noise constraints. Identity spoil removal capability and method to avoid creating hindrance to other activities which may be necessary in the area.

556-5.2 Excess Material and Fluids: Monitor the pumping rate, pressures, viscosity and density of the boring fluids to ensure adequate removal of soil cuttings and the stability of the borehole. Contain excess drilling fluids, slurry and soil cuttings at entry and exit points in pits until they are recycled or removed from the site.

Ensure that all boring fluids and other materials are disposed of or recycled in a manner acceptable to the appropriate Federal, State, and Local Rules and Regulations. When jacking and boring in known or suspected areas of contaminated groundwater or soil, coordinate with the Engineer and District Contamination Coordinator (DCIC) during the pre-construction meeting and prior to the start of boring to determine the best course of action for J&B activities within the contaminated area. If the J&B operation encounters an unidentified area of contamination or abnormal condition indicating the presence of potentially contaminated material, stop operations and contact the Engineer immediately. Do not continue boring without the Engineer's approval.

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556-5.3 Boring Failure: If an obstruction is encountered which prevents completion of the installation in accordance with the design location and Specifications; the pipe may be taken out of service and left in place at the discretion of the Engineer. Immediately fill the product left in place with excavatable flowable fill. Submit a new installation procedure and revised plans to the Engineer for approval before resuming work at another location. If damage is observed to any property, cease all work until a plan of action to minimize further damage and restore damaged property is submitted and approved by the Engineer.

556-6 Documentation Requirements.

556-6.1 Boring Path Report: Submit a bore path report to the Engineer within 14 days of the completion of each bore path. No payment will be made for directional boring work until the bore path report has been delivered to the Department. Include the following information in the report:

1. Location of project and financial project number including the permit number when assigned.
2. Name of person collecting data, including title, position and company name.
3. Investigation site location (Plans station number or reference to a permanent structure within the project right of way).
4. Identification of the detection method used.
5. Spoils removal log.
6. As-built placement plans showing roadway plan and profile, cross-section, boring location and subsurface conditions as defined in bore path plans below. Reference the shown plan elevations to a Department benchmark when associated with a Department project, otherwise to a USGS grid system and datum or to the top of an existing Department head wall.

556-6.2 As-Built Plans: Submit to the Engineer a complete set of as-built plans showing all bores (successful and failed) within 30 calendar days of completion of the work. As-built plans must be PDF files, in the same scale as the Plans. Include notes on the plans stating the final bore path diameter, facility diameter, drilling fluid composition, composition of any other materials used to fill the annular void between the bore path and the facility or facility placed out of service. If the facility is a casing, note this, as well as the size and type of carrier pipes to be placed within the casing as part of the Contract work. Produce the plans as follows:

1. On the Contract plan view, show the centerline location of each facility, installed or installed and placed out of service to an accuracy within 1 inch at the ends and other points physically observed. They show the remainder of the horizontal alignment of the centerline of each facility installed or installed and placed out of service and note the accuracy with which the installation was monitored.
2. As directed by the Engineer, submit either a profile plan for each bore path, or a cross-section of the roadway at a station specified by the Engineer, or a roadway centerline profile. Also show the ground or pavement surface and the crown elevation of each facility installed, or installed and placed out of service, accurately to within 1 inch at the ends and other points physically observed. Show the remainder of the vertical alignment of the crown of each facility installed, or installed and placed out of service and note the accuracy with which the installation was monitored. On profile plans for bore paths crossing the roadway, show the Plans stationing. On the profile plans for bore paths paralleling the roadway show the Plans stationing. If the profile plan for the bore path is not made on one of the Plans, use a 10 to 1 vertical exaggeration.

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3. If a bore path is not completed, show on the Plans the failed bore path along with the name of the utility owner and the final bore path. Note the failed bore path as failed bore path. Also show the location and length of the cutting head and any product not removed from the bore path.

4. Show the crown elevation, diameter and material type of all utilities encountered and physically observed during the subsoil investigation. For all other obstructions encountered during subsoil investigation or the installation, show the type of material, horizontal and vertical location, top elevation and lowest elevation observed, and note if the obstruction continues below the lowest point observed.

556-7 Compensation.

No direct payment will be made under this Section. Include the cost to perform this operation in the Contract unit price for the item being installed.

No compensation will be made for failed bore paths, injection of excavatable flowable fill, products taken out of service or incomplete installations.

No compensation will be made for the pay item associated with the jack and bore until a bore path report has been submitted to the Engineer.

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SECTION 560
COATING NEW STRUCTURAL STEEL

560-1 Description.

Coat new structural steel in accordance with the requirements of this Section. Apply the coating system designated in the Contract Documents.

560-2 Materials.

560-2.1 Coating System: Use only coating products and systems meeting the requirements of Section 975 and listed on the Department's Approved Product List (APL). All components of coating systems must be from the same manufacturer.

Use Type M coal tar or modified glass flake epoxy coatings meeting the requirements of Section 926. Apply these products over a primer listed on the Department's APL for coating of permanent bulkhead sheet piles and H piles.

560-2.2 Thinners, Solvents and Cleaners: Use thinners, solvents and cleaners listed on the coating manufacturer's product data sheet.

560-2.3 Caulking: Use caulks that are paintable, compatible with the coating system and recommended by the coating manufacturer as part of the coating system.

560-2.4 Soluble Salts Test Kit: Measure the soluble salts using methods in compliance with SSPC-Guide 15, Table 1. Use a fully automated conductivity meter, fiber strip or multi-step patch, cell, or ring. Ensure the test sleeve or cell creates a sealed, encapsulated environment during ion extraction and is suitable for testing all structural steel surfaces.

560-2.5 Abrasives: Use properly sized abrasives to achieve the required cleanliness and anchor profile. Use abrasives meeting the requirements of SSPC-AB 1, Mineral and Slag Abrasives, SSPC-AB 2, Cleanliness of Recycled Ferrous Metallic Abrasives, or SSPC-AB 3, Newly Manufactured or Re-Manufactured Steel Abrasive and do not introduce any contamination that interferes with the coating application and performance.

Submit certification to the Engineer that the abrasives used meet the requirements of this Section and do not contain any chlorides and other salts.

For non- metallic abrasives, verify compliance with the conductivity and cleanliness requirements of SSPC-AB1. For recycled abrasives, verify compliance with the conductivity and cleanliness requirements of SSPC-AB 2 after each recycling or more frequently if required by the Engineer. Select a sample from each recycling machine in use and conduct the water-soluble contaminant and oil content tests outlined in SSPC-AB 2 at least one time each week or more frequently if directed by the Engineer. Conduct the non-abrasive residue and lead content tests as directed by the Engineer. If test results do not meet requirements, notify the Engineer immediately, remove and replace the abrasive, clean the recycling equipment, and conduct tests each day to confirm the equipment is functioning properly. Return to the weekly testing interval as directed by the Engineer.

560-2.6 Rust Preventative Compound: Use a Class 3 rust preventative compound meeting the requirements of Military Specification MIL-C-11796C, Corrosion Preventative Compound, Petrolatum, Hot Applied.

560-2.7 Storage: Store materials in conformance with the manufacturer's recommendations.

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560-3 Equipment.

560-3.1 Compressed Air: Use a compressed air system capable of delivering clean, dry, continuous nozzle pressure to achieve the required surface cleanliness and profile or spray pattern. The system must comply with the instructions and recommendations of the manufacturer of the abrasive blasting system or coating application system.

560-3.2 Abrasive Blasting System: Design the blasting system to produce the specified cleanliness and profile.

560-3.3 Coating Application System: Use the coating application equipment approved by and in accordance with the coating manufacturer's technical data requirements.

560-4 Environmental, Health and Safety Requirements.

Isolate the work areas with containment devices, canvasses, tarpaulins or screens during all surface preparation and coating application operations. Dispose of all debris and waste products generated in accordance with all Federal, State and Local regulations.

560-5 Quality Control (QC).

560-5.1 Shop Preparation and Application: Prior to applying coatings, submit a current Corporate Quality Control Plan approved by the American Institute of Steel Construction (AISC) under the Sophisticated Paint Endorsement Program or SSPC under the SSPC-QP3 certification or NACE International Institute Contractor Accreditation Program (NIICAP) AS-1S certification program to the State Materials Office for approval.

560-5.2 Field Preparation and Application: For the surface preparation of steel and application of coatings, submit a current Corporate QC Plan approved by SSPC under the SSPC-QP1 or NIICAP AS-1F certifications and a site specific coating plan to the Engineer at least 14 calendar days prior to beginning coatings work. For the removal of hazardous coatings, submit a current Corporate QC Plan approved by SSPC under SSPC-QP2 and a site specific coating plan to the Engineer at least 14 calendar days prior to beginning coatings work. Do not begin coatings work until the site specific coating plan has been approved by the Engineer.

560-5.3 Inspection: Ensure that all inspection equipment is maintained in accordance with the manufacturer's instructions, calibrated, and in good working condition. Ensure that all activities are observed and approved by a quality control coatings inspector meeting the requirements of this Section. Maintain daily inspection reports at the job site for review by the Engineer. Submit all daily inspection reports upon completion of the project to the Engineer or more frequently as requested by the Engineer.

560-6 Qualifications.

560-6.1 Shop: Submit documentation to the Engineer at least 14 days prior to beginning work that the shop performing any work in accordance with this Section is certified by AISC Sophisticated Paint Endorsement or by SSPC to the requirements of SSPC-QP3.

560-6.2 Field Contractor: Submit documentation to the Engineer at least 14 days prior to beginning work that the field contractor performing any work in accordance with this Section is certified by SSPC to the requirements of SSPC-QP1 and/or SSPC-QP2 as appropriate.

560-6.3 Quality Control (QC) Supervisor in the Shop and Field: Personnel performing inspection of coating activities in the supervisory position must visit the shop at suitable intervals throughout the coating process. Personnel performing inspection of coating activities in the supervisory position must visit the field location at suitable intervals throughout the coating process, as defined in the site specific coating plan. Submit documentation to the

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Engineer that all acting as supervisors are certified, at a minimum, to one of the following certifications:

1. AMPP Bridge Coatings Inspector Level 2
2. AMPP Senior Certified Coatings Inspector
3. NACE Coatings Inspector Level 3
4. SSPC Bridge Coatings Inspector Level 2
5. SSPC Protective Coatings Inspector Level 3

560-6.3.1 Certifications: Maintain certifications for the duration of the Contract. If the certifications expire, do not perform any work until certifications are reissued. The QP-1 requirement for a Coating Application Specialist may be waived on a project when there is no media blasting involved in the operations. The request should be identified in the site specific coatings plan.

Notify the Engineer of any change in certification status.

560-7 Surface Preparation.

560-7.1 General: Ensure all surfaces to be coated are clean, dry, and free from oil, grease, dirt, dust, soluble salts, corrosion, peeling coating, caulking, weld spatter, mill scale and any other surface contaminants. Prepare all surfaces that will become inaccessible after fabrication, erection, or installation while accessible. Sequence the surface preparations and coating operations so that freshly applied coatings will not be contaminated by dust or foreign matter. Protect all equipment and adjacent surfaces not to be coated from surface preparation operations. Protect working mechanisms against intrusion of abrasive. In the event that any rusting or contamination occurs after the completion of the surface preparation, prepare the surfaces again to the initial requirements. Perform surface preparation work only when the temperature of the steel surface is at least 5ºF above the dew point temperature.

560-7.2 Mechanical Removal of Surface Defects: Break all corners resulting from sawing, burning, or shearing. In areas where burning has been used, remove the flame hardened surface of the steel to the extent necessary to achieve the required surface profile after abrasive blast cleaning. Remove all weld slag and weld spatter. Conduct all of this work in accordance with AASHTO/NSBA Steel Bridge Collaboration S 8.1.

560-7.3 Cleaning: Clean all steel surfaces in accordance with the requirements of SSPC-SP 1.

560-7.4 Washing: Clean all steel surfaces in accordance with the requirements of SSPC-SP 12 LPWC WJ4.

560-7.5 Soluble Salts Detection and Removal: When using SSPC Guide 15, Table 1 retrieval methods, determine the chloride, sulfate and nitrate concentrations on all steel surfaces using soluble salts test kits meeting the requirements of 560-2.4. Perform the tests after washing and after each applied coat of the coating system. Ensure the non-visible surface contaminant concentration on blast-cleaned surfaces does not exceed the limits in Table 560-1. When quality control documentation at a fixed location indicates 36 months of historical sequential contaminant levels below those specified in Table 560-1, the Department may allow testing frequency to be reduced to one chloride contamination test per day. When any concentration or conductivity measurement exceeds the levels given in Table 560-1, rewash the entire surface area and retest all potentially contaminated steel to the satisfaction of the Engineer. If additional washing does not reduce the concentration to the acceptable level, a surface treatment or water additive may be used. Use a surface treatment or water additive that is approved by the coating system supplier and the Engineer.

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Table 560-1 Allowable Surface Contaminants		
Coating Stage	Frequency of Test	Acceptance Criteria
Post-Blast, Pre-Coating	1 test (per 1,000 ft^2)	≤ 17 µg/cm^2 Sulfates ≤ 10 µg/cm^2 Nitrates ≤ 70 µS/cm^2 Conductivity ≤ 7 µg/cm^2 Chlorides
Between Coats	3 tests (first 1,000 ft^2) 1 test (ea. Additional 1,000 ft^2)	≤ 7 µg/cm^2 Chlorides

560-7.6 Abrasive Blast Cleaning: Prepare steel by abrasive blast cleaning to "near-white" metal condition as defined in SSPC-SP 10. Use SSPC VIS 1 as an aid in establishing cleanliness. After abrasive blast cleaning, ensure the surface profile meets the requirements of the coating manufacturer's product data sheet. Determine the surface profile in accordance with ASTM D4417, Method B or C.

Perform all abrasive blast cleaning within a containment system to ensure confinement of all particulates. Design the containment system to comply with all applicable Federal, State, and Local regulations. Ensure the abrasive blast cleaning does not produce holes, cause distortion, remove metal, or cause thinning of the substrate.

560-7.7 Hand and Power Tool Cleaning: Prepare steel by power and hand tool cleaning as defined in SSPC-SP 11, SSPC-SP 15, SSPC-SP 3, and SSPC-SP 2 for touch up and repair when approved by the Engineer. Use SSPC-VIS 3 as an aid in establishing cleanliness.

560-8 Surfaces Not to be Coated.

560-8.1 Galvanized Surfaces: Do not coat galvanized surfaces unless specified in the Contract Documents. When painting is required by the Contract Documents, perform sampling and testing in accordance with Section 649 and 975-4.

560-8.2 Surfaces to be in Contact with Concrete: Do not coat the areas of contact surfaces of steel to be encased or embedded in concrete, or coated with concrete unless specified in the Contract Documents. When specified, prepare the contact surfaces and apply primer.

560-8.3 Faying Surfaces: After application of the primer, protect the contact surfaces of members to be joined by high-strength bolts in friction type joints from all other coatings and foreign material.

560-8.4 Machine Finished Surfaces: Apply a coating of rust preventative compound to all machine finished or similar surfaces that are not to be coated, or will not be coated immediately.

560-8.5 Surfaces to be Welded: Mask off surfaces within 1 inch of field welded connections before the application of any shop coating. Apply a mist coat of primer that is less than 1 mil dry film thickness to surfaces where shear studs will be welded.

560-9 Application.

560-9.1 General: Apply a complete coating system to all structural steel surfaces except surfaces indicated in 560-8. Apply a complete coating system to all surfaces that will become inaccessible after fabrication, erection, or installation.

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Apply the prime coat in the shop. Apply the intermediate coat in the shop or field. Only apply the finish coat after erection and after concrete work is complete.

Prior to the application of any coating, inspect the substrate for contamination and defects, and prepare the surface in accordance with 560-7 before application of the next coat.

Apply each coat including a stripe coat in a color that contrasts with the substrate or preceding coat. For exterior surfaces, apply a finish coat color meeting FED-STD-595, Shade 36622, unless otherwise specified in the Contract Documents.

560-9.1.1 Interior Box or Tub Girders: Apply a coat of white amine epoxy directly to the surface of all interior components of steel box or tub girders. Caulk and paint all bolted assemblies and joints in accordance with 560-9.7. When stud welding is specified, apply a mist coat of inorganic zinc-rich primer to the top flange at a dry film thickness no greater than 1 mil. Prevent rust bleeding from the top flange from staining adjacent painted surfaces.

560-9.2 Weather and Temperature Limitations: Do not spray coating when the measured wind speed in the immediate coating area is above 15 miles per hour. Do not apply coatings when contamination from rainfall is imminent or when the ambient air temperature, relative humidity, dew point temperature, or temperature of the steel is outside limits of the coating manufacturer's product data sheet.

560-9.3 Protection of Adjacent Surfaces: Protect all surfaces and working mechanisms not intended to be coated during the application of coatings. Clean surfaces that have been contaminated with coatings until all traces of the coating have been removed. Do not allow material from cleaning and coating operations to be dispersed outside the work site.

560-9.4 Mixing and Thinning: Mix all coatings in accordance with the manufacturer's product data sheet. Only mix complete kits. Use thinners and solvents in accordance with the requirements of the coating manufacturer's product data sheet and confirm that the amount of thinner added does not result in the coating exceeding VOC regulations stated in Section 975.

Perform all mixing operations over an impervious surface with provisions to prevent runoff to grade of any spilled material.

560-9.5 Application Methods: Use coating application equipment and apply coatings per the coating manufacturer's product data sheet. Application with brushes may be permitted for minor touchup of spray applications, stripe coats, or when otherwise approved by the Engineer. Adjust spray equipment to produce an even, wet coat with minimum overspray. Apply coatings in even, parallel passes, overlapping 50 percent. Agitate coatings during application as required by the coating manufacturer's product data sheet.

560-9.6 Stripe Coating: Use an aluminum epoxy mastic that is at least 80% solids by volume and is approved to be compatible with the coating system by the coating system manufacturer. Apply a stripe coat after the prime coat, but prior to applying the intermediate coat. Also, apply a stripe coat after the intermediate coat but prior to the finish coat. Apply the stripe coat per the manufacturers published product data sheet but no less than 3 mils dry film thickness. Apply both stripe coats to achieve complete coverage on welds, corners, crevices, sharp edges, bolts, nuts, rivets, and rough or pitted surfaces. A stripe coat of translucent coatings is not required. Do not apply subsequent coats until the previous stripe coat has cured per the manufacturer's product data sheet for recoating. Stripe coating is not required for the inside surface area of all steel box girders.

560-9.7 Sealing Using Caulk: Apply caulk after the intermediate coat has cured to a condition suitable for recoating in accordance with the manufacturer's product data sheet, and before application of the finish coat. Completely seal the perimeter of all cracks and crevices,

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joints open less than 0.5 inch, and skip-welded joints using caulk. Apply the caulk to the joint following the caulk manufacturer's recommendations. Ensure the caulk bead has a smooth and uniform finish and is cured according to the caulk manufacturer's curing schedule prior to the application of the finish coat. Caulking the perimeter of bolted splice plates are not required unless directed by the Engineer. Caulking cracks or crevices less than 0.003 inches in width within the interior surface of box girders is not required.

560-9.8 Thickness of Coats: Apply coatings to the thickness as identified in the manufacturer's product data sheet. After application of each coat, thoroughly inspect the surfaces and measure the dry film thickness (DFT) in accordance with SSPC-PA 2. As an exception to SSPC-PA2, the DFT of the prime coat shall not be less than the minimum specified by the manufacturer's product data sheet. When the DFT is deficient or excessive, correct in accordance with the coating manufacturer's recommendations and retest the area.

560-9.9 Coating Drying, and Curing: Apply coatings within the time specified by the coating manufacturer's product data sheet for drying and recoating. Test the coating for proper cure before handling and shipping. Test for cure in accordance with the manufacturer's recommended method. Meet the requirements of ASTM D4752 for inorganic zinc primers or ASTM D5402 for organic zinc primers when the manufacturer's technical data sheet does not state a specified cure test. Obtain the acceptance criteria from the coating manufacturer and report the results to the Engineer.

Prior to assembling bolted connections, test and verify that the primer coating on the faying surfaces has cured to a resistance rating of 5 in accordance with ASTM D4752, ASTM D5402, or the coating manufacturer's requirements. If cure testing is performed per the coating manufacturer's requirements, submit the test results to the Engineer for approval prior to assembling the bolted connection.

560-9.10 Coating Finish: Apply each coat free of runs, sags, blisters, bubbles, and mud cracking; variations in color, gloss, or texture; holidays; excessive film buildup; foreign contaminants; orange peeling; and overspray.

560-10 Touchup and Repair.

560-10.1 Faying Surfaces: Reapply primer to all damaged surfaces using an approved organic zinc-rich primer. Do not use epoxy mastics on faying surfaces. Maintain a class B slip-critical coefficient by repairing faying surfaces in slip-critical connections in accordance with 560-8.3.

560-10.2 Repairs Other Than Faying Surfaces: Touch up all flaws and damaged areas. Clean and coat all welds, rivets, bolts, and all damaged or defective coating and rusted areas in accordance with 560-7 and 560-9. Repair damaged surfaces using an approved organic zinc-rich primer. Upon approval by the Engineer, aluminum mastic may be used in accordance with the manufacturer's recommendations and approval by the coating manufacturer. Aluminum mastic must contain aluminum pigment and minimum 80% volume solids.

560-11 Coating of Permanent Sheet, Pipe and H-Piles.

560-11.1 Surface Preparation: Prepare the substrate in accordance with 560-7. Provide a depth of anchor profile in accordance with the manufacturer's product data sheet, but in no case less than 2.5 mils. Re-blast piles not coated during the same shift or if the surface to be coated no longer meets the requirements SSPC-SP 10.

560-11.2 Application of Coating: Unless otherwise shown in the Contract Documents, apply the inorganic zinc primer to all surfaces of H and sheet piles and the exterior surface of

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pipe piles in accordance with the limitations of 560-8. Unless otherwise shown in the Contract Documents, apply coal tar apply coal tar or modified glass flake epoxy coatings to the exposed side of sheet epoxy coatings to the exposed side of sheet piles from the top of the piles to a depth of five feet below the lower of the design ground surface or the design scour depth in accordance with the limitations of 560-8. Apply the inorganic zinc primer in accordance with this Section. Apply the coal tar or modified glass flake epoxy in accordance with the following specific requirements:

1. Apply the coal tar or modified glass flake epoxy system in strict accordance with the coating manufacturer's published specifications. Coal tar epoxies must attain a total dry film thickness (zinc primer and coal tar epoxy) at a minimum 18 mils (on each side). Modified glass flake epoxies must attain a total dry film thickness (zinc primer and modified glass flake epoxy) at a minimum 10 mils (on each side).

2. Ensure that no area measurements of the coating is less than 80% of the specified minimum film thicknesses, as determined by AMPP Paint Application Standard No. 2 (PA-2). The total minimum film thickness for any combination of coats will be the sum total of the averages of the specified thickness range of the individual coats.

3. After applying the coating on the steel piles, the Engineer will thoroughly inspect the surfaces and make film thickness measurements at the approximate rate of one for each 25 square feet of area unless deficient thickness is found. In this case, the rate of additional measurements will be increased as required to determine the extent of the deficient area.

560-12 Method of Measurement.

For coating all new structural steel in I-girder and box or tub girder superstructures and bent caps, the quantity to be paid for will be the lump sum quantity, completed and accepted.

560-13 Basis of Payment.

For I-girder and box or tub girder superstructures and bent caps, price and payment will be full compensation for all work specified in this Section, including furnishing and applying all materials to complete the coating for the new structural steel.

No separate payment will be made for coating all other structural steel.

Payment for coating all new structural steel in I-girder and box or tub girder superstructures and bent caps will be made under:

Item No. 560- 1- Coating System for New Structural Steel - lump sum.

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SECTION 561
COATING EXISTING STRUCTURAL STEEL

561-1 Description.

Coat existing structural steel in accordance with the requirements of this Section by removing and replacing the existing coating or overcoating the existing coating as stated in the Contract Documents.

561-2 Materials.

561-2.1 Coating Systems: For removal and replacement systems, use coating products and systems meeting the requirements of Section 975 and are listed on the Department's Approved Product List (APL).

For overcoating systems, use products and systems as designated in the Contract Documents. Submit product data sheets and product Material Safety Data Sheets (SDS), or in lieu of SDS, submit test reports showing percent weight compositional analysis, Chemical Abstract Number, American Conference of Governmental Industrial Hygienists (ACGIH) time weighted average and ceiling exposure limits for all components, and lower and upper explosive limits, flash point, boiling point, amount of volatile organic compounds by weight, and specific gravity for each component of the coating system.

561-2.2 Thinners, Solvents and Cleaners: Meet the requirements of 560-2.2. In addition, for overcoating systems, use thinners, solvents, and cleaners that do not damage the existing coating system.

561-2.3 Caulking: Meet the requirements of 560-2.3.

561-2.4 Soluble Salts Test Kit: Meet the requirements of 560-2.4.

561-2.5 Abrasives: Meet the requirements of 560-2.5.

561-2.6 Rust Preventative Compound: Meet the requirements of 560-2.6.

561-2.7 Storage: Meet the requirements of 560-2.7.

561-3 Equipment.

561-3.1 Compressed Air: Meet the requirements of 560-3.1.

561-3.2 Abrasive Blasting System: Meet the requirements of 560-3.2.

561-3.3 Coating Application System: Meet the requirements of 560-3.3.

561-4 Quality Control (QC).

561-4.1 Field Preparation and Application: For the surface preparation of steel and application of coatings, submit a current SSPC QP1 or National Association of Corrosion Engineers (NACE) International Institute Contractor Accreditation Program (NIICAP) AS-1F certification with the Corporate QC Plan that was reviewed by SSPC or NIICAP under the current certification and a site specific coating plan to the Engineer at least 14 calendar days prior to beginning coatings work. For the removal of hazardous coatings, submit a current SSPC QP2 certification with the Corporate QC Plan that was reviewed by SSPC under the current certification and a site specific coating plan to the Engineer at least 14 calendar days prior to beginning coatings work. Do not begin coatings work until the site specific coating plan has been approved by the Engineer.

Prepare a traffic control plan for each phase of construction activities signed and sealed by the Contractor's Engineer of Record in accordance with the FDOT Design Manual. Do not begin work until the traffic control plan is approved by the Engineer. Maintain traffic in accordance with Section 102.

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For work over navigable waters, submit a work plan to the United States Coast Guard including any scheduled restrictions to navigation channels or marine traffic. Obtain Coast Guard approval at least 30 days in advance of any restrictions.

561-4.2 Inspection: Meet the requirements of 560-5.3.

561-5 Qualifications.

561-5.1 Field Contractor: Meet the requirements of 560-6.2.

561-5.2 Quality Control (QC) Personnel: Meet the requirements of 560-6.3.

561-5.3 Certifications: Meet the requirements of 560-6.4.

561-6 Surface Preparation.

561-6.1 General: When portions of the existing coating are designated in the Contract Documents to be removed and replaced, clean, wash, test and remove soluble salts, and abrasive blast or hand and power tool clean to remove all existing coating and corrosion in the intended locations. Feather back the edges of all existing coating to remain a minimum of 3 inches around the area of existing coating removed to provide a smooth transition. Verify the edges of the existing coating are intact by probing with a dull putty knife in accordance with SSPC SP 2. Roughen the existing coating in the feathered area to ensure proper adhesion of the new coating. Notify the Engineer immediately when any structural steel appears to be defective.

When the existing coating is to remain, clean, wash, and test and remove soluble salts.

Ensure all surfaces to be coated are clean, dry, and free from oil, grease, dirt, dust, soluble salts, corrosion, peeling coating, caulking, weld spatter, mill scale and any other surface contaminants. Sequence the surface preparations and coating operations so that freshly applied coatings will not be contaminated by dust or foreign matter. Protect all equipment and adjacent surfaces not to be coated from surface preparation operations. Protect working mechanisms against intrusion of abrasive. In the event that any rusting or contamination occurs after the completion of the surface preparation, prepare the surfaces again to the initial requirements. Perform surface preparation work only when the temperature of the steel surface is at least 5^{o}F above the dew point temperature.

561-6.2 Mechanical Removal of Surface Defects: Meet the requirements of 560-7.2. In addition, remove all pack rust prior to solvent cleaning.

561-6.3 Cleaning: Meet the requirements of 560-7.3.

561-6.4 Washing: Meet the requirements of 560-7.4.

561-6.5 Soluble Salts Detection and Removal: Meet the requirements of 560-7.5 except test five random locations in the first 1,000 square feet and one random location for each subsequent 1,000 square feet.

561-6.6 Abrasive Blast Cleaning: Meet the requirements of 560-7.6.

561-6.7 Hand and Power Tool Cleaning: Prepare steel by power and hand tool cleaning as defined in SSPC SP 11, SSPC SP 3, and SSPC SP 2 as stated in the Contract Documents. Use SSPC VIS 3 as an aid in establishing cleanliness.

561-7 Surfaces Not to be Coated.

561-7.1 Galvanized Surfaces: Meet the requirements of 560-8.1.

561-7.2 Machine Finished Surfaces: Meet the requirements of 560-8.4.

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561-8 Application.

561-8.1 General: Apply a complete coating system to all structural steel surfaces except surfaces indicated in 561-7.

Prior to the application of any coating, inspect the substrate for contamination and defects, and prepare the surface in accordance with 561-6 before application of the next coat.

Apply each coat including a stripe coat in a color that contrasts with the substrate or preceding coat. For exterior surfaces, apply a finish coat color meeting FED-STD-595, Shade 36622, unless otherwise specified in the Contract Documents.

561-8.2 Weather and Temperature Limitations: Meet the requirements of 560-9.2.

561-8.3 Sealing Using Caulk: Meet the requirements of 560-9.7.

561-8.4 Protection of Adjacent Surfaces: Meet the requirements of 560-9.3.

561-8.5 Mixing and Thinning: Meet the requirements of 560-9.4.

561-8.6 Application Methods: Meet the requirements of 560-9.5.

561-8.7 Stripe Coating: Meet the requirements of 560-9.6.

561-8.8 Thickness of Coats: Meet the requirements of 560-9.8.

561-8.9 Coating Drying, and Curing: Apply coatings within the time specified by the coating manufacturer's product data sheet for drying and recoating. Before handling, test for cure in accordance with the manufacturer's recommended method. Meet the requirements of ASTM D5402 for organic zinc primers when the manufacturer's technical data sheet does not state a specified cure test. Obtain the acceptance criteria from the coating manufacturer and report the results to the Engineer.

561-8.10 Coating Finish: Meet the requirements of 560-9.10.

561-9 Touchup and Repair.

Clean and coat all welds, rivets, bolts, and all damaged or defective coating and rusted areas in accordance with 561-6 and 561-8. Upon approval by the Engineer, aluminum mastic may be used in accordance with the manufacturer's recommendations. Aluminum mastic must contain aluminum pigment and minimum 80% volume solids.

561-10 Protection of the Environment, Public, and Workers.

561-10.1 General: Establish plans and programs to protect the environment, public, contractor employees, other workers, and property from overspray, exposure to toxic heavy metals and the release and emission of hazardous materials and nuisance dusts. Include in such plans and programs a procedure for the receipt, processing, evaluation and timely written response for claims by the public for damage resulting from the foregoing work. Submit to the Department any written response which denies such damage claims. Conduct all coating application and removal operations in compliance with EPA, OSHA, and other applicable Federal, State and local regulations. Submit a contingency plan for the remediation of water and land in the event of contamination by solid or liquid paint and contaminated water.

561-10.2 Environmental Protection: Prepare and submit to the Engineer, plans and programs for the protection of the environment and public based on the applicable EPA requirements, the requirements of this Section, and the Contract Documents. Include plans and programs for the protection of the air, soil/ground, and water.

561-10.2.1 Pollution Control: Submit a written pollution control and monitoring plan at the preconstruction meeting or as directed by the Engineer which clearly describes the means for complying with all Local, State and Federal regulations including pollution control provisions specified herein. The written plan must be in accordance with SSPC Project Design: Industrial Lead Paint Removal Handbook, Volume II, Phase 6, Environmental Monitoring, and

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specifically include, but not be limited to, providing a scaled map of the work site layout showing the proposed number and location of soil sampling, Total Suspended Particulate (TSP) monitoring sites, waste storage areas, staging areas, temporary waste storage areas, and ambient air and personnel sampling frequency.

Comply with all applicable Federal, State, and Local rules and regulations. Immediately cease all operations in the event a violation of any environmental regulation or a failure to properly execute any pollution control provisions occurs. Resume operations after written proposed corrective procedures have been submitted to and approved by the Engineer and implemented.

561-10.2.2 Permits: Submit all required permits from all applicable regulatory agencies to the Engineer prior to the commencement of any work. Seek permit determination from these regulatory agencies to avoid any potential permit non-compliance issues during work activities. The Contractor is responsible for all liability resulting from non-compliance with pertinent rules and regulations including permit requirements.

561-10.2.3 Ambient Air Quality Compliance and Protection of the Air:

561-10.2.3.1 Visible Emissions: Assess the visible emissions using EPA Method 22, Timing of Emissions as defined by 40 CFR 60, Appendix A, Standards of Performance for New Stationary Sources. During abrasive blasting, do not allow visible emissions from a containment to exceed a random cumulative duration of more than one percent of the workday (SSPC Guide 6, Level 1 Emissions). During pressurized water cleaning, do not allow visible emissions from a containment to exceed a random cumulative duration of more than ten percent of the workday (SSPC Guide 6, Level 3 Emissions).

561-10.2.3.2 Total Suspended Particulate (TSP) Matter: Control emissions from the containment area to prevent exceeding the TSP lead of 1.5 $\mu g/m^3$ over a 90 day period, or the daily and adjusted daily allowances of SSPC-TU 7. Conduct TSP Lead monitoring in accordance with 40 CFR 50, Appendix B, Reference Method for Determination of TSP Matter in the Atmosphere (high volume sampler required), and 40 CFR 50, Appendix G, Reference Method for Determination of TSP Matter Collected from Ambient Air. Position the TSP lead monitoring equipment in general accordance with 40 CFR 58, Ambient Air Quality Surveillance.

When lead is present in the coating, perform TSP Lead background monitoring for a period of 3 days prior to the beginning of abrasive blast cleaning operations. Submit the results from background monitoring and the first week of monitoring during abrasive blast cleaning to the Engineer for review within 5 calendar days after the first week of work. Continue monitoring unless otherwise directed by the Engineer.

561-10.2.3.3 Regulated Area: Establish a regulated area around the work site to prohibit unauthorized persons from areas where exposure to hazardous airborne metals may exceed the following action levels:

Table 561-1
Hazardous Airborne Metals and Action Levels

Airborne Metals	Action Level
Lead	30 $\mu g/m^3$
Cadmium	2.5 $\mu g/m^3$
Arsenic	5 $\mu g/m^3$
Hexavalent Chromium (Cr^{6+})	2.5 $\mu g/m^3$

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Conduct monitoring in accordance with the National Institute for Occupational Safety and Health (NIOSH) procedures upon initiation of dust producing operations and submit the test results to the Engineer within 72 hours of sampling. Report sample results as eight-hour Time Weighted Averages (TWA). Reestablish the regulated area and perform additional sampling when the results exceed the action levels or when directed by the Engineer. Record all pertinent data. Position air-sampling pumps around the project perimeter where the public or personnel can approach the work area. Place sampler inlets at breathing height. Clearly mark the regulated area by the use of warning signs, rope, barrier tape, or temporary construction fencing.

561-10.2.4 Soil/Ground Quality: Inspect the ground beneath and in proximity to the structure in the presence of the Engineer for visible paint chips to establish an initial job site cleanliness standard. When heavy metals are in the existing coatings, test soil samples prior to the beginning of operations and after project completion for heavy metals. Document the number and specific locations where the initial samples are taken as outlined in the SSPC Project Design-Industrial Lead Paint Removal Handbook, Volume 2 to ensure the post samples are collected from the same locations. Submit all samples to the Engineer for review. If the project activities increase the heavy metal content in soil to more than 20% above the pre-job geometric mean or 100% at any one location, return the site to the pre-job levels. Conduct additional soil testing as necessary to determine the extent of contamination.

For structures less than 14 feet minimum height, take one sample north, south, east, and west (where soil is present) of the structure. If the structure is longer than 14 feet, take one additional sample for every 14 feet in length.

For structures greater than 14 feet minimum height, take two samples north, south, east, and west (where soil is present) of the structure. Locate the inner row of samples within 14 feet of the structure. Locate the outer row of samples at a distance equal to the height of the structure. If the structure is longer than 14 feet, take one additional sample for every 14 feet in length.

In addition, submit a pre- and post- soil sampling plan for storage areas identifying the sample location, depth, analyses list, lab certification, and turnaround time. Once approved by the Engineer, submit sampling results along with a scaled drawing indicating designated sample locations.

561-10.2.5 Water Quality: Do not release, discharge or otherwise cause hazardous materials, debris, waste, or paint chips to enter the water. Protect against releases due to rain and methods of surface preparation from reaching rivers, streams, lakes, storm drains, or other bodies of water.

561-10.3 Containment System: Submit a written containment system design plan in accordance with this section and the contract documents at the pre-construction conference or as directed by the Engineer which clearly describes the proposed containment system applicable to the intended removal method and in accordance with the requirements outlined herein and SSPC Guide 6, Guide for Containing Debris Generated During Paint Removal Activities. Ensure the plan includes, but is not limited to, removal method; methods for collecting debris; and containment enclosure components. Use fire retardant materials. Submit containment drawings, calculations, assumptions, ventilation criteria if applicable, and a structural analysis that verifies the existing structure can withstand the additional dead, live and wind loads imposed by the containment system, signed and sealed by a Specialty Engineer. However, for more complex structures incorporating cables stayed, suspension, or truss designs, the analysis must be performed by the Contractor's Engineer of Record qualified in Type Work Category 4.3, Complex Bridge Design. Submit a contingency plan addressing natural weather events such as

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tropical storms and hurricanes. Ensure the lighting inside the containment is in accordance with SSPC Guide 12, Guide for Illumination of Industrial Painting Projects. Provide lighting to a minimum intensity of 10 ft-cd for general, 20 ft-cd for work, and 50 ft-cd for inspection. All drawings and calculations must be submitted and accepted before any work begins. Include a clear description of the ventilation system components and information including the fan curve and design point on the proposed dust collector. Design to provide ventilation according to the notes provided in SSPC Guide 6: 100 feet per minute for cross draft and 50-60 feet per minute for downdraft.

Isolate the immediate area of the structure to ensure compliance with current and permit requirements for air, water, soil, and pollution prevention. Protect the containment system from vehicular and pedestrian traffic. Ensure paint, paint chips, or other debris will not fall outside of the containment area under any circumstances. Repair any damage created by fastening, bracing, or handling the scaffolding and staging. If a suspended platform is constructed, use rigid or flexible materials as needed to create an air and dust impenetrable enclosure. Verify that the platform and its components are designed and constructed to support at least four times its maximum intended load without failure, with wire cables capable of supporting at least six times their maximum intended load without failure. Strictly comply with all applicable OSHA regulations regarding scaffolding. The category and class of containment shall be as required in the Contract Documents.

561-10.4 Protection of Adjacent Areas: Protect all areas adjacent to abrasive blast cleaning, including machinery and deck grating. Before the commencement of any cleaning and coating operations, submit a control plan for the protection of adjacent surfaces from damage by nearby blasting and coating to the Engineer for review. Repair any damage to adjacent areas. The repair procedure must be submitted to the Engineer for acceptance prior to any remediation.

561-10.5 Worker Protection: Comply with the requirements of OSHA 29 CFR 1926 and applicable portions of 29 CFR 1910. Include specific programs as required by 29 CFR 1926.62 (lead), 29 CFR 1926.1118 (inorganic arsenic), 29 CFR 1926.1126 (hexavalent chromium), and 29 CFR 1926.1127 (cadmium) when these hazardous agents are present. Implement appropriate safety procedures for all hazards on the job site whether specifically identified herein or not.

561-11 Waste Handling and Management.

561-11.1 General: Prepare a waste management program plan which addresses the applicable requirements from EPA regulations for hazardous waste management and the Contract Documents. Include provisions for the handling and disposal of non hazardous waste. Dispose of all waste in accordance with all federal, state, and local laws and regulations.

561-11.2 Collection and Handling of Waste: Properly classify, package, and store all paint removal debris, both solid and liquid in accordance with SSPC Guide 7, Guide for the Disposal of Lead-Contaminated Surface Preparation Debris, the Federal Water Pollution Control Act with amendments, and all other current government regulations and guidelines. Comply with the Resource Conservation and Recovery Act to include, at a minimum, CFR 40 260 through CFR 40 268. Prior to identification and storage, separate solid and liquid waste, and separate individual waste streams.

561-11.3 Testing and Analysis: Laboratory analyses for all waste stream and environmental samples shall be conducted by an EPA certified, independent laboratory with an approved Quality Assurance Plan. Laboratory analyses for worker monitoring and regulated area samples shall be conducted by an American Industrial Hygiene Association (AIHA) metals

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accredited laboratory. Submit all sampling and test reports no later than 72 hours after collection of samples.

561-11.4 Waste Identification: Collect samples in accordance with EPA SW 846, Test Methods for Evaluating Solid Waste - Physical/Chemical Methods. Use a random and representative sampling technique. Collect a minimum of four representative samples of each waste stream. These waste streams include, but are not limited to, water, paint chips, dust, and paint chips mixed with disposable abrasives and debris. Complete the initial sampling of each waste stream immediately upon filling the first drum, but do not allow waste to accumulate for longer than 7 days before sampling.

After the representative samples are collected, send them immediately to the EPA certified laboratory for analysis. Unless otherwise directed by the Engineer, required by State regulations, or required by the waste recycling or disposal facility, once each waste stream is sampled, tested, and classified, additional sampling and analysis are not required for subsequent shipments unless the waste stream changes. Submit samples to an approved laboratory to be tested for arsenic, barium, cadmium, hexavalent chromium, lead, mercury, selenium, and silver in accordance with EPA Method 3050 and Method 6010 (content) and EPA Method 1311, Toxicity Characteristics Leaching Procedures (TCLP).Clearly label each sample with sample number, date and time of sampling, name of collector, and location of collection.

Maintain chain of custody forms for each sample. Enter each sample on a sample analysis request form. Record sample numbers, type of waste, amount of each sample, distribution of samples, signature and all other information.

561-11.5 Waste Storage: Collect waste from the control devices, equipment, and all work surfaces on a daily basis. Keep hazardous and non-hazardous waste separate. Do not mix blasting debris with any other type of waste. Place waste in approved storage drums.

Locate all hazardous waste within a regulated area. The maximum weight for each drum, when filled, is 821 pounds. Properly seal and label all drums. Transport waste storage drums to a secured, marked, temporary storage area. Locate the temporary storage area on well-drained ground not susceptible to flooding or storm water run-off. Place drums on a pallet and cover with fiber reinforced, impermeable tarpaulins. Store drums no more than two drums wide and two drums high. Arrange drums so that labels are easily readable. Do not store waste in the temporary storage area longer than 90 days.

561-11.6 Waste Disposal: Transport, treat and dispose of all hazardous and non-hazardous waste. Notify the Engineer a minimum of three weeks prior to the date of shipment of any waste to an off- site facility. Submit to the Engineer documentation that the receiving disposal facilities are properly licensed. Submit manifests for all hazardous and non-hazardous waste shipments. Identify any waste disposal subcontractors and submit verification of their licensing to perform waste disposal and transport operations.

561-11.7 Permits: The Contractor is responsible for all liability resulting from non-compliance with pertinent rules and regulations including permit requirements.

561-12 Method of Measurement.

When a lump sum pay item is provided, the quantity to be paid for coating existing structural steel will be the lump sum quantity for the areas shown in the Plans, completed and accepted.

When a square foot item is provided, the quantity to be paid for coating existing structural steel will be the plan quantity in square feet of surface area as shown in the Plans, completed and accepted.

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561-13 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 561- 1- Coating Existing Structural Steel - lump sum.

Item No. 561- 2- Coating Existing Structural Steel - per square foot.

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SECTION 562
REPAIR OF GALVANIZED SURFACES

562-1 Description.

Apply a coating of galvanizing compound over welded areas of galvanized structural members and over areas of previously galvanized members on which the galvanizing has become damaged.

562-2 Materials.

562-2.1 Areas 100 Square Inches or Less: Use a cold galvanizing compound containing at least 92% zinc dust in the dry film.

562-2.2 Areas Greater than 100 Square Inches: Use a galvanizing compound as specified in 975-2.4.1 and listed on the Approved Product List (APL).

562-3 Construction Methods.

Prepare surfaces and apply the galvanizing compound according to ASTM A780 and manufacturer's recommendations. Apply additional coats on rough or pitted surfaces, when in the opinion of the Engineer it is necessary to obtain acceptable cover. Follow the manufacturer's recommended dry time between coats.

Re-clean the areas not coated on the same day the cleaning is accomplished, or surfaces that have rusted, prior to coating.

Apply the galvanizing compound to attain a uniform appearance free from all defects or failures. Submit repair procedures to the Engineer for approval. All deficiencies will be corrected at no cost to the Department.

562-4 Basis of Payment.

No direct payment will be made for galvanizing compound coating of welded surfaces or for field repair of damaged galvanized surfaces. Include the cost to perform these operations, in the Contract price for the item which includes the member being so treated.

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SECTION 563
ANTI-GRAFFITI COATINGS

563-1 Description.

Apply an anti-graffiti coating in accordance with the requirements of this Section to the areas shown in the Plans.

563-2 Materials.

Use anti-graffiti coating products meeting the requirements of Section 975 that are recommended for the base substrate by the manufacturer and listed on the Department's Approved Product List (APL). Do not use sacrificial coatings on steel structures.

563-3 Application.

563-3.1General: Apply anti-graffiti coatings in accordance with the manufacturer's product data sheet.

563-3.2 Protection of Adjacent Surfaces: Consider wind direction, velocity and geographic location as having a major impact on all cleaning and anti-graffiti coating operations. Use all necessary precautions to prevent cleaning and anti-graffiti coating materials from being dispersed outside the work site. If conditions are such that material is dispersed to areas where vehicles or other property may be damaged, suspend operations until conditions improve and work can continue without affecting adjacent property.

Protect all surfaces not intended to be coated, which are adjacent to, or in close proximity to the surfaces to be coated, during the application of anti-graffiti coating. Clean surfaces that are to be coated, as per the manufacturer's product data sheet.

563-3.3 Surface Preparation: Remove all graffiti from the substrate. Prior to applying any anti-graffiti coatings, prepare all surfaces to be coated in accordance with ASTM D4261 or ASTM D4258 and the manufacturer's product data sheet.

When the anti-graffiti coating or coating system is to be applied over an existing coating, apply a test patch (minimum area of 4 square feet) in accordance with this Section. Allow the test patch to cure a minimum of 7 days without any defects. No time extension will be granted as a result of this test requirement.

563-3.4 Correction of Deficiencies: Remove all applied anti-graffiti coatings identified by the Engineer as damaged, defective, or otherwise not meeting these Specifications, in accordance with the manufacturer's recommendations.

Prepare the surface and reapply the coating in accordance with the manufacturer's recommendations and as specified herein.

Remove and correct all deficiencies at no additional cost to the Department.

563-4 Method of Measurement.

The quantity to be paid for will be plan quantity, in square feet, of the area of anti-graffiti coating completed and accepted.

The area will be based on the surface area shown in the Plans with no allowance for surface texture or variable depth surface profiles.

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563-5 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including furnishing and applying all materials to complete the anti-graffiti coating.

Payment shall be made under:

Item No. 563- 3-	Anti-Graffiti Coating Sacrificial - per square foot.
Item No. 563- 4-	Anti-Graffiti Coating Non Sacrificial - per square foot.

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SECTION 570
PERFORMANCE TURF

570-1 Description.

Establish a growing, healthy turf over all areas designated in the Plans. Use sod in areas designated in the Plans to be sodded. Use seed, hydroseed, bonded fiber matrix, or sod in all other areas. Maintain performance turf areas until final acceptance of all Contract work in accordance with Section 5-11 and the establishment requirements of 570-4 have been met.

570-2 Materials.

Meet the following requirements:

Turf Materials .....Section 981
Fertilizer .....Section 982
Water .....Section 983

570-3 Construction Methods.

570-3.1 General: Remove all construction debris in performance turf areas. Install performance turf at the earliest practical time for erosion control and establishment.

Shape the areas to be planted to the plan typical sections and lines and grade shown in the Plans.

Except in areas where the Contract Documents requires specific types of turf to match adjoining private property, any species of turf designated in Section 981 may be used. All of the permanent performance turf material shall be in place prior to final acceptance.

The Department will only pay for replanting as necessary due to factors determined by the Engineer to be beyond control of the Contractor.

Install all performance turf on shoulder areas prior to the placement of the friction course on adjacent pavement.

570-3.2 Seeding: At the Contractor's option, wildflower seed may be included in the performance turf seeding operation or performed separately from the performance turf seeding. Seed must produce visible seedlings within 45 days of planting.

Use of compost meeting the requirements of Section 987 as mulch is acceptable unless otherwise specified.

570-3.3 Sod: Place the sod on the prepared surface, with edges in close contact. Do not use sod which has been cut for more than 48 hours.

Place the sod to the edge of all landscape areas as shown in the Plans and the Standard Plans.

Place rolled sod parallel with the roadway and cut any exposed netting even with the sod edge.

Monitor placed sod for growth of exotic or invasive pest plants and noxious weeds. If exotic or invasive pest plants and/or noxious weeds manifest themselves within 30 days of placement of the sod during the months April through October, within 60 days of placement of the sod during the months of November through March treat affected areas by means acceptable to the Department at no expense to the Department. If pest plants and/or noxious weeds manifest themselves after the time frames described above from date of placement of sod, the Engineer, at his sole option, will determine if treatment is required and

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whether or not the Contractor will be compensated for such treatment. If compensation is provided, payment will be made as Unforeseeable Work as described in 4-4.

Remove and replace any sod as directed by the Engineer.

570-3.4 Hydroseeding: Use equipment specifically designed for mixing the mulch, seed, fertilizer, tackifier and dye, and applying the slurry uniformly over the areas to be hydroseeded.

Use mulch that does not contain reprocessed wood or paper fibers. Ensure that 50% of the fibers will be retained on a twenty-five mesh screen.

Mix fertilizer as required into the hydroseeding slurry.

Ensure that the dye does not contain growth or germination inhibiting chemicals.

When polyacrylamide is used as part of hydroseeding mix, only anionic polymer formulation with free acrylamide monomer residual content of less than 0.05% is allowed. Cationic polyacrylamide shall not be used in any concentration. Do not spray polyacrylamide containing mixtures onto pavement. These may include tackifiers, flocculants or moisture-holding compounds.

570-3.5 Bonded Fiber Matrix (BFM): Meet the minimum physical and performance criteria of this Specification for use of BFM in hydroseeding operations or temporary non-vegetative erosion and sediment control methods.

Provide evidence of product performance testing, manufacturer's certification of training and material samples to the Engineer at least 7 calendar days prior to installation.

Provide documentation to the Engineer of manufacturer's testing at an independent laboratory, demonstrating superior performance of BFM as measured by reduced water runoff, reduced soil loss and faster seed germination in comparison to erosion control blankets.

Use only BFMs that contain all components pre-packaged by the manufacturer to assure material performance. Deliver materials in UV and weather resistant factory labeled packaging. Store and handle products in strict compliance with the manufacturer's directions.

When polyacrylamide is used as part of hydroseeding mix, only anionic polymer formulation with free acrylamide monomer residual content of less than 0.05% is allowed. Cationic polyacrylamide shall not be used in any concentration. Do not spray polyacrylamide containing mixtures onto pavement. These may include tackifiers, flocculants or moisture-holding compounds.

Meet the following requirements after application of the formed matrix:

Ensure that the tackifier does not dissolve or disperse upon re-wetting.

Ensure that the matrix has no gaps between the product and the soil and that it provides 100% coverage of all disturbed soil areas after application.

Ensure that the matrix has no germination or growth inhibiting properties and does not form a water-repelling crust.

Ensure that the matrix is comprised of materials which are 100% biodegradable and 100% beneficial to plant growth.

Mix and apply the BFM in strict compliance with the manufacturer's recommendations.

Apply the BFM to geotechnically stable slopes at the manufacturer's recommended rates.

Degradation of BFM will occur naturally as a result of chemical and biological hydrolysis, UV exposure and temperature fluctuations. Re-application, as determined by the

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Engineer, will be required if BFM-treated soils are disturbed or water quality or turbidity tests show the need for an additional application.

570-3.6 Watering: Water all performance turf areas as necessary to produce a healthy and vigorous stand of turf. Ensure that the water used for turf irrigation meets the requirements of Section 983.

570-3.7 Fertilizing: Fertilize as necessary to promote turf growth and establishment based on soil testing. Refer to Section 982 for fertilizer rates.

For bid purposes, base estimated quantities on an initial application of 265 lb/acre and one subsequent application of 135 lb/acre of 16-0-8.

570-3.8 Shoulder Treatment: Provide soil for shoulder treatment in accordance with Standard Plans, Index 570-010. Soil needed for these purposes will be included in the corresponding Pay Item.

570-4 Turf Establishment.

Perform all work necessary, including watering and fertilizing, to sustain an established turf, free of noxious weeds, at no additional expense to the Department. Provide the filling, leveling, and repairing of any washed or eroded areas, as necessary.

Established turf is defined as follows:

1. An established root system (leaf blades break before seedlings or sod can be pulled from the soil by hand).
2. No bare spots larger than one square foot.
3. No continuous sod seams running perpendicular to the face of the slope.
4. No bare areas comprising more than 1% of any given 1,000 square foot area.
5. No deformation of the performance turf areas caused by mowing or other Contractor equipment.
6. No exposed sod netting.
7. No competing vegetation, exotic or invasive pest plants or noxious weeds.

Monitor turf areas and remove all competing vegetation, exotic or invasive pest plants, and noxious weeds (as listed by the Florida Exotic Pest Plant Council, Category I “List of Invasive Species”, Current Edition, https://www.fleppc.org). Remove such vegetation regularly by manual, mechanical, or chemical control means, as necessary. When selecting herbicides, pay particular attention to ensure use of chemicals that will not harm desired turf or wildflower species. Use herbicides in accordance with 7-1.7.

If at the time that all other work on the project is completed, but all turf areas have not met the requirements for established turf set forth in 570-4, continuously maintain all turf areas until the requirements for established turf set forth in 570-4 have been met.

During establishment and until the performance turf is established in accordance with this Section, continue the inspection, maintenance, and documentation of erosion and sedimentation control items in accordance with Section 104. Remove and dispose of all erosion and sedimentation control items after the performance turf has been established.

Notify the Engineer, with a minimum of seven calendar days advance notice, to conduct inspections of the performance turf at approximate 90-day intervals during the establishment period to determine establishment. Results of such inspections will be made available to the Contractor within seven calendar days of the date of inspection. Determination of an established turf will be based on the entire project and not in sections.

Upon the determination by the Engineer that the requirements of 570-4 have been met and an established turf has been achieved and all erosion and sedimentation control items have

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been removed, the Engineer will release the Contractor from any further responsibility provided for in this Specification.

The Contractor's establishment obligations of this specification will not apply to deficiencies due to the following factors, if found by the Engineer to be beyond the control of the Contractor, his subcontractors, vendors or suppliers:

1. Determination that the deficiency was due to the failure of other features of the Contract.

2. Determination that the deficiency was the responsibility of a third party performing work not included in the Contract or its actions.

The Department will only pay for replanting as necessary due to factors determined by the Department to be beyond the control of the Contractor.

570-5 Responsible Party.

For the purposes of this Specification, the Contractor shall be the responsible party throughout construction and establishment periods.

Upon final acceptance of the Contract in accordance with 5-11, the Contractor's responsibility for maintenance of all the work or facilities within the project limits of the Contract will terminate in accordance with 5-11; with the sole exception that the facilities damaged due to lack of established turf and the obligations set forth in this Specification-for performance turf shall continue thereafter to be responsibility of the Contractor as otherwise provided in this Section.

570-6 Statewide Disputes Review Board.

The Statewide Disputes Review Board in effect for this Contract will resolve any and all disputes that may arise involving administration and enforcement of this Specification related to the remedial work performed during the warranty period. The Responsible Party and the Department acknowledge that use of the Statewide Disputes Review Board is required, and the determinations of the Statewide Disputes Review Board for disputes arising out of this Specification will be binding on both the Responsible Party and the Department, with no right of appeal by either party. Meet the requirements of 8-3.

570-7 Failure to Perform.

Should the Contractor fail to timely submit any dispute to the Statewide Disputes Review Board, refuse to submit any dispute to the Statewide Disputes Review Board, fail to provide an established turf in accordance with 570-4 within six months of final acceptance of the Contract in accordance with 5-11, or fail to compensate the Department for any remedial work performed by the Department in establishing a turf and other remedial work associated with lack of an established turf, including but not limited to, repair of shoulder or other areas due to erosion and removal of sediments deposited in roadside ditches and streams, as determined by the Statewide Disputes Review Board to be the Contractor's responsibility, the Department shall suspend, revoke or deny the Contractor's certificate of qualification under the terms of Section 337.16(d)(2), Florida Statutes, until the Contractor provides an established turf or makes full and complete payment for the remedial work performed by the Department. In no case shall the period of suspension, revocation, or denial of the Contractor's certificate of qualification be less than six months. Should the Contractor choose to challenge the Department's notification of intent for suspension, revocation or denial of qualification and the Department's action is upheld,

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the Contractor shall have its qualification suspended for a minimum of six months or until the remedial action is satisfactorily performed, whichever is longer.

570-8 Method of Measurement.

The quantities to be paid for will be plan quantity in square yards based on the area shown in the Plans, completed and accepted.

570-9 Basis of Payment.

Prices and payments will be full compensation for all work and materials specified in this Section.

Payment will be made under:

Item No. 570- 1- Performance Turf - per square yard.

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SECTION 571
PLASTIC EROSION MAT

571-1 Description.

Furnish and install plastic erosion mat on areas as shown in the Plans. Conduct this work in conjunction with the performance turf work as specified in Section 570.

571-2 Materials.

Use a plastic erosion mat consisting of continuous or fused synthetic polymer fibers, which are entangled to form a three-dimensional matrix (netting or distorted netting may be included as part of the matrix). Ensure that the mat is capable of maintaining its shape throughout installation. Ensure that the mat is inert to chemicals encountered in a natural soil environment, and meets the requirement of Section 985 according to its application.

571-3 Installation of Plastic Erosion Mat.

Before installing the plastic erosion mat, submit to the Engineer certified test reports from the manufacturer certifying that the geotextile to be incorporated into this project meets the requirements of Section 985. Also, submit the manufacturer's written installation instructions.

Install a plastic erosion mat of uniform thickness, not less than 1/4 inch or more than 3/4 inch on the prepared soil surface in accordance with these Specifications, the manufacturer's recommendations and in conformity with the lines, grades and dimensions as shown in the Plans. Ensure that all joints are shingle lapped such that the bottom of each section fits over the top of the section below to prevent uplift of the ends or edges by water flow. Overlap ends of adjacent rolls a minimum of 3 feet. Overlap edges of adjacent rolls a minimum of 4 inches. Stake all edges at 3 to 5 feet intervals with staples as recommended by the manufacturer unless otherwise directed by the Engineer. Ensure that overlaps and anchor trenches are in conformance with the Plans and the manufacturer's installation recommendations.

Ensure that after installation there are no protrusions, projections or exposures of the plastic erosion mat. Do not compact the installed plastic erosion mat with any type of equipment employing a foot or grid.

The Engineer will reject any material having defects, tears, punctures, flaws, deterioration or other damage before, during or after installation. Remove and replace all rejected plastic erosion mat at no additional expense to the Department.

Fill all voids in the mat with soil meeting the requirements of Section 987. Establish performance turf meeting the requirements of Section 570.

571-4 Method of Measurement.

The quantity to be paid for will be the surface area of plastic erosion mat installed and accepted in square yards with no allowance for overlaps.

Performance turf will be paid for separately in accordance with Section 570.

571-5 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including furnishing, handling, placement of plastic erosion mat, all labor, equipment, and miscellaneous materials necessary for a complete and accepted installation.

Payment will be made under:

Item No. 571- 1- Plastic Erosion Mat - per square yard.

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SECTION 591
LANDSCAPE IRRIGATION SLEEVES

591-1 Description.

Furnish and install landscape sleeves for irrigation pipes and wires in accordance with the Plans and Standard Plans, Index 591-001.

591-2 Materials.

Meet the following requirements:

Schedule 40 Polyvinyl Chloride (PVC) pipe.....Section 630

591-3 Installation Requirements.

591-3.1 General: Construct sleeves along a straight alignment at the location and depth shown in the Plans. Deviations in location or alignment may be made with prior approval of the Engineer. Provide a minimum of 24 inches between irrigation sleeves and other utilities.

591-3.2 Backfill: Backfill in accordance with Section 120.

591-3.3 Coated Conductive Tape: Install coated conductive tape directly above the sleeves with the repeated warning of "CAUTION WATER LINE BURIED BELOW," unless otherwise shown in the Plans.

591.3.4 Pull String: Install a continuous No. 12 American Wire Gauge pull wire or polypropylene cord within the full length of all sleeves. Ensure that a minimum of 36 inches of pull string is accessible at each sleeve termination.

591.3.5 Sleeve Terminations: Terminate the sleeves as shown in Standard Plans, Index 591. Fit sleeve caps at all terminations with a removable PVC threaded or slip cap.

Install a survey marker cap fastened to a 18 inch by 24 inch long permanent marker made of No. 5 rebar, a steel survey stake, or 4 inch square concrete monument above the terminating end of all sleeve pairs. Ensure that the top of cap is flush to grade with message "IRRIGATION SLEEVE" permanently imprinted on the top of monument, and will not peel, fade, or deteriorate.

591-4 Method of Measurement.

The quantity to be paid will be the plan quantity of landscape irrigation sleeve in place and accepted. No separate payment will be made for contractor's choice of installation method.

591-5 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 591- 1- Landscape Irrigation Sleeve - per foot.

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SECTION 603
GENERAL REQUIREMENTS FOR TRAFFIC CONTROL SIGNALS AND DEVICES

603-1 Description.

The provisions contained in this Section include general requirements for all traffic control signals and devices.

603-2 Equipment and Materials.

603-2.1 General: Only use traffic control signals and devices that are listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their products for the APL must submit an application in accordance with Section 6.

Only use new equipment and materials, except as specified in the Contract.

603-2.2 Exceptions: The Department may grant exceptions to the requirements of 603-2.1 by permit to evaluate new technology or for other circumstances that are found to be in the public interest.

603-2.3 Uniformity: Only use compatible units of any one item of equipment, such as signal heads, detectors, controllers, cabinets, poles, signal system or interconnection equipment, etc.

603-2.4 Hardware and Fittings Used for Installation: Ensure that all assembly hardware, including nuts, bolts, external screws and locking washers less than 5/8 inch in diameter, are Type 304 or 316 passivated stainless steel. Use stainless steel bolts, screws and studs meeting the requirements of ASTM F593. Use nuts meeting the requirements of ASTM F594. Ensure all assembly hardware greater than or equal to 5/8 inch in diameter is galvanized. Use bolts, studs, and threaded rod meeting the requirements of ASTM A307. Use structural bolts meeting the requirements of ASTM F3125, Grade A325.

Use high-strength steel anchor bolts and U-bolts, having a minimum yield strength of 55,000 psi and a minimum ultimate strength of 90,000 psi.

603-2.5 Galvanizing: Meet the requirements of Section 962 when galvanizing for fittings and appurtenances for all structural steel (including steel poles).

603-2.6 Environmental Specifications: Ensure system electronics intended for installation outdoors or within a roadside cabinet satisfactorily performs all required functions during and after being subjected to the environmental testing described in National Electrical Manufacturers Association (NEMA) TS 2-2021, Sections 2.2.7, 2.2.8, and 2.2.9.

603-3 Definitions.

Traffic Control Signals and Devices: Any signal or device; manually, electrically, or mechanically operated, by which traffic is alternately directed to stop and permitted to proceed or controlled in any manner. Traffic control signals and devices regulate, warn, or guide traffic on, over or adjacent to a street, highway, pedestrian facility, or bikeway by authority of a public agency having jurisdiction. Traffic control signals and devices include controller assemblies (controller cabinets and their contents); signal heads including their hanging or mounting devices; vehicle detection systems ; pedestrian detection systems; motorist information systems,

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video equipment, network devices, electrically powered signs, cameras, and other equipment used within a traffic control system.

603-4 Systems Approval Requirement.

The Engineer will review and approve any system design plan of traffic control signals and devices, that is controlled or operated from a remote location by computers or similar devices, and which affects the movement of traffic on any portion of the State Highway System, prior to installation.

603-5 Submittal Data Requirements.

Prior to the installation of equipment and within 30 days after the preconstruction conference, submit a listing of all traffic control signals, devices, and hardware with Department APL approval numbers to the Engineer for approval on Form 750-010-02, Submittal Data - Traffic Control Equipment. Alternate or modified forms are unacceptable. Submit a separate form for each cabinet location. For non-structural equipment or materials that do not have an APL approval number, submit the manufacturer's descriptive literature and technical data fully describing the equipment to the Engineer for approval. The Engineer will submit forms received from the Contractor to the District Traffic Operations Engineer for concurrence.

Develop shop drawings for all structural support materials and other special designs, such as non-electrical, non-mechanical, or other fabricated items, which may not be specifically detailed in the Plans. Provide a complete operable signal installation as specified in the Contract regardless of any failure of the Department to discover or note any unsatisfactory material.

603-6 Documentation for Electronic Equipment.

Prior to final acceptance, submit the following documentation obtained from the manufacturer for the electronic equipment listed below:

1. Operation Manual
2. Troubleshooting and Service Manual
3. Assembly and installation instructions
4. Diagram of the field installation wiring (as applicable)
5. Warranty information

Submit documentation for the following equipment:

1. Controllers
2. Vehicle detectors
3. Load switches
4. Flasher units
5. Preemption units
6. Conflict monitors
7. Special sequence relays
8. Cameras
9. Dynamic message signs
10. Road weather information systems
11. Any other equipment which has a logic, timing, or communications function
12. Other equipment specified in the Contract Documents

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603-7 Department-Furnished Equipment Installed By Contractor.

Where the Contract includes installation of Department-furnished equipment, the Department will turn over such equipment to the Contractor when the construction progress allows or as designated in the Contract. The Department will test and certify the equipment to be in proper condition and ready to use and will bear the costs of correcting any defects in the equipment prior to pick-up by the Contractor. The Engineer will coordinate the pick-up and installation of the equipment. Maintain the equipment in proper operational condition after pick-up at no cost to the Department, until either final acceptance or the equipment is returned to the Department.

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SECTION 608
MANUFACTURERS' WARRANTIES FOR TRAFFIC CONTROL SIGNALS AND DEVICES

608-1 Description.

This Section sets forth manufacturers' warranty requirements for traffic control signals and devices furnished to the Department. Manufacturer and Contractor costs associated with transferring, submitting, and delivering equipment warranties, requirements, terms, and conditions are part of the work and are included in the pay item for the equipment or construction feature utilizing the equipment.

608-2 Manufacturers' Warranty Provisions.

608-2.1 General: Submit all warranties provided by the equipment manufacturer for the specific equipment included in the Contract. Ensure that all warranties are fully transferable from the Contractor to the owner of the equipment within the project limits. Ensure that warranties cover defects for at least the duration specified in the Contract Documents from the date of final acceptance in accordance with 5-11. Transfer warranties upon final acceptance in accordance with 5-11. Submit all warranties and warranty transfers to the Engineer.

In accordance with 611-6, the Contractor's responsibility for warranty repairs, warranty replacement, troubleshooting, or other costs associated with repair or replacement of traffic control signals and devices within the contract's project limits will terminate 90 days after final acceptance in accordance with 5-11.

608-2.2 Terms and Conditions: Ensure that the terms and conditions of warranties are documented by the manufacturer for equipment submittals on construction projects. Include terms for a specified service performance with provisions for repair parts and labor, or for replacement.

Ensure warranties require the manufacturer to furnish replacements for any part or equipment found to be defective during the manufacturer's warranty period at no cost to the owner of the equipment within the project limits.

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SECTION 611
ACCEPTANCE PROCEDURES FOR TRAFFIC CONTROL SIGNALS, DEVICES, AND INTELLIGENT TRANSPORTATION SYSTEM DEVICES

611-1 Description.

This Section sets forth Contract acceptance procedures for installations of traffic control signals and devices and for equipment purchase contracts.

611-2 Acceptance of Traffic Control Signal and Device Installations.

611-2.1 Partial Acceptance: The Engineer may make inspection for partial acceptance under the Contract in accordance with 5-10 of a complete traffic control signal and device installation upon its completion in accordance with the Contract Documents and at such time that other parts of the total Contract are at a stage of completion that either require or allow the installation to operate in a manner which is in accordance with the Contract Documents. Before inspection for partial acceptance, the Engineer will require the satisfactory completion of all field tests of completed installations in accordance with the requirements of 611-4. The Engineer will make inspection for partial acceptance in accordance with 5-10 in company with a Contractor's representative and, when applicable, a representative of the agency designated to accept maintenance responsibility.

611-2.2 Final Acceptance: The Engineer will make inspection for final acceptance of traffic control signal and device installations as part of all work under the Contract in accordance with 5-11, only after satisfactory completion of all field tests of completed installations and on the basis of a comprehensive field inspection of all equipment installations.

611-2.2.1 Traffic Control Signal and Device Installation: Submit Form 750-010-02, Submittal Data – Traffic Control Equipment for each cabinet location to the Engineer. The Engineer will make the final inspection with a Contractor's representative and a representative of the agency designated to accept maintenance responsibility. The Engineer will submit the approved form to the District Traffic Operations Engineer and place a hard copy in the cabinet at each location. Transfer warranties and guarantees on equipment to the Department in accordance with Section 608. For traffic signal installations, submit form 700-010-22, Final acceptance of Traffic Signal Installation(s), and Transfer of Maintenance, to the Engineer.

611-2.2.2 Intelligent Transportation System Device Installation: The Engineer will make the final inspection with a Contractor's representative and a representative of the agency designated to accept maintenance responsibility. Transfer warranties and guarantees on equipment to the Department in accordance with Section 608. Final acceptance of ITS installation is contingent on successfully completing the ITS Acceptance Test section.

611-2.3 As-Built Documentation: As a condition precedent to acceptance under 611-2.1 or 611-2.2, submit as-built drawings for all installations, signed and sealed by a Professional Engineer or Professional Surveyor and Mapper registered in the State of Florida, along with supplemental as-built information using Feature Import Templates and Attribute Forms used for the Department's ITS Facility Management (ITSFM) System. Feature Import Templates can be found on the Department's web site: https://www.fdot.gov/traffic/itsfm.

611-2.3.1 Submittal Requirements: Submit as-built plans for review by the Engineer. As-built plans must be PDF files, in the same scale and content as the Plans and formatted on 11-inch by 17-inch sheets. Signing and pavement marking plan sheets may be used instead of signalization plan sheets, if a substantial number of changes from the original Plans

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must be recorded. If, in the opinion of the Engineer, the changes cannot be clearly delineated on the existing drawings, clearly delineate all changes on 11-inch by 17-inch detail sheets, enlarged 200% from the reproductions.

Submit fiber optic splicing diagrams detailing all cable splices, terminations, equipment port assignments, and optical circuit path names within the communication network. Include cable manufacturer, type, strand count, and cable sequential reading at each pull box entrance/exit, each side of the splice enclosure, and at patch panel terminations.

As-built submittals must include an inventory of all traffic control signals and devices, and support structures. The inventory must include horizontal position geographic coordinate data collected using Differential Global Positioning System (DGPS) equipment. The inventory must include, at a minimum, the manufacturer, model, and serial number for each device or completed assembly. Submit coordinate data for pull boxes as well as conduit and cable at 100-foot intervals including changes in direction. All support structures, equipment cabinets and other fixed location features must be assigned a unique site ID name to create a common association between the as-built plans, inventory forms, and the ITSFM system. Include data for all components listed in 611-2.3.2, except those listed in 611-2.3.2.2 and 611-2.3.2.5.

Aerial photographs may be submitted with as-built plan submittals to provide supplementary information. The aerials should not include extra features such as the right of way, baseline, or roadway edges. The aerials may be used as a base for the as-built plans with mile post and offset dimensions. Make any corrections resulting from the Engineer's review and resubmit as-built plans as a condition precedent to acceptance of the installation. Submit the ITSFM electronic files in any of the following software formats:

1. As-built Plans – Design Files (DGN) and Portable Document Format (PDF)
2. Feature Import Templates – Spreadsheet format (XLSX)
3. Feature Attribute Forms – Portable Document Format (PDF)
4. Differentially Corrected GPS files – (COR)
5. GPS Export Files – Comma-Separated Values (CSV)
6. Photos – Joint Photographic Experts Group (JPG)

611-2.3.2 Components: As a minimum, identify all traffic control devices, poles, support structures, cabinets, pull and splice boxes, hubs, conduit duct banks, access points, and power services, and utility demarcation points.

611-2.3.2.1 Conduit and Cable: Identify all conduit and cable with unique line styles for routing (communication, electrical, and joint-use trenched) that are clearly identified in a legend on each plan sheet. Identify the type of cable (example - 7 conductor signal cable) and label the number of conductors, fiber strands or other identifying features of the cable. For conduit duct banks, clearly note conduit and innerduct size, length, material, and number of runs.

611-2.3.2.2 Loops and Detection Zones: Identify the location of all installed loops (including the distance from the stop bar for the advance loops), the path of each loop to the pull box, the loop window and the path of the loop lead-in to the controller cabinet. Identify the device location and the approximate detection area for detection systems that are not embedded in or under pavement.

611-2.3.2.3 Pull Boxes: Label unused and out of service pull boxes clearly. Show distances to each pull box from the nearest edgeline, stop bar, or other permanent

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feature. If an edgeline is not near a pull box or would not clearly identify its location; a fixed monument may be used (example - FDOT pole or structure).

611-2.3.2.4 Poles: Identify poles from the nearest edgeline of both approaches. If an edgeline is not near a pole or would not clearly identify its location, a fixed monument may be used.

611-2.3.2.5 Signal Heads: As-built plans must show the final location of signal heads. Each signal head shall be identified by its corresponding movement number.

611-2.3.2.6 Cabinet: The type of cabinet and inventory of internal components must be documented. Controller manufacturer along with the controller model number shall be submitted for all traffic signal cabinets. A cabinet corner "blow up" shall be submitted detailing pull box locations with all conduit and cable.

611-2.4 Installation Inspection Requirements: Meet the requirements of Section 105.

611-3 Signal Timing.

Set the timing of a traffic signal or system of traffic control devices in accordance with the Contract Documents, unless approved otherwise in writing by the Engineer.

611-4 Field Tests of Installations.

Perform the following tests in the presence of the Engineer and, when applicable, a representative of the agency designated to accept maintenance responsibility.

611-4.1 Traffic Control Signal and Device Installation:

Continuity: Test each signal head circuit, pedestrian detector circuit, vehicle detector loop circuit, and interconnect signal circuit for continuity.

Functional: Perform a functional test that demonstrates that every part of the installation functions as specified.

Induced Voltage on traffic signal connections: Measure the voltage between each signal head indication field terminal and the AC neutral circuit in the controller cabinet during the off (dark) state of each signal head indication. Ensure that the voltage does not exceed 2 $V_{AC, RMS}$. If this value is exceeded, take the following action to reduce the value to 2 $V_{AC, RMS}$:

1. Check for loose or broken connections in the signal head circuit from the controller cabinet to the signal heads.
2. If (1) above does not correct the problem, connect additional neutral circuits between the signal head and the controller cabinet.

Inductive Loop Assembly: An inductive loop assembly is defined as a loop plus the lead-in cable. Measure and record the series resistance of each inductive loop assembly. Ensure that the resistance does not exceed 10 Ω. Perform an insulation resistance megger test, at 500 V_{DC}, for each inductive loop assembly at the cabinet in which the inductive loop assembly is terminated. Do not connect the inductive loop assembly to the cabinet terminal strips during the test, except for the drain wire of a shielded lead-in cable. Insulation resistance is defined as the resistance between one wire of the lead-in cable and a ground rod or bussbar. Record the insulation resistance of each inductive loop assembly. Ensure that the resistance is equal to or greater than 100 MΩ.

Perform the 48-hour test only after achieving acceptable results from the other tests listed in 611-4.

48-Hour Test for Traffic Signal installations:

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1. Before beginning the 48-hour test, place all new signal installations (no existing signals) in flash for 48 to 336 hours. The length of the flash period will be determined by the Engineer.

2. Continuously operate each new or modified traffic signal installation or system for not less than 48 hours. If unsatisfactory performance of the system develops, correct the condition, and repeat the test until obtaining 48 hours of satisfactory continuous operation.

3. During the 48-hour test period, the Contractor is fully responsible for the signal or signal systems. Provide a responsible representative (technically qualified) who can monitor signal operation and troubleshoot any malfunctions within a one-hour period.

When coordination is specified in the Contract Documents, provide a two-hour training session on the operation and programming of the coordination features of the controller units during the 48-hour test. Arrange the time and place of the training session with the Engineer.

4. Perform a 48-hour test for flashing beacon installations in the same manner as for traffic signal installations.

5. Start the 48-hour test on a Monday, Tuesday, or Wednesday. Ensure the 48-hour test does not include weekends, Holidays, or Special Events.

6. Start the 48-hour test between 9:00 AM and 2:00 PM.

7. Before the 48-hour test, install and have standing by all equipment specified in the Contract Documents.

611-4.2 Intelligent Transportation System Device Installation: Test all stand-alone functions of the ITS devices as detailed in the Contract Documents and as approved by the Engineer.

For the managed field Ethernet switch (MFES), complete FDOT Form Number 750-040-07 for all installed field switches.

For the closed--circuit television (CCTV) camera, complete FDOT Form Number 750-040-08 for all installed CCTV cameras.

For microwave vehicle detection system (MVDS), complete FDOT Form Number 750-040-09 for all installed MVDS sensors.

For the camera lowering device (CLD), complete FDOT Form Number 750-040-10 for all installed CLDs.

For the dynamic message sign (DMS), complete FDOT Form Number 750-040-11 for all installed DMS.

For the remote power management unit (RPMU), complete FDOT Form Number 750-040-12 for all installed RPMU.

For the ITS cabinet, complete FDOT Form Number 750-040-13 for all installed ITS cabinets.

For ITS devices without official FDOT forms, evaluate ITS devices as per Contract Documents and as approved by the Engineer.

Complete approved data forms and turn them over to the Engineer for approval. Provide a minimum notice of 10 calendar days prior to all tests to permit the Engineer or their representative to observe each test.

If any unit fails to pass its stand-alone test, correct the unit, or substitute another unit in its place, then repeat the test.

If a unit has been modified as a result of a stand-alone test failure, prepare a report describing the nature of the failure and the corrective action taken and submit it to the Engineer prior to re-testing the unit. If a failure pattern develops, the Engineer may direct that

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modification be made to all units without additional cost to the Department or an extension of the Contract Time.

611-5 ITS System Acceptance Test.

After the stand-alone tests have been completed and approved by the Engineer, perform the System Acceptance Test in the presence of the Engineer and, when applicable, a representative of the agency designated to accept maintenance responsibility.

Conduct an approved 30-day System Acceptance Test during which all ITS Systems, Sub-Systems and, at a minimum, all control, monitoring, and communication functions of the field equipment are evaluated from a Transportation Management Center (TMC). Complete the System Acceptance Test documentation and turn them over to the Engineer for approval.

During the 30-day test period, limit device outages to 10% or less, a minimum of a single unit if less than 10 devices or the allowable threshold required in the Contract Documents, whichever is less. Should an outage of more than 10% of the total number of devices occur, a single unit or more if less than 10 devices or the allowable threshold in the Contract Documents, then the System Acceptance Test has failed.

Upon the failure of the System Acceptance Test, the 30-day testing window shall pause until all devices are fully functional. In addition to pausing and extending the test period by the number of days lost by failure and repair time, the Engineer has the option of restarting the full 30-day test.

Upon the successful completion of the System Acceptance Test, the Engineer will submit to the Contractor a letter of approval stating the first and last day of the 30-day system test period.

611-6 Contractor's Warranty Period for Installations.

611-6.1 General Requirements: Repair or replace any defective components or work of the installations for a 90-day period after final acceptance.

611-6.2 Contractor's Responsibilities: During the warranty period, the Contractor is responsible for the following:

1. Repair or replacement of equipment that fails to function properly due to defective materials or workmanship.

2. Upon notification by the Engineer of a malfunction, restore the equipment to proper operating condition within 12 hours after notification by the Engineer.

If the Contractor fails to restore the equipment to proper operating condition within 12 hours after notification, the Engineer has the authority to have the remedial work performed by other forces. The Contractor is responsible for all incurred costs of the work performed by other forces. Remedial work performed by other forces does not alter any of the requirements, responsibilities, or obligations of this warranty.

3. If the equipment does not function or malfunctions due to defective materials or workmanship, the Contractor is liable for any impairment to the safety of pedestrian and vehicular traffic resulting from such malfunction.

611-6.3 Department's Responsibilities: During the warranty period, the Department is responsible for the following:

1. Electrical energy costs which are paid for by the local maintaining agency.

2. All adjustments, such as timing, necessary for the normal operations of equipment.

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3. Documentation of the individuals involved and the time of Contractor notification upon failure or malfunction of equipment.

4. Repair or replacement of any part of the installation damaged as a result of natural causes or those resulting from vehicular or pedestrian traffic not associated with Contractor activities.

611-7 Manufacturer's Tests and Certifications.

For materials which may not require formal testing, the Engineer reserves the right to require certifications from the manufacturer of such equipment and material, to the effect that they meet all Specification requirements, and, in the event of questionable equipment or material, to require that such material or equipment be tested at no expense to the Department.

The Engineer reserves the right to withhold any payments which may be due; if the Engineer determines that the equipment does not meet the Specifications or evaluation criteria.

611-8 Contracts for Purchase of Equipment.

611-8.1 Acceptance Tests Required: For each unit of equipment furnished under purchase contracts (furnish only), the Engineer will perform the following tests:

1. Visual inspection within 5 days after delivery.

2. Operational tests which determine whether the equipment performs in accordance with the requirements of the Contract Documents. The Engineer will complete such tests within 15 days after delivery. If the equipment is listed on the Department's Approved Product List (APL), the Engineer may verify the APL Certification number in lieu of the operational tests.

611-8.2 Eligibility for Payment: The Department will base payment for equipment furnished under purchase contracts on satisfactory completion of the visual inspection and operational tests required by 611-7.1.

Before any payment will be made for each functional group, deliver to the Engineer, and receive from the Engineer acceptance of all units of each functional group of equipment required to be furnished by the Contract Documents. The Department will make separate payment for a staged delivery of each functional group of equipment only when staged delivery is specified in the Contract Documents.

611-8.3 Equipment Failing to Pass Acceptance Tests: When any unit of equipment fails to pass the acceptance tests, correct the deficiencies (by repair or replacement), at no expense (including all freight costs) to the Department, to attain compliance. If the original Contract Time has expired, the Department will charge and continue to assess liquidated damages in accordance with 8-10 until final acceptance of the equipment. Upon compliance with such correction requirements, the Engineer will perform tests on the equipment as specified above and will determine their eligibility for payment.

The Department will not assess liquidated damages during the acceptance test period in 611-7.1. The Department will allow only one acceptance test exclusion regarding liquidated damages assessment per LOT of units required to be delivered.

611-9 Method of Measurement.

611-9.1 General: Measurement for payment will be in accordance with the following work tasks.

611-9.2 ITSFM Sub-surface Documentation: The Contract unit price per mile of documented conduit, cable, boxes, vaults, enclosures, and all other subsurface utilities will

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include furnishing all hardware, tools, and materials and all data collection, verification, and submission as specified in this Section and the Contract Documents, and all labor, travel, MOT, programs, training, equipment, and other requirements necessary for a complete and accepted documentation submission. Payment for facilities located underground will be based on the linear length of the project as stated in the Contract Documents regardless of the length or number of conduits, cables, enclosures, or other subsurface facilities documented. No allowance will be made for sweeps or vertical distances below the ground.

611-9.3 ITSFM Location Documentation: The Contract unit price per location, will include documenting all above ground ITS Facilities at, or associated with, an ITS location as specified in this Section and the Contract Documents, and all labor, travel, training, equipment, programs, MOT, and other requirements necessary for a complete and accepted documentation submission. Payment for location documented will be based on the ITS location including cabinets, poles, utility hardware such as meter cans, utility demarcation sites, disconnects, etc., as well as all ITS devices, auxiliary devices, and other items, attributes, and fields called for in the ITSFM documentation and Contract Documents, regardless of the type or number of devices installed.

611-9.4 As-Built Drawings: All costs incurred in submitting as-built drawings are incidental to the other items of work associated with traffic control signals and devices.

611-10 Basis of Payment.

Price and payment will be full compensation for all work costs incurred in submitting ITSFM requirements including, all data gathering, data entry, transportation, protection of all items, protection of traffic, furnishing of all tools, machines and equipment, and all incidentals necessary to complete the work. Final payment will be withheld until all deficiencies are corrected.

Item No. 611- 1- ITSFM Sub-surface Documentation - per mile
Item No. 611- 2- ITSFM Location Documentation - each

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SECTION 620
GROUNDING AND LIGHTNING PROTECTION

620-1 Description.

Furnish and install grounding and lightning protection to provide personnel and equipment protection against faults, surge currents and lightning transients. Provide a grounding and lightning protection system in accordance with the details shown in the Standard Plans unless otherwise shown in the Plans.

620-2 Materials.

620-2.1 Ground Rods: Use ground rods meeting the requirements of UL 467 that are listed by an OSHA Nationally Recognized Testing Laboratory (NRTL). Ground rods must be made of copper-clad steel with a nominal diameter of 5/8 inches. Ground rod sections must be a minimum of eight feet in length and manufactured for the sole purpose of providing electrical grounding.

620-2.2 Ground Rod Assembly: Provide a ground rod assembly consisting of one or more ground rods coupled together, such that the total length of the assembly is a minimum of 20 feet, driven into the earth at a single point, without disrupting the electrical continuity of the assembly.

620-2.3 Ground Rod Array: Provide ground rod arrays, as required, consisting of two or more ground rod assemblies, bonded together and spaced a minimum of 40 feet apart.

620-2.4 Grounding Conductors: For installing grounding conductor in conduit, provide an insulated conductor that is stranded in accordance with ASTM B8 and color code the grounding conductor green. For installing grounding conductor without conduit, provide bare solid copper wire meeting the requirements of ASTM B3 for grounding conductors. Connect the grounding conductor from the system ground bus or barrier plates to the ground rod assembly. Size equipment grounding conductors according to NEC Section 250.122. Size grounding electrode conductors according to NEC Section 250.66.

620-2.5 Exothermic Grounding Bond: Make all connections to the ground rod assemblies using exothermic welds.

620-2.6 Air Terminals: Use air terminals that comply with UL 96A and NFPA 780 standards and are listed by a NRTL.

620-2.7 Surge Protective Devices (SPDs): Install SPDs on all power, data, video, and any other conductive circuit. SPD requirements for lighting must meet the minimum requirements of Section 992 and the Standard Plans. Use SPDs that meet the requirements of Section 996 and are listed on the Department's Approved Product List (APL).

Provide primary and secondary surge protection on AC power at traffic control device field sites.

620-2.7.1 SPD for 120 Volt or 120/240 Volt Power: Install a SPD at the utility disconnect to the cabinet.

Ensure an SPD is provided where the supply circuit enters the cabinet. Locate the SPD on the load side of the main disconnect, ahead of electronic devices, and connected in parallel with the AC supply.

620-2.7.2 SPD at Point of Use: Install an SPD at the point the ITS devices receive 120 volt power and connected in series with the circuits.

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620-2.7.3 SPDs for Low-Voltage Power, Control, Data and Signal Systems: Install a specialized SPD on all conductive circuits including, but not limited to, data communication cables, coaxial video cables, and low-voltage power cables.

620-2.7.4 Manufacturer's Warranty: Ensure that the SPD has a manufacturer's warranty covering failures for a minimum of 2 years from the date of final acceptance.

The term "failure" for warranty replacement is defined as follows:

Parallel-connected, power-rated SPD units are considered in failure mode when any of the visual indicators shows failure mode when power is applied to the terminals at the unit's rated voltage, or the properly functioning over-current protective device will not reset after tripping.

Series-connected, low-voltage power, data, or signal units are considered in the failure mode when an open circuit condition is created and no data/signal will pass through the SPD device or a signal lead is permanently connected to ground.

If the SPD, including any component of the unit, should fail during the warranty period, the entire SPD must be replaced by the manufacturer at no cost to the Department or maintaining agency.

620-3 Installation.

620-3.1 General: Construct a single-point grounding system. Install the primary ground rod assembly in an electrical pull box so that the top four inches are accessible for inspection, resistance testing, and maintenance. The primary ground rod assembly and electrical pull box shall be installed between 12 inches to 36 inches from the element being grounded. The top of all other ground rod assemblies connected to the primary ground rod assembly in an array must be buried a minimum of 18 inches below grade. Direct bury grounding conductors used to connect ground rod assemblies a minimum of 18 inches below finished grade.

Bond all ground rod assemblies and ground rod arrays together with solid bare tinned copper wire unless otherwise shown in the Plans. Install grounding conductors in a straight path.

Make all bonds between ground wires and ground rod assemblies and ground rod arrays with an exothermic bond with the following exception: do not exothermically bond sections of ground rods to create the ground rod assembly and do not exothermically bond connections within a cabinet. Apply an anti-oxidant compound to all mechanical connections.

Connect primary surge protection for power at the service entrance or main disconnect. Connect secondary surge protection at point of use, unless otherwise shown in the Plans.

Ensure that lightning protection systems conform to the requirements of the National Fire Protection Association (NFPA) Code NFPA 780, Standard for the Installation of Lightning Protection Systems. Install SPDs that have an operating voltage appropriate for the characteristics of the circuits they protect. The NFPA requirements do not apply to lighting systems.

620-3.2 Grounding Resistance:

620-3.2.1 Minimum Resistance Required: Obtain a resistance to ground of not more than 5 ohms for the following grounding applications. Install multiple ground rod assemblies totaling a maximum length of up to 80 feet, as required to achieve minimum grounding resistance.

1. Power service for traffic control devices
2. Signal and ITS cabinets

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3. ITS Poles/Structures with electronic equipment
4. DMS and DMS structures

Install a minimum of one primary ground rod assembly. If a grounding and lightning protection system using a single ground rod assembly does not achieve the required resistance to ground, extend the length of the ground rod assembly an additional 20 feet or install an additional ground rod assembly 40 feet away and connect it to the main ground rod assembly to create a ground rod array. Continue installing ground rod assemblies connected in an array until the required resistance is obtained or until the maximum required total length of ground rod is installed.

Grounding systems formed from horizontally constructed conductive radials are permitted if site conditions prohibit the use of vertically driven rods as permitted by the NEC Article 250.53(G). A grounding system consisting of the maximum total length of ground rod required is acceptable in cases where soil conditions prevent the grounding system from achieving the required resistance to ground. Submit the site resistance measurement to the Engineer.

620-3.2.2 Minimum Resistance Not Required: Install a single ground rod assembly for the following applications. No resistance to ground measurements are required.

1. Conventional lighting
2. External lighting for signs
3. Signal cable & span wire
4. Aerial interconnect messenger wire
5. Pedestals for pedestrian signals
6. Pull boxes with metal covers when 120 volts (or greater) AC power is present
7. Splice boxes with wire grounding units.

620-3.3 Grounding Traffic Control Systems at Signalized Intersections: Ensure that all separately grounded elements at an intersection (signal cabinet, power service, mast arms or strain poles, etc.) are bonded together to form an intersection grounding network array.

For traffic signal poles, including pedestals for pedestrian signals, accommodate the ground connection from signal heads and electrically powered signs through span wires to the ground rod assembly or array located at the pole base in accordance with the details in the Standard Plans.

For span wire assemblies, use the span wire to connect the ground rod assemblies or arrays of the poles. Do not use guy wires for grounding purposes, however bond any guy wire to the span wire as part of the intersection grounding network.

620-3.4 Grounding Traffic Control Systems on Highways: Install the primary ground rod assembly at the base of the traffic control device supporting structure. Bond all metal components of the system (such as cabinets, steel poles, and concrete pole grounding wire) to the grounding system using a mechanical connection on the equipment side and an exothermically welded connection at the down cable. Do not use split bolts for grounding system connections.

Connect all ground rod assemblies and any associated grounded electrical system within a 100 foot radius (but not beyond the edge of the roadway) of the primary ground rod assembly. Connect the primary ground rod assembly to a single point main grounding bar inside the equipment cabinet or mount it to the base of the traffic control device supporting structure unless otherwise shown in the Plans.

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Place multiple ground rod assemblies, as required, in a ground rod array as depicted in the Standard Plans unless otherwise shown in the Plans. If a required array cannot be placed in the right of way, submit an alternate placement detail for approval.

620-3.5 Grounding Highway Lighting Systems: Ground each metal light pole.

For poles on bridge structures, bring the grounding conductors out to a pull box at each end of the structure and connect them to driven ground rods 20 feet in length.

Ground all high mast poles in accordance with the details for grounding in Standard Plans, Index 715-010.

620-3.6 Grounding Equipment Shelters: Install all grounds for the equipment shelter on the side of the building that utilities, communication cables, and fiber enter. Connect all earth grounds to this point, including the grounding system for SPDs. Make all connections to SPDs according to the manufacturer's recommendations.

Ensure that communication cables, AC power, emergency generator, and equipment frames are connected by the shortest practical route to the grounding system. Protect the lead lengths from each device to the SPD.

Use compression type connection for all interior connections to bond grounding conductors to equipment in the shelter. For connections to bus bars, use mechanical connections having two bolts on a double-lug connector. Install star washers, or another means that accommodates the fasteners used and achieves reliable electrical connections that will not deteriorate. Crimp and solder all wires connected to lugs or clamps. Verify electrical continuity of all connections. Remove all non-conducting surface coatings before each connection is made.

Ensure that ground conductors are downward coursing, vertical, and as short and straight as possible. Ensure that the minimum bending radius for interior equipment shelter grounds is eight inches. Avoid sharp bends and multiple bends in grounding conductors.

620-3.6.1 Interior Grounding: Install a No. 2 AWG solid bare copper wire approximately one foot below the ceiling on each wall and mount it using insulated standoffs. Ensure that the wire encircles the equipment room, forming a ring or continuous loop. Mechanically connect the cable trays to the interior perimeter ground using stranded copper wires with green insulation and bolted terminal connectors at the cable tray ends. Make all points where cable tray sections meet electrically continuous by use of a short jumper wire with terminals attached at each end.

Directly bond all other metallic objects, such as door frames and doors, air conditioners, alarm systems, wall-mounted communication equipment, etc., to the closest interior perimeter ground with the shortest possible stranded copper wire with green insulation. Bond the door to the doorframe using flexible welding cable.

620-3.6.2 Exterior Grounding: Install an exterior grounding system consisting of multiple ground rod assemblies around the exterior perimeter of the equipment shelter. Place the ground rod assemblies a minimum of two feet from the building foundation in a suitable access point. Bond the following items to the shelter's grounding system:

1. Metal building parts such as downspouts and siding.
2. Ground rods provided by power or telephone utilities for grounding of AC power or surge protection devices, as permitted by local codes.
3. Shelter support skids, bases, or foundations, if applicable.
4. Any metal object larger than four square feet.
5. External metal fencing.

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620-3.6.3 Punch Block SPD Grounding: Ground Type 66 punchdown blocks in accordance with the manufacturer's recommendations and mechanically connect them to the shelter's interior perimeter ground.

620-3.6.4. Equipment Shelter Fence Grounding: Ensure that the metal Type B fence is grounded to fence perimeter grounding conductors consisting of No. 2 AWG solid bare tinned copper wires that encircle the entire compound to achieve required resistance to ground required in 620-3.2.

Exothermically bond any splices in the grounding conductors. Bury the fence perimeter grounding conductor a minimum of 2.5 feet below finished grade. Bond all fence posts to the fence perimeter ground wire using No. 2 AWG solid bare tinned copper wire. Bond the gate and gatepost together with a flexible ground, such as welding cable wires. Ground the gatepost to the fence perimeter ground wire using No. 2 AWG solid bare tinned copper wire. Exothermically bond all connections to the fence perimeter ground wire.

Connect the fence's top rail to each corner post and in the middle of each side. Ground the fence fabric with No. 2 AWG solid bare tinned copper wire connected to the fence posts. Connect the fence perimeter wires to the ground rod assemblies of the equipment shelter's ground system with No. 2 AWG solid bare tinned copper wire, as shown in the Plans.

Ensure that all ground leads are No. 2 AWG solid bare tinned copper wires for all above- and underground grounding wire installations. Ensure that all exothermic bonds are appropriate for the application. Do not use welding or other forms of bonding without prior written approval.

620-4 Ground Resistance Testing and Inspection.

620-4.1 Testing: Measure the ground resistance with an instrument designed specifically to measure and document earth/ground resistance, soil resistivity, and current flow. Conduct the test by using the fall-of-potential method as described in the Institute of Electronic and Electrical Engineers (IEEE) Standard 81. The fall-of-potential test is used to verify the minimum resistance required in 620-3.2.1. If fall-of-potential tests cannot be performed, it is acceptable to measure resistance at each accessible ground rod using a clamp-on ground resistance tester. Submit to the Engineer certified test results for each testing location. Submit the following information on the test results:

1. The formal name or ID for the location where the test was performed
2. The GPS latitude and longitude for the location where the test was performed
3. The date on which the test was performed
4. The make and model number, serial number, and last date of calibration (by an independent testing facility within the previous 12 months) for the grounding resistance testing device used
5. Contact information (including name, signature, and employer name) for each person conducting, witnessing, or certifying the test
6. Description of the local environmental and soil conditions at the time of testing
7. A rough sketch of the site grounding system; along with the corresponding measured data points
8. Page numbering showing the current page number and total page count (e.g., Page 1 of 3)

Only clamp-on ground resistance testing is required for roadway lighting installations.

620-4.2 Inspection: Do not backfill below-grade grounding installations and grounding connections until inspected and approved. The Engineer will inspect the installation for proper

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connection types, tightness, workmanship, and conformance to the Plans. Replace any exothermic bonds that are deemed unsatisfactory with new exothermic bonds. Repair or replace any mechanical connections that are deemed unsatisfactory. Measure the resistance at each accessible ground rod using a clamp-on earth tester. The measurement at any individual rod is the cumulative resistance of all rods in a parallel circuit.

For grounding system inspections, notify the Engineer at least five days prior to completion of the installation. Record all test results in a standardized format approved by the Engineer prior to testing. All recorded test report data shall be dated, witnessed, and signed by at least one representative of the Department and the Contractor. Remedy all deficiencies at no cost to the Department.

620-5 Basis of Payment.

The work specified in this Section will not be paid for directly, but will be considered as incidental work.

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SECTION 630
CONDUIT

630-1 Description.

Furnish and install conduit for traffic control signals and devices, highway lighting, and other electrically powered or operated devices as shown in the Contract Documents.

630-2 Materials.

630-2.1 Conduit: Use materials that have been tested and listed by a Nationally Recognized Testing Laboratory to the following industry standards:

Schedule 40 and 80 Polyvinyl Chloride (PVC)[1] ..... UL 651
Fiberglass Reinforced Epoxy[2] (below ground) ..... UL 2420
Fiberglass Reinforced Epoxy[2] (above ground) ..... UL 2515
Intermediate Metal[3] ..... UL 1242
Rigid Galvanized Metal[3,4] ..... UL 6
Rigid Aluminum[4] ..... UL 6A
PVC Coated Intermediate Metal[4] ..... ASTM A135/A135M,
..... ASTM A513, ASTM A568/A568M, NEMA RN1-2005
Liquid Tight Flexible Metal ..... UL 360
High Density Polyethylene (HDPE) Standard Dimension
Ratio (SDR) 9-11[5] ..... ASTM F2160
HDPE SDR 13.5[5] ..... ASTM F2160, NEMA TC-7
Schedule 40 and 80 HDPE ..... UL 651A

1. Use conduit with solvent weld slip-fit plastic couplings unless approved by the Engineer.

2. Use conduit having a minimum stiffness value of 250. Ensure that each section has a duct bell with an integral gasket on one end and a duct spigot on the other end.

3. Use conduit that is hot-dipped galvanized with a minimum coating of 1.24 ounces per square foot on both the inside and outside of the conduit. The weight of the zinc coating shall be determined using ASTM A90.

4. Use conduit with both ends reamed and threaded.

5. Can be used with preassembled cable and rope-in-conduit.

630-2.2 Locate Wire: Ensure that locate wire is a single copper conductor with a minimum gauge of No. 12 AWG. Ensure locate wire is insulated using a 45 mil minimum thickness polyethylene sheath that is orange in color and marked to identify the manufacturer and the conductor size.

630-2.3 Locate Wire Grounding Unit: Ensure that locate wires are attached to a wire grounding unit (WGU) dedicated to safely dissipate high transient voltages or other foreign electrical surges induced into the designated system. Ensure the WGU conforms to the following:

1. Allows signals generated by locate system transmitters to pass through the protection system without going to ground.

2. The protection system automatically resets and passes locate system transmitter signals after the unit has been grounded to dissipate over-voltages.

3. Is intended for below or above grade applications. Ground the WGU to a driven rod within 10 feet of the system using a No. 6 AWG single conductor wire with green insulation.

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Ensure that the WGU is enclosed for protection from environmental hazards and is accessible for the connection of portable locate system transmitters.

4. The WGU system meets the minimum standards listed in Table 630-1 for surge protection:

Table 630-1 Minimum Standards for Surge Protection	
Surge Element	3-element maximum duty fail-safe gas tube.
Rating	40,000 A surge capacity (single-cycle, 8 by 20 microsecond waveform).
Life	Minimum 1,000 surges (1000 A to ground).
Fail-Safe	Integral fail-shorted device.
Insulation Resistance	1,000 megohm minimum at 100 volts of direct current (V_{DC}).
Clamp Voltages	a. Impulse at 100 volts per microsecond: Typically 500 volts. b. Direct Current: 300 to 500 volts.

630-2.4 Warning Tape: Ensure that the buried cable warning tape is flexible, elastic material 3 inches wide, 6 mil thick, intended for burial and use as an underground utility warning notice, and that the surface of the warning tape is coated and sealed to prevent deterioration caused by harsh soil elements. Ensure that the warning tape color follows the American Public Works Association color code for underground utilities and has the repeating message "CAUTION: FDOT CABLE BURIED BELOW" or other wording approved by the Engineer, permanently printed on its surface. Ensure that the tape material and ink colors do not change when exposed to acids, alkalis, and other destructive chemical variances commonly found in Florida soils.

630-2.5 Route Markers: Route markers may be either a standard route marker (SRM) type or an electronic route marker (ERM) type. Ensure the SRM is a rigid, tubular, driven post used for location and notification purposes only. Ensure the ERM is physically identical to the SRM, but also includes a termination board to provide aboveground access to locate wire buried alongside conduit and cable runs.

Ensure that each SRM is labeled and identified as an FDOT fiber optic cable marker unless otherwise shown in the Plans. The labels must include the Department's logo, contact information for the local FDOT District, and a telephone number to call prior to any excavation in the area. Ensure that the identification information is permanently imprinted on the top fitting, and will not peel, fade, or deteriorate.

630-2.5.1 Standard Route Marker (SRM): Ensure that SRM posts are white with an orange top fitting cover with black or white lettering and graphics. Ensure that the SRM is a tubular configuration, and both the marker post and the top fitting are made from virgin Type 111 HDPE. Ensure that any fasteners used with the SRM are constructed of stainless steel.

Ensure that all SRMs have a minimum outside diameter of 3.5 inches with a minimum wall thickness of 0.125 inch. Ensure that the top fitting cover is a minimum of 1.5 feet long and has an outside diameter of 3.75 inches with a minimum wall thickness of 0.125 inch. Ensure that each SRM provides a tensile strength of 4,200 pounds per square inch as required in ASTM D638.

Ensure the SRM can withstand an impact force of 70 pounds per foot at 32°F in accordance with ASTM D2444, before and after UV conditioning for 2,000 hours in

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accordance with ASTM G154. Ensure that the control sample of any material tested maintains a minimum of 70 percent of its original tensile strength.

Ensure that SRMs installed at the minimum 2 foot depth can withstand at least one impact at 45 miles per hour by a vehicle weighing at least 3,500 pounds and that after impact, post returns to an upright position within 10 degrees of vertical alignment within 30 seconds from the time of impact.

630-2.5.2 Electronic Route Marker (ERM): Ensure ERMs meet the same material and performance requirements as the SRMs with the following exceptions. Equip each ERM with a removable, top-fitting cover that is black with white lettering. Ensure that each ERM contains a terminal board equipped with locate wire and ground connectors.

Ensure that the terminal board is made from corrosion-resistant materials and includes terminal facilities labeled according to function and provides uniform spacing between connection points.

630-3 Installation Requirements.

630-3.1 General: Install the conduit in accordance with NEC or National Electrical Safety Code (NESC) requirements and the Standard Plans. Consider the locations of conduit as shown in the Plans as approximate. Construct conduit runs as straight as possible and obtain the Engineer's approval for all major deviations in conduit locations from those shown in the Plans. Include buried cable warning tape with all trenched conduit. Mark the location of the conduit system with route markers as shown in the Plans and approved by the Engineer. Ensure that all route markers used are new and consistent in appearance.

For conduit installed by directional bore, install in accordance with Section 555. For conduit installed by jack and bore, install in accordance with Section 556.

Use only intermediate galvanized metal conduit, rigid galvanized metal conduit, rigid aluminum conduit or PVC coated intermediate metal conduit for above-ground electrical power service installations and rigid galvanized metal conduit or rigid aluminum conduit for underground electrical power service installations. Meet the requirements of Section 562 for coating all field cut and threaded galvanized pipe.

Use Schedule 80 PVC, Schedule 40 PVC, or fiberglass reinforced epoxy for conduit inside of or embedded within structural elements. Use Schedule 80 PVC or fiberglass reinforced epoxy for conduit that are outside or attached to the exterior of structural elements.

For non-structural, above ground ITS communication and electrical conduit, use intermediate galvanized metal conduit, rigid galvanized metal conduit, or Schedule 80 PVC conduit.

Use HDPE with an SDR number less than or equal to 13.5, Schedule 80 HDPE, Schedule 40 HDPE, Schedule 80 PVC, or Schedule 40 PVC for underground installations of electrical conduit in earth for ITS electrical applications.

Use HDPE with an SDR number less than or equal to 11, Schedule 80 PVC or Schedule 40 PVC for underground installations in earth or concrete for ITS and traffic control signal applications, except, use only HDPE with an SDR number less than or equal to 11 for blown fiber optic cable installations on limited access facilities.

Use Schedule 40 PVC Split Duct Conduit only for temporary repairs or relocation of conduit containing active fiber optic communications for distances less than 100 feet.

Use HDPE with an SDR number less than or equal to 13.5, Schedule 80 PVC, or Schedule 40 PVC for underground installations of electrical conduit in earth for lighting applications and landscape irrigation applications.

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Use HDPE with an SDR number less than or equal to 13.5, Schedule 80 PVC, Schedule 40 PVC, or rigid galvanized metal for underground installations of electrical conduit in concrete for lighting applications.

Use the following conduit for toll site applications:

1. HDPE with SDR number less than or equal to 11 for directional bores.
2. Schedule 80 PVC for open trenching of exterior conduits and vertical conduits under the footprint of a toll equipment building/cabinet, except for power service conduits.
3. Rigid steel conduit coated with PVC or a bituminous coating painted up to 6 inches above finished grade for power service conduit and vertical conduits entering or leaving the ground outside the footprint of a toll equipment building/cabinet.
4. Rigid galvanized steel elbows and bends for HDPE and PVC conduit raceways longer than 200 feet in length and 2 inches trade size and larger, except for conduits serving vehicle detection loop pull boxes.
5. Use Electrical Metallic Tubing (EMT) for the portion of conduit that extends greater than 24 inches into the toll equipment building interior.
6. Rigid galvanized steel conduit for exterior above grade conduit and conduit mounted to toll gantries.
7. Do not use Electrical Nonmetallic Tubing (ENT).

Do not place more than the equivalent of three 90 degree bends or a total of 270 degrees of bends, including the termination bends, between the two points of termination in the conduit, without a pull box. Obtain the Engineer's approval to use corrugated flexible conduits for short runs of 6 feet or less.

When a conduit installation changes from underground to above-ground, make the change a minimum of 6 inches below finished grade.

Install a No. 12 AWG pull wire or polypropylene cord inside the full length of all conduits. Ensure that a minimum of 24 inches of pull wire/cord is accessible at each conduit termination.

Ensure the conduit includes all required fittings and incidentals necessary to construct a complete installation.

When earth backfill and tamping is required, place backfill material as per Section 120 in layers approximately 12 inches thick and tamp each layer to a density equal to or greater than the adjacent soil.

When backfilling trenches in existing pavement, use a flowable fill meeting the requirements of Section 121.

Provide a standard clearance between underground control cable and electrical service cable or another parallel underground electrical service cable that meets NESC requirements.

Prevent the ingress of water, dirt, sand, and other foreign materials into the conduit prior to, during, and after construction. Seal the ends of conduit after wiring is complete with a moisture resistant sealant that is designed for this specific application.

630-3.1.1 Fiber Optic Cable Conduit: Install the conduit system so the fiber optic cable maintains a minimum bend radius of 20 times the cable diameter. Use approved methods for connecting inner duct or conduit within or between plowed portions, trenched portions, and bored portions. Submit the conduit manufacturer's coupling method and material to the Engineer for approval.

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630-3.2 Conduit Sizes: Size the conduit to be used on all installations, unless otherwise shown in the Contract Documents. Use conduit of sufficient size to allow the conductor to be installed without any damage and meeting NEC requirements. Use conduit that is at least 2 inches in diameter, with the following exceptions:

For conduit protecting the ground wire on the side of a pole, use conduit that is at least 1/2 inch in diameter.

For ITS applications where Contractor chooses to install fiber optic cable by blowing, use conduit that is at least 1-1/4 inch in diameter.

For traffic control signal and device electrical service conduit, use the minimum conduit size required by the local maintaining agency and the electrical service provider.

630-3.3 Conduit Joints: Make conduit joints using materials as specified by the manufacturer. When conduit crosses an expansion joint of a structure and where shown in the Plans, install an expansion or expansion/deflection fitting as specified by the manufacturer. Certify that expansion/deflection fittings are rated to accommodate a minimum rotation of 30 degrees and that both the expansion and expansion/deflection fittings are rated to accommodate the anticipated longitudinal movement (minimum of 2 inches for expansion fittings and 0.7 inches for expansion/deflection fittings). Ensure that all installed joints are waterproof. As an exception to the threaded coupling for intermediate metal conduit, at locations where it is not possible to screw the threaded coupling properly, the Contractor may use a waterproof slip-joint coupling approved by the Engineer. Secure the joint and tighten threaded connections.

Prior to insertion into the coupling, clean, prime and coat the ends of PVC conduit with solvent-type cement as specified by the manufacturer.

For toll site conduit applications: Join lengths of smooth wall HDPE conduit using the Butt Fusion process or universal aluminum couplings. Use PVC to HDPE threaded transition couplings to join PVC conduit to HDPE conduit.

630-3.4 PVC Coating: Apply PVC coating to exposed metal surfaces of the conduit, except for the threads, to attain a nominal thickness of 40 mils. Ensure that the coating is free of sags and drips.

Attach the coupling to the conduit prior to the application of the coating for conduit of 1 inch diameter or less.

Use a coupling with sleeve extensions on conduit larger than 1 inch. Ensure that the sleeve extensions on all threaded female openings have a length equal to the diameter of the conduit up to and including size number 53.

630-3.5 Conduit Terminations: Where conduit enters a box, fitting, or other enclosure, provide a bushing or adapter (end bell, conduit adapter, etc.) to protect the conductor or cable from abrasion unless the box, fitting, or enclosure provides equivalent protection.

For conduit to be encased in concrete, wrap with tape or otherwise protect all terminations to prevent the entrance of concrete.

Connect new underground conduits to existing underground conduits with a pull box.

Install conduit terminating in a concrete strain pole through the cable entry hole and up the center of the pole to a location approximately 6 inches below the handhole.

Seal conduits terminating in a controller base, pole, pull box, junction box, or pedestal base with a moisture resistant sealant approved by the Engineer.

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For mast arm poles, high mast poles, and steel strain poles, terminate conduit at least 6 inches above the top of the foundation. For all other poles, controller bases, pedestal bases, and junction boxes, terminate conduit runs into the center of the base or box at least 2 inches above the surface of the base.

630-3.6 Restoration of Trench Areas: Restore the conduit trench construction area to an acceptable condition. Such work includes repair or replacement of all pavement areas, sidewalks, driveways, curbs, structures, landscaping, grass areas (including removal of excavated materials and spoils), removal and disposal of drilling fluids, and backfilling areas disturbed by the conduit installation.

630-3.7 Above-Ground Installation: Use conduit designed and manufactured for use in long-term above-ground applications with UV stabilization to prevent material deterioration. Securely attach above-ground conduit installations to the surface of the supporting structure using conduit straps. As a minimum, use conduit straps located on 5 foot centers. Use galvanized metal conduit straps when installing intermediate galvanized metal conduit, fiberglass reinforced epoxy conduit, rigid galvanized conduit, rigid aluminum conduit or PVC coated intermediate metal conduit above ground.

Use the same PVC coating for the metal straps as the conduit, when using PVC coated intermediate metal conduit.

630-3.8 Elbows: The radius of curvature of the centerline of any bend shall not be less than shown below in Table 630-2:

Table 630-2
Elbow Curvature

Size	Standard Radius
1/2 inch	4 inches
3/4 inch	4-1/2 inches
1 inch	5-1/2 inches
1-1/4 inches	7-1/4 inches
1-1/2 inches	8-1/4 inches
2 inches	9-1/2 inches
2-1/2 inches	10-1/2 inches
3 inches	13 inches
3-1/2 inches	15 inches
4 inches	16 inches
5 inches	24 inches
6 inches	30 inches

630-3.9 Fiber Optic Cable Locate Wire.

630-3.9.1 Fiber Optic Cable Locate Wire Installation: Install locate wire in the trench or bore with all underground conduits to provide end-to-end electrical continuity for electronically locating the underground conduit system. When conduit is placed by trenching, bury locate wire along the centerline of the top outer surface of installed conduit. Do not install locate wire in a conduit with fiber optic cable.

Do not run locate wires into field cabinets. Terminate locate wires at the following locations or as shown on the Plans, nearest pull box to a field cabinet, nearest pull box

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to a building, and splice box locations. Ensure that wire termination occurs in a pull box as shown in Standard Plans, Index 635-001.

In a trenching operation, install the locate wire no more than 3 inches above the conduit. Ensure that the locate wire enters all pull and splice boxes, and that a minimum of 10 feet of slack locate wire is coiled and neatly stored in each box.

In a boring operation, install the locate wire in an encasement, install the conduit detection wire external to the conduit with no separation between conduit and wire, or use conduit with integral locate wire. Locate wire may also be placed in the void between the inner wall of conduit and innerducts contained within the conduit as long as no other cables are present within the void.

Make locate wire splices in a flush grade-level box. Ensure that locate wire splices are waterproof and suitable for direct burial. Ensure that locate wire splices at the pull box meet NEC requirements. Ensure that locate wire splices are constructed of and in the following order: a mechanical crimp connection with a butt sleeve, an oxide-preventing aerosol lacquer, mastic electrical splicing tape, and standard electrical tape. At the completion of the installation, provide the Engineer with as-built drawings that document all splice locations.

Install WGUs in pull boxes and splice boxes as shown in the Plans or directed by the Engineer. Mount the device in a location high enough from the bottom of the box to allow access to terminal facilities without disturbing cables present within the box. Terminate the locate wires and connect the WGU to ground in accordance with the manufacturer's instructions.

630-3.9.2 Fiber Optic Cable Locate Wire Testing: Test the locate wire system after installation to ensure that it functions and can be used to accurately locate the conduit system. Perform continuity tests and insulation resistance tests on all locate wires and provide the Engineer with all test results. Replace, or repair defective locate wire at no additional cost.

630-3.10 Route Markers: Install route markers for new fiber optic cable installations, replace route markers as shown in the Plans, and ensure the following:

1. Markers are plumb, level, and the notification information is clearly visible when viewed from the side facing the roadway.
2. Markers are set within the right of way.
3. Markers are placed at a 1 foot offset from the conduit system.
4. The top of the marker post is a minimum of 5 feet and maximum of 6 feet above the finish grade
5. Markers are spaced a maximum of 500 feet apart.
6. A clear line of sight is maintained from one marker to the next.
7. Markers are installed on both sides of the roadway at any crossing point where the conduit system changes to the opposite side of the roadway.
8. Markers are installed at the center point of any conduit run between two pull or splice boxes.
9. Markers are installed at gate locations when the conduit system is adjacent to a fence line.
10. Markers are installed on both sides of a stream, river, or other water crossing, and on both sides of aboveground attachments such as bridges and walls.

Remove and replace all marker posts damaged during installation at no additional cost. Ensure that route marker signs are labeled with a unique identification number, as detailed in the Plans or as approved by the Engineer. Provide as-built documentation at the completion of

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installation that includes identification number and location of all installed route markers and correlates the marker to the fiber optic infrastructure that it signifies.

Ensure that installation of ERMs includes connection of the route marker to the locate wire associated with the conduit run that the markers identify. Install locate wire through the base of the marker and terminate the locate wires to connectors mounted on the terminal board inside the marker. Install an underground magnesium anode a minimum of 10 feet away from the marker and perpendicular to the conduit system. Terminate the anode lead on the connector mounted on the terminal board inside the marker. Install the bond straps between the anode connector and all locate wire connectors to provide cathodic protection for the locate wire conductor.

630-4 Method of Measurement.

The Contract unit price per foot of conduit, furnished and installed, will include furnishing all hardware and materials and all testing as specified in this Section and the Contract Documents, and all labor, casings, removal of excavated materials and spoils, removal and disposal of drilling fluids, locate wire, trenching, boring, backfilling, flowable fill and restoration materials necessary for a complete and accepted installation.

Payment for conduit placed underground will be based on the horizontal length of the trench or bore measured in a straight line between the centers of pull boxes, cabinets, poles, etc., in linear feet, regardless of the length or number of conduits installed. No allowance will be made for sweeps or vertical distances below the ground.

Payment for conduit placed aboveground or bridge mounted will be based on the actual length of conduit installed.

Payment for each individual conduit run embedded in concrete barriers or traffic railings, as shown in Standard Plans, Index 630-010, will be based on the length of the concrete barrier or traffic railing section that includes the conduit, regardless of the actual length of conduit installed. This length is limited by the begin and end of the concrete barrier or traffic railing run and includes the portions of the conduit exiting the structure towards the ends of the concrete barrier or traffic railing as shown in the Standard Plans. This includes all expansion and expansion/deflection fittings, but no allowance will be made for sweeps or vertical distances below the ground.

Payment for conduit embedded in miscellaneous concrete structures will be based on the length of each individual conduit run, measured in a straight line between centers of junction boxes, regardless of the length of conduit installed, and will include all expansion and expansion/deflection fittings. Conduit that does not both begin and end at a junction box will be considered incidental to their related items of work.

Payment for replacement of route markers, per each, will be made only for those markers identified in the Plans.

Payment for split duct conduit placed will be based on the actual length of each conduit installed.

630-5 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment for conduit placed under existing turf will be made as open trench.

Payment for conduit placed under existing pavement (roadway, driveways, or sidewalk) will be made as directional bore, unless specifically identified as open trench. If conduit is being placed under both existing turf and existing pavement between two pull boxes, payment for the

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total pull box-to-pull box length will be made as directional bore. Payment for conduit placed by jack & bore will be made as jack & bore, for the total pull box to pull box length.

Payment for conduit embedded in concrete structures or traffic railings will be made as embedded conduit.

No additional payment will be made for multiple conduits in the same trench.

No payment adjustment will be made if the Contractor chooses to use an alternative method approved by the Engineer.

No payment will be made for failed bore paths, injection of excavatable flowable fill, products taken out of service, or incomplete installations.

Payment for replacement of route markers will include all the work, labor, equipment, and materials specified in this Section. No separate payment for route markers will be made for new conduit installation.

Payment will be made under:

Item No. 630- 2- Conduit - per foot.

Item No. 630- 3- Replace Route Marker for Existing Conduit - per each.

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SECTION 632
SIGNAL CABLE

632-1 Description.

Furnish and install underground and aerial signal cable as shown in the Plans and in accordance with Standard Plans, Index 634-001.

632-2 Materials.

Use only new materials meeting the requirements of this Section.

632-2.1 Signal Cable: Use either polyethylene insulated, polyvinyl chloride jacketed signal cable conforming to the requirements of the International Municipal Signal Association, Inc. (IMSA) Specification No. 19-1 or polyethylene insulated, polyethylene jacketed signal cable conforming to the requirements of IMSA Specification No. 20-1. Use signal cable conductors of stranded copper, No. 14 AWG or larger.

632-2.2 Cable Support Wire: Provide utilities grade zinc-coated support wire meeting the requirements of ASTM A475, whether separate or integral to signal cable, having a minimum nominal diameter of 1/4 inches.

632-2.3 Cable Attachment Hardware: Ensure that all bolts and nuts less than 5/8 inch in diameter are passivated stainless steel, Type 316 or Type 304 and meet the requirements of ASTM F593 and ASTM F594 for corrosion resistance. Ensure that all bolts and nuts 5/8 inch and over in diameter are galvanized and meet the requirements of ASTM A307. Use attachment hardware with sufficient tensile strength for the application. Use stainless steel lashing wire, galvanized or stainless steel lashing rod, cable rings or self-locking cable ties of UV stabilized black plastic having a minimum tensile strength of 100 pounds.

632-3 Installation Requirements.

Except for mast arm assemblies, install signal cable in continuous lengths between the traffic signal controller cabinet and the first disconnect hanger (or traffic signal head) on the span and between the traffic signal controller cabinet and each pedestrian signal head and pedestrian detector.

Do not use the neutral return conductor for pedestrian detectors as a neutral return for any other device. Conductors for the pedestrian signal head and the push button must be separated at the base of the pedestal and routed to the detection panel using separate raceways.

632-3.1 Number of Conductors: Determine the number of conductors required for each signal cable unless specified in the Contract Documents.

Provide three spare conductors for each signal cable used at all signal installations. Install the three spare conductors from the controller cabinet through each disconnect hanger (or traffic signal head) to the furthermost disconnect hanger (or traffic signal head).

Identify all spare conductors in a controller cabinet and ground them to the controller cabinet ground bus bar. Provide spare conductors within the controller cabinet of sufficient length to reach the furthermost field wiring terminals in the cabinet.

632-3.2 Protection of Cable: Ensure cable drawn through conduit, ducts, drilled holes protected by a rubber grommet, or support structures is installed in such a manner as to prevent damage to conductors or insulation.

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632-3.3 Cabling for Mast Arm Assembly: Continuous lengths of cable between the traffic signal controller cabinet, signal heads (or disconnect hangers), pedestrian signal heads and pedestrian detectors will be allowed only when specified in Contract Documents.

632-3.4 Cable Terminations: Terminate signal cable in the terminal by inserting the bared conductors into a compression type terminal block.

When barrier terminal blocks are specified in the Contract Documents, crimp insulated fork or ring terminals to the bared conductors using a calibrated ratchet-crimping tool and connect the forks or ring terminals to the barrier terminal block.

Neatly form and tie wrap all cable terminations.

If disconnect hangers are specified in the Contract Documents, terminate spare wires at the terminal strip located inside the disconnect hangers. Individually cap or tape any additional spares in the disconnect hanger.

Connect signal cables for a mast arm assembly in the terminal compartment when provided.

632-4 Method of Measurement.

The Contract unit price for signal cable, furnished and installed, will include furnishing all material, hardware, support wire, cable ties, cable clamps, lashing wire, terminal connectors, cable grounding and labor necessary for a complete and accepted installation.

For intersections where new strain poles, monotubes, or mast arms are installed, payment for signal cable will be based on the number of intersections at which signal cable is furnished and installed.

For all other applications, including repair and replacement of signal cable, payment for signal cable will be based on the linear feet of cable used.

632-5 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 632- 7- Signal Cable

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SECTION 633
COMMUNICATION CABLE

633-1 Description.

Furnish and install underground and aerial communication cable as shown in the Plans and Standard Plans.

633-2 Materials.

633-2.1 Fiber Optic Cable and Connections.

633-2.1.1 Single Mode Fiber Optic Cable: Provide all-dielectric, dry-filled, loose-tube, dispersion-unshifted, single-mode fiber (SMF) with low water peak, gel free, and suitable for underground (i.e., in conduit) and aerial outside plant installation. All fiber optic cable shall be splice-compatible with the Department's existing dispersion-unshifted SMF and require no electronic equipment for dispersion compensation between new and existing fiber. Ensure that all components that comprise a single length of cable are continuous and of the same material. Furnish only commercial off-the-shelf materials, equipment, and components.

633-2.1.1.1 Optical Fiber: Ensure that the optical fibers used in the cable meet or exceed the Telecommunications Industry Association (TIA) TIA-492-CAAB specification, U.S. Department of Agriculture Rural Utilities Service (RUS) 7 CFR 1755.902, and International Telecommunication Union ITU-T G.652.D requirements. Use only optical fibers meeting the additional requirements as follows:

Table 633-1
Geometry
Core-to-Cladding Concentricity: ≤0.5 µm
Cladding Noncircularity: ≤0.7%
Mode Field Diameter: 1,550 nm; 10.4 µm, ±0.5 µm
Optical
Cabled Fiber Attenuation: 1,310 nm, ≤0.35 dB/km; 1,550 nm, ≤0.25 dB/km
Dispersion: 1,550 nm ≤18.0 ps/(nm·km)
Polarization Mode Dispersion Link Design Value (PMDQ): ≤0.04 $ps/\sqrt{km}$

Ensure that all fiber in the buffer tube is usable fiber that complies with attenuation requirements. Ensure that fibers do not adhere to each other. Ensure that the fiber is free of surface imperfections and inclusions. Ensure that all fiber optic core glass is from the same manufacturer.

633-2.1.1.2 Buffer Tubes: Ensure that the fiber optic cable includes loose buffer tubes that isolate internal optical fibers from outside forces and provide protection from physical damage as well as water ingress and migration. Ensure that buffer tubes provide freedom of movement for internal optical fibers. Ensure buffer tubes allow for expansion and contraction of the cable without damage to internal optical fiber. Ensure that fiber does not adhere to the inside of the tube. Ensure that buffer tubes permit intentional scoring and breakout

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without damage to the fiber. Ensure that each fiber optic cable buffer tube contains 12 fibers per tube unless otherwise shown in the Plans.

633-2.1.1.3 Color Code: Ensure that the marking and color-coding of the fibers and buffer tubes conforms to the TIA-598-D standard.

Ensure that colors are permanent and stable during temperature cycling, and not subject to fading or smearing onto each other or into the water-blocking material. Ensure that fibers are colored with UV curable inks that remain clearly distinguishable as the intended color.

633-2.1.1.4 Strength Member: Ensure that the fiber optic cable contains a dielectric central and outside elements that prevent buckling of the cable and provide tensile strength. Ensure that the fiber optic cable can withstand a pulling tension of 600 lbs. without damage to any components of the fiber optic cable.

633-2.1.1.5 Water Blocking Compound: Ensure that the fiber optic cable contains a dry water-blocking material to prevent the ingress of water within the outer cable jacket. Ensure that water-blocking materials are non-nutritive, dielectric, and homogeneous, and free from dirt and foreign matter. Use dry water-blocking material for fiber optic cables used for either aerial or underground installations. Apply dry water-blocking compound longitudinally around the outside of the central buffer tubes. Construct all cables with water-blocking material that complies with the requirements of the EIA/TIA-455-81B standard and is subjected to water penetration tests as defined in the EIA/TIA-455-82B standard.

633-2.1.1.6 Ripcord: Ensure that the cable contains at least one ripcord under the sheath or alternate method that allows the removal of the sheath by hand or with pliers.

633-2.1.1.7 Filler: Fillers or rods may be included in the cable core to lend symmetry to the cable cross section if required.

633-2.1.1.8 Outer Jacket: Ensure that the fiber optic cable is jacketed with medium density polyethylene (MDPE) that is free of blisters, cracks, holes, and other deformities. Ensure that the nominal jacket thickness is a minimum of 0.03 inches. Ensure the outer jacket provides UV protection and does not promote the growth of fungus.

Mark the jacket with the cable manufacturer’s name, fiber type, fiber count, date of manufacture, the words “FDOT FIBER OPTIC CABLE” unless otherwise shown in the Plans, and the sequential cable lengths marked in feet. Ensure that the actual length of the cable is within 1% of the length indicated by the marking. Provide legible marking with contrasting color to that of the cable jacket.

633-2.1.1.9 Performance Requirements:

633-2.1.1.9.1 Operating Temperature: Ensure that the shipping and the operating temperature range of fiber optic cable meets or exceeds minus 40º to 158º F. Ensure that the installation temperature range of fiber optic cable meets or exceeds minus 22º to 158ºF.

633-2.1.1.9.2 Bend radius: Ensure that the fiber optic cable is capable of withstanding a minimum unloaded bend radius of 10 times the cable diameter and a minimum loaded bend radius of 20 times the cable diameter when loaded to pulling tension of 600 pounds. Test the cable as required in the TIA -455-33B standard. Ensure that bending the fiber optic cable up to the minimum bend radius does not affect the optical characteristics of the fiber.

633-2.1.1.9.3 Cable Strength: Ensure that the fiber optic cable is capable of withstanding a pulling tension of 600 pounds during installation . Ensure that optical

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fiber is proof-tested by the fiber manufacturer at a minimum of 100 kilo pounds per square inch. Ensure that the cable will withstand 25 impact cycles and the change in attenuation does not exceed 0.2 decibel at 1,550 nanometers when tested according to the requirements as detailed in the TIA-455-25D standard. Ensure that the fiber optic cable can withstand a minimum compression load of 125 pounds per square inch when applied uniformly over the length of the sample at the rate of 0.15 inches to 0.8 inches per minute and maintained for 10 minutes as defined in the TIA/EIA-455-41A standard.

633-2.1.1.9.4 Water Penetration: Ensure that the fiber optic cable is capable of withstanding the tests for water penetration defined in the TIA/EIA-455-82B standard. Ensure that a one-meter length of cable is able to withstand a one-meter static head of water applied at one end for 24 hours without water leaking through the other open cable end.

633-2.1.2 Fiber Optic Connection Hardware: Ensure that all splice enclosures, organizers, cable end preparation tools, and procedures are compatible with the fiber optic cable, and are approved by the Engineer.

633-2.1.2.1 Splice Enclosures: Contain all optical fiber splices within a splice enclosure. Ensure that the enclosures provide storage for splices, fiber, and buffer tubes. Ensure that the splice enclosure restores the mechanical and environmental integrity of the fiber optic cable, encases the sheath opening in the cable, and organizes and stores optical fiber. Ensure all hinges and latching devices are stainless steel. Ensure that the enclosure is airtight and prevents water intrusion. Ensure that the splice enclosure can accommodate pressurization and has the ability to be reentered without requiring specialized tools or equipment. Ensure that the enclosure provides fiber and splice organizers including splice trays and strain relief.

Ensure that splice enclosures are hermetically sealed to protect internal components from environmental hazards such as moisture, insects, and UV light. Fiber optic splice enclosures shall also:

Comply with the Telcordia Technologies' GR-771-CORE standard and all applicable NEC requirements.

Provide space for future expansion equal to 100% of the initial utilization.

Provide fiber optic cable penetration end caps to accommodate a minimum installation of two trunk fiber optic cables and two fiber optic drop cables. Ensure that the enclosure end caps are factory-drilled to the proper diameter to accept and seal the fiber optic cable entries. Ensure that the cable entry locations can accommodate an assortment of cables with outside diameters ranging from 0.45 inch to 0.75 inch, plus 10%, without jeopardizing the waterproof characteristics of the enclosure.

Ensure that splice enclosures are permanently labeled using machine printed, waterproof labels suitable for outside plant applications.

633-2.1.2.2 Splice Trays: Ensure that splice trays are securely attached and accessible, and provide sufficient storage for the fiber cable. Ensure splice trays provide access to individual fibers without disrupting other fibers in the tray. Ensure that splice trays hold the buffer tubes rigidly in place and provide protection for fusion splices. Ensure that the raceway accommodates the minimum bend radius of the fiber. Ensure that splice trays allow visible inspection of the fiber. Ensure that splice trays include a cover with a locking mechanism to hold it in place.

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633-2.1.3 Cable Terminations: Use Type LC connectors for all new network installations. Use Type ST, SC, or FC connectors only for connections to existing equipment or as specified in the Plans or by the Engineer. Use ultra physical contact (UPC) pre-terminated cable assemblies with factory-installed connectors for all new network installations. Use UPC field-installed connectors only for connections or temporary repairs to existing equipment as specified in the Plans or by the Engineer. Ensure that all connectors include a ceramic ferrule and provide a strain relief mechanism when installed on a single fiber cable that contains strength elements. Ensure that ST and FC connectors include a metallic body. Ensure that all connectors provide a minimum 11 pound pullout strength. Ensure that the optical fiber within the body of all connectors is mechanically isolated from cable tension, bending, and twisting.

Ensure that all connectors are compliant with the TIA/EIA-604 standards, as applicable, and are tested according to the Telcordia/Bellcore GR-326-CORE standard. When tested according to the TIA and EIA's Fiber Optic Test Procedure (FOTP)-171 (TIA/EIA-455-171B) at the manufacturer, ensure that the connectors have an insertion loss, as reflected on the manufacturer data sheet, less than or equal to 0.30 decibel for pre-terminated cable assemblies with factory-installed connectors and a maximum loss of less than or equal to 0.50 decibel for field-installed temporary connectors. Test the connectors as detailed in FOTP-107 (TIA -455-107A) to reflectance values of less than or equal to minus 45 decibels.

633-2.1.3.1 Pre-terminated Connector Assemblies (Pigtails): Ensure that pre-terminated cable assemblies consist of fiber optic cables with factory-installed connectors on one end of the cable and an un-terminated optical fiber on the other. Ensure that the pre-terminated connector assemblies are installed with fusion splices. Ensure that all buffer tubes and fibers are protected once the attachment of pre-terminated connector assemblies is complete.

633-2.1.3.2 Buffer Tube Fan-out Kits: Ensure that a buffer tube fan-out kit is installed when fiber optic cables are terminated. Use a kit compatible with the fiber optic cable being terminated and that is color-coded to match the optical fiber color scheme. Ensure that the buffer tube fan-out kit supports 12 fiber strands. Ensure that output tubing and the fiber strands contained therein are of sufficient length for routing and attachment of fiber optic cable to connected electronics or as directed by the Engineer. Ensure that the kit and the connectors are supplied by the same manufacturer.

633-2.1.4 Patch Panels: Ensure that the patch panel is compatible with the fiber optic cable being terminated and color coded to match the optical fiber color scheme. Ensure that the patch panel has a minimum of 12 LC-type panel connectors unless otherwise shown in the Plans. Ensure that the patch panel dimensions do not exceed 14 inches x 6 inches x 4 inches for fiber counts of twelve or less. Ensure the patch panel is suitable for mounting within an approved cabinet at the field device location. Ensure patch panels are sized to accommodate specified coupler housings and maintain sufficient bend radius for cables. Ensure the patch panel is sized to occupy the minimum space required for capacity.

633-2.1.4.1 Pre-terminated Patch Panels: Ensure that the pre-terminated patch panel includes a factory installed all-dielectric SMF cable stub. Ensure that the panel includes factory installed and terminated LC-type panel connectors unless otherwise shown in the Plans. Ensure that the cable stub is of sufficient length to splice the stub and provide a fiber connection between the panel and the backbone fiber cable or as directed by the Engineer.

633-2.1.4.2 Field Assembled and Terminated Patch Panels: Ensure that the field-assembled patch panel is a termination panel that includes a connector panel and the

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hardware required to mount the patch panel within an approved cabinet at the field device location and connect the panel to the backbone fiber cable.

633-2.1.4.2.1 Connector Panel: Ensure that the connector panel provides 12 LC-type, bulkhead-mount coupling connectors unless otherwise shown in the Plans. Ensure that each coupling connector allows connection of a cable terminated on one side of the panel to a cable on the opposite side.

Ensure that each bulkhead-mount coupling connector includes a locknut for mounting the connector in predrilled or punched holes in the connector panel.

633-2.1.5 Fiber Optic Jumper Cables: Ensure that the fiber optic jumper cables include a factory installed all-dielectric SMF. Ensure that the fiber optic jumper cables include factory installed and terminated LC-type connectors, a connector type shown in the plans, or a connector type directed by the Engineer.

633-2.1.6 Handling:

633-2.1.6.1 Cable End Sealing: Ensure that fiber optic cable ends are capped or sealed to prevent the entry of moisture during shipping, handling, storage, and installation. Equip one end of the fiber optic cable with flexible pulling eyes.

633-2.1.6.2 Protective Wrap: Ensure that the fiber optic cable is shipped and stored with a protective wrap or other approved mechanical reel protection device over the outer turns of the fiber optic cable on each reel. Ensure that the wrap is weather resistant and protects the cable reel from environmental hazards. Ensure that the cable reel remains wrapped until cable is to be installed.

633-2.1.6.3 Packaging, Shipping and Receiving: Ensure that the packaging and delivery of fiber optic cable reels comply with the following minimum requirements:

1. Ensure cable is shipped on reels of marked continuous length.
2. Ensure each cable is shipped on a separate, strongly constructed reel designed to prevent damage to the cable during shipment and installation.
3. Ensure each reel has a minimum of 6 feet on each end of the cable available for testing.
4. Ensure that all fiber optic cable is continuous and free from damage.
5. Ensure no point discontinuities greater than 0.1 decibel per reel.
6. Submit the transmission loss test results as required by the TIA-455-78 standard, as well as results from factory tests performed prior to shipping.
7. Ensure that the manufacturer submits the date of manufacture; product and serial numbers; cable data, including the reel length; refraction index; the project name and location; type of fiber and quantity of strands used; technical product data sheets; and reel numbers.

633-2.1.7 Manufacturer Testing and Certification: Submit documentation of all factory tests performed by the manufacturer for all fiber optic cable, splicing material, cable terminations, and patch panels.

633-2.2 Twisted Pair Cable: Use shielded underground and aerial cable. Underground and aerial cables include telephone cables and multiconductor communication cables.

633-2.2.1 Aerial Cable Support Wire: Meet the requirements of 632-2.2.

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633-2.2.2 Aerial Cable Attachment Hardware: Meet the requirements of 632-2.3.

633-2.2.3 Telephone Cable: Use aerial telephone cable with separate support wire conforming to Rural Electrification Administration (REA) Specification PE-39, filled telephone cables. Aerial telephone cable must comply with REA Specification PE-38, aerial telephone cables. Use only No. 22 AWG solid cables for copper connections in traffic signal closed loop systems.

Use underground telephone cable conforming to the United States Department of Agriculture (USDA), Rural Utilities Service (RUS) Bulletin 1753F-205 (PE-39), "REA Specification for Filled Telephone Cables".

633-2.2.4 Multiconductor Cable: Multi-conductor communication cable is used to carry communication and electrical signals between equipment, including Ethernet data or serial data, low voltage power, and may also be used to energize signaling equipment as part of signaling circuits.

633-2.2.4.1 Category 6 Cable: Use polyethylene jacketed Category 6 (CAT 6) cable conforming to the requirement of TIA 568 C.2 with Edison Testing Laboratories (ETL) verification. Cables run outside of equipment enclosures must be shielded cable (F/UTP) using an aluminum foil shield with drain wire and solid copper conductors, and shall be terminated with shielded RJ-45 connectors. Cable which remains within the equipment enclosure where it originates may be un-shielded twisted pair (UTP), include stranded copper conductors, and be terminated with un-shielded RJ-45 connectors. Use straight-through cables when connecting data terminating equipment (DTE) to data communications equipment (DCE), and cross-over cables when connecting DTE to DTE or DCE to DCE. For RJ-45 connector color coding: use TIA T-568B connectors as the standard configuration for straight-through cables and use TIA T-568B on one end and TIA T-568A on the other end for cross over cables.

633-2.2.4.2 Composite Cable: Composite cable consists of multiple conductors and cables housed within a single overall UV resistant polyethylene or polyvinyl jacket. The composite cable must carry communication and power to equipment using the type, number of conductors, and wire gauges as shown in the Plans and recommended by the equipment manufacturer. The cable must include an overall metallic shield with drain wire or individual shields with drain wires for each conductor.

633-3 Installation Requirements.

633-3.1 Fiber Optic Cable Installation: Install all materials and equipment according to the latest version of the manufacturer's installation procedures. Ensure that all materials and installation practices are in accordance with the applicable OSHA requirements as found in 29 CFR Part 1926, Safety and Health Standards for Construction. In addition, perform the following:

1. Ensure conduit and inner-duct is clean and free from damage prior to installing fiber optic cable.

2. Document the sequential cable length markings at each splice box and pull box wall that the cable passes through and include the information with the as-built documentation.

Provide all incidental parts needed to complete the installation, but not specified in the Plans, as necessary for a complete and properly operating system.

633-3.1.1 Cable Identification: Develop a nomenclature plan for identification of fiber optic cable. Submit the nomenclature plan to the Engineer for approval. Use approved

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cable nomenclature to create cable tags for the identification of fiber optic cable. Provide cable tag identification on all test results or fiber related documents submitted to the Engineer.

Install cable tags within 1 foot of each splice and/or termination point indicating the cable type, fiber count, and each fiber optic cable origination and termination points. Ensure that the cable tags are machine printed, waterproof, and permanent labels suitable for outside plant applications and are affixed to all fiber optic cables. Ensure that lettering is in permanent ink and displays the phrase “FDOT FIBER OPTIC CABLE”.

633-3.1.2 Pulling: Install the fiber optic cable by hand or by using a mechanical pulling machine. If a mechanical pulling machine is used, equip the machine with a monitored or recording tension meter. Ensure that at no time the manufacturer’s recommended maximum pulling tension is exceeded. Ensure that the central strength member and aramid yarn are attached directly to the pulling eye during cable pulling. Use pulling attachments, such as “basket grip” or “Chinese finger” type, to ensure that the optical and mechanical characteristics are not degraded during the fiber optic cable installation.

Ensure that excess cable is coiled in a figure eight and fed manually when pulling through pull boxes and splice boxes by hand. If pulleys and sheaves will be used to mechanically pull through pull boxes and splice boxes, submit a drawing of the proposed layout showing that the cable will never be pulled through a radius less than the manufacturer’s minimum bend radius. Use large diameter wheels, pulling sheaves, and cable guides to maintain the appropriate bend radius. Provide tension monitoring at all times during the pulling operation. Ensure that cable pulling lubricant used during installation is recommended by the optical fiber cable manufacturer.

633-3.1.3 Blowing: Use either the high airspeed blowing (HASB) method or the piston method. When using the HASB method, ensure that the volume of air passing through the conduit does not exceed 600 cubic feet per minute or the conduit manufacturer’s recommended air volume, whichever is more restrictive. When using the piston method, ensure that the volume of air passing through the conduit does not exceed 300 cubic feet per minute or the conduit manufacturer’s recommended air volume, whichever is more restrictive.

633-3.1.4 Slack Cable Storage: Provide and store fiber optic cable at each pull box and splice box to allow for future splices, additions, or repairs to the fiber network. Store the fiber optic cable without twisting or bending the cable below the minimum bend radius.

Store a total of 200 feet of fiber optic backbone cable in splice boxes, with 100 feet of cable on each side of the cable splice point or as shown in the Plans.

Store a minimum of 100 feet of fiber optic drop cable in splice boxes or as shown in the Plans.

Store 50 feet of spare fiber optic cable in pull boxes.

633-3.1.5 Fiber Optic Connection - Splicing: Perform all optical fiber splicing using the fusion splicing technique, and according to the latest version of the manufacturer’s cable installation procedures; industry accepted installation standards, codes, and practices; or as directed by the Engineer. Ensure that all splices match fiber and buffer tube colors unless shown otherwise in the Plans. Ensure that splice loss does not exceed a maximum of 0.05 db per splice as measured on the fusion splice machine when splicing newly installed fibers together. Ensure that splice loss does not exceed a maximum of 0.1 db per splice as measured on the fusion splice machine when splicing newly installed fibers to existing fibers. Where a fiber cable is to be accessed for lateral or drop signal insertion, only open the buffer tube containing the fiber to be accessed and only cut the actual fiber to be accessed. If a fiber end is not intended for use, cut the

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fiber to a length equal to that of the fiber to be used and neatly lay it into the splice tray. Treat any fibers exposed during splicing with a protective coating and place in a protective sleeve or housing to protect the fiber from damage or contaminants. Neatly store all splice enclosures within a splice box. Attach the splice enclosure to the splice box interior wall to prevent the enclosure from lying on the bottom of the splice box. Splices shall be performed only at locations as shown in the plans, or as approved by the Engineer.

633-3.1.5.1 Splice Plan: Submit a splice plan showing the location and configuration of splices in the system for approval by the Engineer. Perform all splicing according to the splice plan. Document each splice location and identify the source and destination of each fiber in each splice tray. Document all fiber colors and buffer jacket colors used during installation, and develop a sequential fiber numbering plan as required in the TIA - 598-D standard for color-coding in the documentation.

633-3.1.5.2 Splice Equipment: Use a fusion splice machine to splice all optical fiber. Ensure that splice equipment is new from the factory, or serviced and certified by the factory or its authorized representative within the previous 12 months from the commencement of its use. Ensure that the calibration certificate is maintained in the splicing equipment case or provided electronically when requested. Submit to the Engineer documentation from the manufacturer or his authorized representative certifying compliance. Clean all splicing equipment and calibrate according to the manufacturer's recommendations prior to each splicing session at each location.

633-3.1.6 Cable Termination Installation: Ensure that fiber optic cables, buffer tubes, and strands are neatly routed, secured, and terminated in a patch panel. Ensure every fiber strand within all fiber drops terminating in field cabinets are terminated in a connector panel using LC connectors unless otherwise shown in the Plans. Ensure all cable termination points include documentation regarding the identification, route, and function of each fiber installed at that location. Ensure that a copy of this information is placed alongside the installed equipment (for instance, in a document pouch or drawer within a field cabinet).

633-3.1.7 Patch Panel Installation: Ensure that patch panels are neatly installed and secured in a weatherproof enclosure. Ensure all patch panel connectors are clearly and permanently labeled using machine printed, waterproof labels suitable for outside plant applications. Ensure all installed patch panels include documentation regarding the identification, route, and function of each patch panel connector at that location. Ensure that a copy of this information is placed alongside the installed equipment in a document pouch or drawer within the cabinet.

633-3.1.8 Installation Testing: Notify the Engineer of cable testing at least 14 calendar days in advance. Submit the testing procedures to the Engineer for approval prior to commencement of testing. Perform all tests at 1,310 and 1,550 nanometer wavelengths and include the last calibration date of all test equipment with the test parameters set on the equipment in the test documentation. Ensure that the last calibration date of all test equipment is within the last 12 months and that the calibration certificate is maintained in the test equipment case or provided electronically when requested. Test all installed fibers (terminated and un-terminated) using methods identified in this Section. All tests must be conducted with a launch box.

Fibers containing splices, fibers terminated on both ends, terminated on one end, or backbone fibers (inside project limits and continuing outside of project limits) must be bidirectionally tested.

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Drop fibers without splices (inside project limits and continuing outside of project limits), with only terminations on one end, and bare fiber on the other must be tested unidirectionally at a minimum, unless otherwise specified in the Contract Documents.

Drop fibers without splices which are unterminated on both ends (inside project limits and continuing outside of project limits) must be tested using a bare fiber adapter and tested unidirectionally at a minimum, unless otherwise specified in the Contract Documents.

Present the results of the OTDR testing (i.e., traces for each fiber) and a loss table showing details for each splice and termination tested to the Engineer in an approved electronic format. Ensure all OTDR testing complies with the EIA/TIA-455-78 standard.

633-3.1.8.1 Optical Time Domain Reflectometer (OTDR) Attenuation Testing: Perform testing on all fibers to ensure that attenuation does not exceed allowable loss (0.35 db/km for 1310 nanometer wavelength, 0.25 db/km for 1550 nanometer wavelength, plus 0.5 db for any connectors and 0.1 db for splices). Repair or replace cable sections exceeding allowable attenuation at no cost to the Department.

633-3.1.8.1.1 OTDR Tracing: Test all fibers with an optical time domain reflectometer (OTDR) at wavelengths of 1310 and 1550 nanometer.

633-3.1.8.1.2 Splice Loss Testing: Ensure that the splice loss for a SMF fusion splice does not exceed a maximum bidirectional average of 0.1 decibel per splice when measured using an OTDR. Repair or replace splices that exceed allowable attenuation at no cost to the Department.

633-3.1.8.1.3 Connector Loss Testing: Ensure that the attenuation in the connector at each termination panel and its associated splice does not exceed 0.6 decibel when measured using an OTDR. Repair or replace connectors exceeding allowable attenuation at no cost to the Department.

633-3.2 Twisted Pair Cable Installation: Install all materials and equipment according to the latest version of the manufacturer's installation procedures.

Ensure cable drawn through conduit, ducts, drilled holes is protected by a rubber grommet, and is installed in a manner that prevents damage to conductors or insulation. Ensure all connections to outdoor equipment are weatherproof and prevent water intrusion into equipment, connections, and cable entrances. Cables exposed to the elements must be rated for outdoor use.

633-3.2.1 Cable type and Number of Conductors: Determine the appropriate cable type and conductor count required for each twisted pair communication cable unless specified in the Contract Documents. Identify all spare conductors.

633-3.2.2 Number of Cables: Do not install more than four separate cables at any point on a single support wire.

633-3.2.3 Telephone Cable: Install telephone cables in continuous lengths to and between cabinets and junction boxes. The Contractor may install junctions at intervals less than shown in the Plans; however, the Contractor must provide any additional materials (such as junction boxes, cabinets, risers, and mounting hardware) and labor for additional junctions and terminations at no expense to the Department. Obtain the Engineer's approval for any additional junctions or terminations.

633-3.2.4 Multiconductor Cable: Install multi-conductor communication cable in continuous lengths between cabinets and from cabinets to devices. Separate multi-conductor communication cables from high voltage conductors. Keep cable on the unprotected side of

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surge suppression devices separate from cable on the protected side to prevent induction of lightning and other high voltage transient currents.

633-3.2.5 Surge Protective Devices: Install surge protective devices meeting the requirements of Section 620 on cables entering cabinets or enclosures, and as shown in the Plans, prior to connection of Ethernet switches, PoE injectors, or other equipment.

633-4 Warranty.

Ensure that the fiber optic cable, the enclosures, terminations, and twisted pair cables and connectors have a manufacturer's warranty covering defects for a minimum of 2 years from the date of final acceptance. Ensure the warranty includes providing replacements, within 10 calendar days of notification, for defective parts and equipment during the warranty period at no cost to the Department or the maintaining agency.

633-5 Fiber Optic Cable Locator.

Locate and mark all existing Department owned or maintained fiber optic facilities within project limits prior to performing any subsurface work.

Locate and mark as necessary to ensure that all fiber optic facilities are located and visibly marked at all times.

633-6 Method of Measurement.

The quantities to be paid will be: the length, in feet, of fiber optic cable; the number, per each, of fiber optic connections; the number, per each, of fiber optic connection hardware; the number of calendar days from contract time start to final acceptance for fiber optic cable locator; the length, per foot, of telephone cable; and the length, per foot, of multi-conductor communication cable accepted by the Engineer.

The Contract unit price for communication cable, furnished and installed, will include furnishing, placement, and testing of all material, and for all tools, labor, equipment, installation hardware (such as support wire, cable ties, cable clamps, and lashing wire), supplies, support, personnel training, documentation, and incidentals necessary for a complete installation.

Payment for conductive cable terminal connectors and conductive cable grounding is considered incidental and shall be included in the price for twisted pair communication cable.

Fiber optic splices and terminations, as shown in the Plans, shall be measured per each fiber optic connection furnished and installed.

The price per day for a Fiber Optic Cable Locator will include all tools, labor, equipment, locating and marking hardware (such as flags, paint, and shovels), supplies, support, personnel training, documentation, and incidentals.

633-7 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 633- 1	Fiber Optic Cable - per foot.
Item No. 633- 2	Fiber Optic Connection - each.
Item No. 633- 3	Fiber Optic Connection Hardware - each.
Item No. 633- 4	Telephone Cable - per foot.
Item No. 633- 6	Fiber Optic Cable Locator - per day.
Item No. 633- 8	Multi-Conductor Communication Cable – per foot.

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SECTION 634
SPAN WIRE ASSEMBLY

634-1 Description.

Install a span wire assembly for supporting traffic signals, signs, and other traffic control devices. Provide fiberglass insulators when required.

634-2 Materials.

634-2.1 General Requirements: For a single point attachment, use only a catenary wire to support the imposed dead and wind load from the attached signs and traffic signals. For a single point attachment, the catenary wire also supports the signal conductor cables and interconnect cables.

For a two point attachment, the catenary wire is used to support the imposed dead load and a portion of the imposed wind load from the attached signs and traffic signals. The two point attachment also includes a messenger wire to resist a significant portion of the imposed wind load and to support the signal conductor cables and interconnection cables.

Use a tether wire for maintaining the alignment of signal heads when specified in the Plans.

634-2.2 Wires: For span wire assemblies, only use wire cables of seven-wire strands manufactured and provided with a Class A zinc coating in accordance with ASTM A475.

Provide utility grade catenary or messenger wires. The Contractor may use Siemens-Martin grade tether wires. Meet the following additional requirements for span wire assembly strands:

Table 634-1
Additional Requirements for Span Wire Assembly Strands

Span Wire Assembly Strand Type	Nominal Diameter Inch	Required Minimum Breaking Strength Pounds
Catenary Wire or Messenger Wire *	3/8 7/16 1/2	11,500 18,000 25,000
Tether Wire	3/16	1,900

*Supply catenary or messenger wire of the nominal diameter as specified in the Contract Documents.

634-2.3 Hardware and Fittings: For utility or Siemens-Martin grade wires, use the connection hardware as specified herein. For installations that use other grades of wire, provide the hardware and fittings indicated in the Plans. Provide only hardware and fittings made of galvanized steel or non-corrosive metal unless the fiberglass insulators specified in 634-2.4 are also required. Provide hardware and fittings of sufficient strength to resist the breaking strength of the wire with which they are used.

Use an alloy steel eyebolt meeting the requirements of ASTM F541, Type 2 and a matching heavy hex nut meeting the requirements of ASTM A563, Grade C or D, to connect the automatic compression dead-end clamp of the catenary wire or messenger wire to the wood or concrete strain poles. Eyebolts and hex nuts must be zinc coated in accordance with ASTM A153, Class C. Sizes of eyebolts, supplied with nuts and washers, are as following: Use a

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3/4 inch diameter bolt for maximum of one 7/16 inch diameter catenary or messenger wire, or maximum of two 3/8 inch diameter catenary or messenger wires. Use a 1 inch diameter bolt for maximum of one 1/2 inch diameter catenary or messenger wire, or maximum of two 7/16 inch diameter catenary or messenger wires. Use 1-1/4 inch diameter bolt for maximum of two 1/2 inch diameter catenary or messenger wires. For two point attachments, connect the messenger wire at the lower attachment location. Do not use thimble eye bolts for these connections.

Only use thimble eye and eye bolts, 3/4 inch in diameter, minimum, to connect the automatic compression dead-end clamps of tether wires to wood or concrete strain poles.

Only use “S” hooks, 5/16 inch in diameter, minimum, when connecting the tether wire to all poles.

Ensure that other hardware and fittings, as required for the attachment of a span wire assembly to support poles or structures, are in accordance with the details shown in the Standard Plans.

Furnish and install new catenary and messenger wire clamps for steel strain pole s when existing poles are to remain and the span wire assemblies will be replaced or modified.

634-2.4 Fiberglass Insulators: Install fiberglass insulators of the length specified in the Plans on span wire assemblies located within 6 feet of overhead electric power lines.

Use a fiberglass insulator of a cylindrical shape, fabricated from epoxy-resin impregnated fiberglass strands and having a breaking strength 50% greater than that of the structural support wire to which it is to be attached. Equip the insulator with thimble eye fittings on each end for attachment of the wire. Furnish all fittings and hardware necessary for the complete installation with the insulator and ensure that such fittings and hardware are of at least equal strength to the insulator.

634-2.5 Cable Attachment Hardware: Meet the requirements of 632-2.3.

634-3 Installation Requirements.

634-3.1 Span Wire Assembly Types: Use either of the following span wire assemblies as shown in the Contract Documents:

1. Single Point Attachment Assembly: This type of assembly requires a catenary wire with an optional tether wire if specified in the Plans.

2. Two Point Attachment Assembly: This type of assembly requires a catenary wire, a messenger wire and an optional tether wire if specified in the Plans.

634-3.2 Span Types: Install span wire assemblies on the following span types:

1. Perpendicular Span: Use this type span at an intersection to support a single span wire assembly upon which traffic signals, signs, and other traffic control devices are attached. Attach the span wire assembly to two support poles or structures, located on opposite sides of the roadway, and extend the assembly across the roadway at an angle of approximately 90 degrees to the roadway approach.

2. Diagonal Span: Use this span type at an intersection to support a single span wire assembly upon which traffic signals, signs, and other traffic control devices are attached. Attach the span wire assembly to two poles, located in opposite quadrants of the intersection, and extend the assembly across the intersection at an angle of approximately 45 degrees to the approach lanes of the intersection. Locate traffic control devices for all approaches at appropriate locations on the span wire assembly.

3. Box Span: Use this span type at an intersection to support a perimeter system of four span wire assemblies upon which traffic signals, signs and other traffic control devices for

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each approach to the intersection are attached. Attach the span wire assembly to four poles, one located in each quadrant of the intersection, and extend each span wire between two poles at an angle of approximately 90 degrees to the roadway approaches. Place traffic control devices for an approach on the span wire on the far side of the intersection.

4. Special Design Span or Suspended Box Span: Use this span type to support two or more span wire assemblies upon which traffic signals, signs and other traffic control devices for one or more roadway approaches are attached. Attach the span wire assembly to three or more poles.

634-3.3 General Requirements: Provide a span wire assembly with catenary, messenger and tether wires of one continuous length of wire cable with no splices except when an insulator is required by 634-2.4. Connect the insulator, if required, to the cable with automatic compression dead-end clamps.

Attach the span wire assemblies to the support poles or structures by means of automatic compression clamps and accessory hardware.

Assemble the washer and nut on the oval eye bolt with the flat washer next to the pole. Tighten the nut sufficiently to prevent the oval eye bolt from rotating.

For two point attachments, install the messenger wire with the following tensions per 100 feet. Linearly prorate cable tensions for other lengths from these values:

Table 634-2
Two Point Attachment Tension Requirements per 100 Feet

Cable Size Inch	Wire Tension Lbs.
3/8	340.0
7/16	500.0
1/2	645.0

The catenary wire shall be tensioned to provide a 5%, plus or minus 0.5% sag.

Install the span wire assemblies in accordance with Standard Plans, Index 634-001, and at a height on the support poles which will provide a clearance from the roadway to the bottom of the signal head assemblies in accordance with 650-3.

Connect all span wires to the pole grounding system in accordance with Section 620.

Obtain and meet all provisions of the National Electric Safety Code (ANSI-C2) regarding clearance from electric lines, contacting of utility owners, and safety requirements prior to span wire installation.

Prior to installation of the two point attachment span wire assembly, submit the method of providing the required tension in the messenger wire to the Engineer for approval.

634-4 Method of Measurement.

The Contract unit price per intersection for span wire assembly and per foot of fiberglass insulator, furnished and installed, between supporting poles and structures will include furnishing all materials and hardware as required in 634-2, and all labor, equipment, and miscellaneous materials necessary for a complete and accepted installation.

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634-5 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section. When a tether wire is specified in the Plans, the payment of the tether wire shall be included in the compensation for the span wire assembly.

Payment will be made under:

Item No. 634-	4-	Span Wire Assembly - per intersection.
Item No. 634-	5-	Fiberglass Insulator - per foot.

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SECTION 635
PULL, SPLICE, AND JUNCTION BOXES

635-1 Description.

Furnish and install pull, splice, and junction boxes as shown in the Plans.

635-2 Materials.

635-2.1 General: Use pull and splice boxes listed on the Department's Approved Product List (APL).

635-2.2 Pull and Splice Boxes:

635-2.2.1 General: Use only boxes that meet the requirements of Section 996 and are listed on the Department's Approved Product List (APL). Ensure box bodies and covers are free of flaws such as cracks, sharp, broken, or uneven edges, and voids.

Ensure in-ground boxes have an open bottom design.

635-2.2.2 Marking: Mark boxes in accordance with 996-5.

635-2.2.3 Dimensions: Unless otherwise shown in the Plans, provide pull and splice boxes with dimensions in accordance with 996-5.

635-2.3 Junction Boxes:

635-2.3.1 Fabrication: Provide galvanized steel, aluminum or NEMA 4X non-metallic junction boxes. Ensure all attachment hardware is Type 316 or 304, passivated stainless steel.

Ensure the outside surface has a smooth, uniform finish. Ensure boxes are free of burrs, pits, sharp corners and dents. Ensure all welds are neatly formed and free of cracks, blow holes, and other irregularities.

635-2.3.1.1 Aerial Junction Boxes: Unless otherwise shown in the Plans, provide aerial junction boxes with minimum inside dimensions of 8 inches wide by 8 inches long and at least 3 inches deep.

635-2.3.1.2 Mounted Junction Boxes: Provide mounted junction boxes fabricated of 5052 sheet aluminum alloy with a minimum thickness of 1/8 inch. Ensure all mounted junction boxes have a hinged door and lock as specified in Section 676.

Unless otherwise shown in the Plans, provide mounted junction boxes for the following installations:

For pole and cabinet mounted installations, provide junction boxes with minimum inside dimensions of 13 inches long by 10 inches wide and at least 3 inches deep.

For base mounted installations, provide junction boxes with minimum inside dimensions of 21 inches long by 10 inches wide and at least 8 inches deep.

635-2.3.1.3 Embedded Junction Boxes: Provide weatherproof embedded junction boxes for use in concrete structures or traffic railings. Include gasketed weatherproof covers made of the same material as the box and stainless steel, tamper resistant screws for securing the cover. Fabricate galvanized steel boxes and their covers from steel meeting the requirements of ASTM A36 and galvanized in accordance with ASTM A123.

For embedded junction boxes not exposed to vehicular impacts, provide the following types of junction boxes. Where the structure's environmental classification is slightly or moderately aggressive, provide a galvanized steel or NEMA 4X (non-metallic) box,

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as approved by the Engineer. Where the structure's environmental classification is extremely aggressive, provide a NEMA 4X (non-metallic) box, unless otherwise directed by the Engineer.

For embedded junction boxes exposed to vehicular impacts, provide a galvanized steel box regardless of the structure's environmental classification.

635-2.3.2 Barrier Terminal Blocks: Provide a barrier terminal block with a minimum of ten positions and rated at 600 V_{AC} in all aerial and mounted junction boxes. Ensure each terminal block position has two screws electrically connected by a shorting bar or other Department approved method. Ensure all terminal block positions are numbered sequentially.

635-3 Installation.

635-3.1 General: Do not install power and communication cables in the same box unless otherwise shown in the Plans.

When signal or 120 volt (or greater) power is present, ground all metal covers in accordance with Section 620.

Ensure metal junction boxes are grounded and bonded in accordance with the NEC Section 314.4.

635-3.2 Pull and Splice Boxes: Install pull and splice boxes in accordance with Standard Plans, Index 635-001. Ensure pull and splice boxes are sized for the amount of cable to be placed inside. Ensure that the pull or splice box cover is flush with the concrete apron or sidewalk. Do not install pull or splice boxes in roadways, driveways, parking areas, or public sidewalk curb ramps. Avoid placing pull and splice boxes in low-lying locations with poor drainage. Ensure that pull and splice boxes house fiber optic cable without subjecting the cable to a bend radius less than 14 times the diameter of the cable. Install identification plates according to the box manufacturer's instructions.

635-3.2.1 Placement and Spacing: Place pull and splice boxes as shown in the Plans and at the following locations, unless directed otherwise by the Engineer:

1. At all major fiber optic cable and conduit junctions.
2. Approximately every 2,500 feet for fiber optic cable applications in rural areas with any continuous section of straight conduit if no fiber optic cable splice is required.
3. At a maximum of 1,760 feet for fiber optic cable applications in metropolitan areas.
4. At a maximum of 500 feet for electrical applications.
5. At each end of a tunnel, and on each side of a river or lake crossing.
6. On each side of an aboveground conduit installation, such as an attachment to a bridge or wall.
7. At all turns in the conduit system.
8. Near the base of a service pole or communication cabinet to provide:
    a. A transition point between the fiber optic conduits extending from the fiber backbone and the conduit feeding the communication cabinet.
    b. An assist point for the installation of fiber optic drop cable.
    c. Storage of slack fiber optic drop cable.

635-3.2.2 Electronic Box Marker: Equip all pull and splice boxes buried below finish grade with an electronic box marker inside the pull or splice box to mark the location. Ensure that the electronic box marker is a device specifically manufactured to electronically mark and locate underground facilities. Ensure that the electronic box marker includes circuitry and an antenna encased in a waterproof polyethylene shell. Ensure that the outer shell is

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impervious to minerals, chemicals, and temperature extremes normally found in underground plant environments. Ensure that the electronic box marker does not require any batteries or active components to operate. Ensure that electronic box markers used to mark fiber optic cable and general telecom applications are orange in color and operate at 101.4 kHz. Ensure that the electronic box marker's passive circuits produce an RF field when excited by a marker locator to direct the locator to the marker's position. Ensure that the electronic box marker has a minimum operating range of 5 feet from the marker locator.

635-3.3 Aerial Junction Boxes: Install aerial junction boxes in accordance with Standard Plans, Index 634-002.

635-3.4 Mounted Junction Boxes: Install mounted junction boxes in accordance with Standard Plans, Index 676-010. Ensure that the bottom surface of pole mounted junction boxes is a minimum of 4 feet above the finished grade.

635-3.5 Cable Terminations: Make cable terminations in junction boxes in accordance with Section 632. Route and form the cable to allow access to the terminal screws. Do not cover the terminal identification numbers with the cable.

635-4 Relocation of Pull, Splice, and Junction Boxes.

Relocation of pull, splice, and junction boxes shall consist of removing an existing box and installing the box at the location shown in the Plans. Restore the area of the box removal and relocation to the condition of the adjacent area. The costs for restoration will be included in the Contract unit price of the relocation.

Boxes damaged due to the Contractor's operations must be replaced by the Contractor at no cost to the Department. Replacement boxes must be of the same material and size of the existing box, unless directed otherwise by the Engineer.

635-5 Warranty.

Ensure all pull, splice, and junction boxes have a manufacturer's warranty covering defects for a minimum of one year from the date of final acceptance in accordance with 5-11 and Section 608. Ensure the warranty includes providing replacements, within 30 calendar days of notification, for defective parts and equipment during the warranty period at no cost to the Department or the maintaining agency.

635-6 Method of Measurement.

The Contract unit price each for pull, splice, and junction box, furnished and installed, will consist of the pull, splice, and junction box including all required hardware for the type of box and location as specified in the Contract Documents, and all labor and materials necessary for a complete and accepted installation.

635-7 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, except grounding.

No separate payment will be made for the removal of pull, splice, and junction boxes.

Payment will be made under:

Item No. 635- 2- Pull and Splice Boxes - each.
Item No. 635- 3- Junction Boxes - each.

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SECTION 639
ELECTRICAL POWER SERVICE ASSEMBLIES

639-1 Description.

Power service assemblies are utilized for signals, lighting, ITS, and other roadway applications. Install electrical power service assemblies for either overhead service or underground service in accordance with the details shown in Standard Plans, Index 639-001 or 639-002.

Coordinate with the power company to provide electrical service to the locations shown in the Plans. Consult and cooperate with the power company when power is needed at the service point. Furnish and install only those parts of the metering equipment or connections that are required by the power company in the locality involved.

639-2 Definitions.

1. Overhead Service: A service assembly which is supplied electrical power from an overhead power company source. Include with an overhead electrical power service assembly the following components:
    a. Weatherhead
    b. Conduit
    c. Electrical Service wire
    d. Meter base (when required)
    e. Service disconnect
    f. Surge Protective Device
2. Underground Service: A service assembly which is supplied electrical power from an underground power company source. Include with an underground electrical power service assembly the following components:
    a. Conduit
    b. Electrical Service wire
    c. Meter base (when required)
    d. Service disconnect
    e. Surge Protective Device

639-3 Materials.

639-3.1 Weatherhead: Use a weatherhead made of a copper free aluminum alloy with three electrical service wire entrance holes, meeting National Electric Code (NEC) requirements.

639-3.2 Conduit: Use conduit meeting the requirements of Section 630. Meet the requirements of Section 562 for coating all field cut and threaded galvanized pipe.

639-3.3 Electrical Service Wire: For signal and ITS service points, use stranded copper wire with XHHW (cross-linked polyethylene (XLPE) high heat-resistant, water-resistant) insulation, rated at 600 V in dry and wet conditions, no smaller than No. 6 AWG for connections between service disconnect and traffic and ITS cabinets, unless otherwise shown in the Plans.

For lighting service points, use single-conductor cable Type THWN-2 no smaller than No. 6 AWG for connections between service disconnect and load center.

639-3.4 Meter Base: Use meter bases approved by the local electric power company.

639-3.5 Service Disconnect:

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639-3.5.1 Enclosure (Cabinet): Use an enclosure conforming to National Electrical Manufacturers Association (NEMA) Standards for Type 3R, Type 3S or Type 4, made of galvanized steel, aluminum, stainless steel or other materials approved by the Engineer. Ensure that the enclosure has a hinged door which can be locked with a padlock. Provide padlock and two keys. Do not use external handles or switches. Ensure that the inside dimensions meet NEC requirements.

639-3.5.2 Circuit Breaker: Use a manually resettable circuit breaker which has a current rating above the current rating of the circuit breaker to which electrical power is provided. Do not use less than a 40A circuit breaker.

639-3.6 Surge Protective Device: Use a lightning arrester rated for a maximum permissible line to ground voltage of 175 V_{AC}.

639-3.7 Electrical Power Transformer: Provide a dry type, air-cooled, factory assembled transformer. All units must be UL listed under the requirements of UL 5085 and UL 1561, IEEE Standard 259, and meet the requirements of NEMA ST-20. Provide transformers for the primary and secondary voltages indicated on the Plans. Provide two 2.5% full capacity below normal taps and two 2.5% above normal taps on the primary side. All taps are full capacity taps.

639-3.7.1 Enclosure: Use an enclosure conforming to NEMA Standards for Type 3R, made of hot-dip galvanized steel, aluminum, stainless steel or other materials approved by the Engineer.

639-3.7.2 Electrical Rating: Transformer electrical ratings may range from 3 KVA to 300 KVA, 120V to 600 V, single phase or three phase, primary or secondary, as shown in the plans.

639-3.7.3 Temperature classifications: Transformers rated less than 15 KVA shall utilize Class 180 or 185 insulation systems, with a 115°C or lower winding temperature rise. Transformers rated 15 KVA and greater shall utilize Class 220 insulation systems, with a 150°C or lower winding temperature rise. The transformer shall utilize an insulation system that has been properly temperature classified in accordance with NEMA ST-20.

Encapsulated transformers rated 15KV A to 25KV A using a Class 180 or 185 insulation system with a 115°C or lower winding temperature rise may be utilized if approved by the Engineer. Transformer windings shall be all aluminum or all copper.

639-3.7.4 Load rating: Furnish and install transformers with load ratings as described in the Plans. Transformers shall be capable of operating continuously at 100 percent of nameplate rating in an ambient temperature not exceeding 40°C. Transformers 5 KVA and above shall be capable of meeting overload requirements per ANSI C57.96 with normal life maintained.

639-3.7.5 Sound rating: Sound levels shall not exceed the following:

Table 639-1

Transformer Rating (KVA)	Average Sound Level Decibels per NEMA ST-20
0-9	40
10-50	45
51-150	50
150-300	55

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639-3.8 Attachment Hardware: Use attachment hardware that meets the requirements of Section 603.

639-4 Installation Requirements.

639-4.1 General: Meet the following requirements for the installation of individual components of the electrical power service assembly:

Use extreme care and caution in the installation of all components of the electrical power service assembly.

Follow installation procedures recommended by NEC and National Electrical Safety Code (NESC).

Consider the location of electrical power service assemblies as shown in the Plans to be approximate, and coordinate with the appropriate electrical power company authority to determine the exact locations of each assembly.

Do not use transformers or spliced electrical wire on a traffic signal power service.

639-4.2 Weatherhead: Securely attach the weatherhead to the upper end of the conduit which extends upward from the meter base (or service disconnect if a meter base is not required) to a minimum height of 22 feet above grade.

639-4.3 Conduit: Securely attach all conduit to the pole or cabinet with a maximum distance of 5 feet between conduit attachment hardware.

639-4.4 Electrical Service Wire: Install the electrical service wire in a manner which will ensure that damage to the installation will not occur.

Ensure that the service wire is of sufficient length after installation in the conduit to provide for attachment to the power company service and for termination within the cabinet for which power is required.

Use waterproof gel-filled splices to splice electrical wires in pull boxes only when the length of the cable run prohibits use of continuous wire. Wire nuts and electrical tape splicing are not acceptable.

639-4.5 Meter Base: When a meter base is required, securely fasten the meter base to the pole or cabinet. Install pole mounted meter bases at a minimum height of 5-1/2 feet above grade when measured from the center of the meter base or meet the local electric power company requirement, whichever is greater.

639-4.6 Service Disconnect: Securely fasten the service disconnect to the pole (or cabinet with the Engineers approval), and electrically position the service disconnect between the service meter and the traffic control device cabinet to which electrical service is being supplied. Install pole mounted service disconnects a minimum of 4 feet above grade when measured from the bottom of the disconnect. For cabinet installations, mount the service disconnect at a height approved by the Engineer or as shown in the Plans.

639-4.7 Electrical Power Transformer: Follow installation procedures recommended by NEMA ST-20, National Electric Code (NEC), and National Electrical Safety Code (NESC). Set the ground mount transformer unit level on the pad and secured to the pad with bolts. Pole mount transformers are required to be fastened securely to the pole using bolts, stainless steel straps, or galvanized strut channel.

Conduct field acceptance testing in accordance with Section 611. Perform local field inspection at each site to verify and confirm the following:

1. Check wiring connections for damage and torque, as applicable, prior to energizing the transformer.

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2. Check grounding and bonding of transformer enclosure. Ensure that separately derived systems, which are required to be grounded by the NEC 250.30 or the Plans, are fitted with an appropriately installed and sized system bonding jumper in accordance with the NEC 250.30.

3. Measure primary and secondary voltages under normal load conditions.

639-5 Method of Measurement.

639-5.1 General: Measurement for payment will be in accordance with the following work tasks.

Payment for electrical service wire between service disconnect and traffic cabinet is based upon the distance of the cable run and includes payment for all conductors used in the run. For lighting applications, payment for service conductors will be made in accordance with Section 715.

Payment for conduit and electrical service wire which is vertically attached to the electrical power assembly is considered incidental and paid under item 639-1.

639-5.2 Furnish and Install: The Contract unit price per foot of electrical service wire, or the Contract unit price each for electrical service disconnect, furnished and installed, will include furnishing all materials and hardware as specified in the Contract Documents, and all labor, equipment, and miscellaneous materials necessary for a complete and accepted installation.

639-5.3 Furnish: The Contract unit price per foot of electrical service wire, or the Contract unit price each, for electrical service disconnect, furnished, will include the cost of the required materials and hardware as specified in the Contract Documents, plus all shipping and handling costs involved in delivery as specified in the Contract Documents.

639-5.4 Install: The Contract unit price per foot of electrical service wire, or the Contract unit price each, for electrical service disconnect, installed, will include all labor, equipment, and miscellaneous materials necessary for a complete and accepted installation. The Engineer will supply electrical service wire or electrical service disconnect.

639-5.5 Electrical Power Service: The Contract unit price per assembly for electrical power service will include furnishing and installing all material and hardware as specified in the Contract Documents, and all labor and equipment necessary to make a complete and accepted installation.

639-5.6 Electrical Power Transformer: The Contract unit price for each Electrical Power Transformer will include furnishing, installing, and testing all materials and hardware as specified in the Contract Documents, and all labor, equipment, and miscellaneous materials necessary for a complete and accepted installation.

639-6 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 639-	1-	Electrical Power Service - per assembly.
Item No. 639-	2-	Electrical Service Wire - per foot.
Item No. 639-	3-	Electrical Service Disconnect - each.
Item No. 639-	6-	Electrical Power Transformer - each.

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SECTION 641
PRESTRESSED CONCRETE POLES

641-1 Description.

Furnish and install prestressed concrete poles as shown in the Plans.

Obtain precast, prestressed concrete poles from a manufacturing plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.

Ensure that each pole is constructed and permanently and legibly marked in accordance with Standard Plans, Index 641-010, including the date cast. Concrete closed circuit television (CCTV) poles must be constructed and permanently and legibly marked in accordance with Standard Plans, Index 641-020, unless shown otherwise in the Plans. The marking shall be visible after installation.

Ensure that the shipment of the products to the job site meets the requirements of 450-16.3 and Section 105.

641-2 Materials.

641-2.1 Poles: Meet the following requirements:

Portland Cement Concrete*	Section 346
Reinforcing Steel	931-1
Prestressed Strands	933-1
Spiral Reinforcing	ASTM A1064

* Class VI

641-2.2 Camera Lowering Device: Use lowering devices that meet the requirements of Section 996 and are listed on the Department's Approved Product List (APL).

641-2.2.1 Connector Block: Lubricate all components, including the connector block and contacts, in accordance with the manufacturer's recommendations.

641-2.2.2 Lowering Tool: Provide a minimum of one lowering tool and any additional tools as required in the Plans. Deliver the lowering tool to the Department before final acceptance.

641-2.2.3 Wiring: All wiring must meet NEC requirements and be installed in accordance with the equipment manufacturers' recommendations for each device connected on the pole, at the lowering device, and in the field cabinet.

641-2.2.4 External-Mount Lowering System Enclosure for Mounting to Existing Structures: The cabinet must allow for unobstructed operation of the winch, access for servicing and provide sufficient clear area for operation of the winch manually and with an electric drill. Include a pin tumbler lock keyed for use with a No. 2 key and two keys, unless otherwise directed by the Plans. Provide all necessary mounting hardware, conduits, standoffs, and conduit mounts required for a complete and functional system.

641-3 Concrete Pole Construction.

Construct concrete poles in accordance with Section 450. Assume responsibility for performance of all quality control testing and inspections required by Sections 346 and 450; however, the PCI personnel certifications are not required. Plant certification, in accordance with Section 105, is not required for plants that manufacture prestressed concrete poles.

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641-4 Installation Requirements.

641-4.1 General: Furnish poles of the type and length shown in the Plans. Provide catenary cable of the size shown in the Plans. Ground poles in accordance with Section 620. Install span wire assemblies in accordance with Section 634.

Do not consider the poles acceptable for use if the camber of the pole, measured as the maximum deviation between the centerline of the pole and a straight line connecting the centroids of the cross-sections at each end of the pole, is greater than the total pole length in inches divided by 140.

641-4.2 Foundations: Provide foundations 3 feet 6 inches in diameter and of the depth specified in the Plans for strain poles used for span wire support of traffic signals. Provide foundations for concrete CCTV poles in accordance with Standard Plans, Index 641-020. Provide foundations for all other pole applications as specified in the Plans. Construct the foundation with concrete as specified in Section 347.

For the excavation and backfill of the foundation, meet the requirements specified in 125-4 and 125-8.2 with the exception of the backfill density. In lieu of the requirements for obtaining the specified density, the Contractor may hand tamp the backfill in 4 inch maximum layers or machine tamp the backfill in 6 inch maximum layers. When performing such operations, ensure that the material is neither dry nor saturated. The Contractor may backfill with concrete.

Use forms, when required, meeting the requirements of 400-5. If the foundation is cast in an oversize hole, place the concrete in the top 6 inches in a form. Trowel all exposed surfaces to a smooth finish.

641-4.3 Orientation of Poles: For poles supporting one catenary wire, orient the pole so that the load face is perpendicular to the catenary wire. For poles supporting two catenary wires, orient the pole so that the load face is perpendicular to a line bisecting the angle between the two catenary wires.

Rake pole back from the span wire as necessary to achieve a final rake of 1/2 inch per foot, plus or minus 1/4 inch.

641-4.4 Camera Lowering Device: Install the lowering device in a manner that does not place the operator directly under the device when it is being raised or lowered. Submit documentation showing connector block pin assignment for approval prior to installation.

The divided support arm and receiver brackets must self-align the contact unit with the pole centerline during installation. Additionally, the lowering device support arm must self-align the disconnect unit and attached device with the pole centerline and remain centered after installation, without moving or twisting.

House the stainless steel lowering cable inside 1.25 inch PVC conduit and provide a conduit mount adapter for the interface between the conduit and the internal back side of the lowering device.

The connection between the lowering device and tenon must be weather resistant. Use conduit straps to secure lowering cable conduit to the pole for externally mounted lowering systems. Stainless steel bands will not be allowed. Ensure that only the lowering cable is in motion inside the pole when the lowering device is operated. All other cables must remain stable and secure during lowering and raising operations. Label all wire leads with their function, label spares as spares. Install the correct length of lowering cable to prevent cable slack and to prevent the cable from jumping off the winch spool. The lowering cable strands must not twist or unwind when the lowering device is operated.

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Ensure that crimps and other cable connection hardware associated with the lowering cable do not come in direct contact with the winch tool or guides when operating the system.

Furnish the Engineer with the manufacturer recommended field installation instructions, inspection instructions (including recommended schedules and procedures), and operating instructions.

641-5 Pole Removal.

When removal of the pole and partial foundation removal is specified in the Plans, the remaining pole, foundation and any protrusions, such as pole keys, dead men, guying apparatus, conduit, anchor bolts, or reinforcing steel, must be removed to a minimum depth of 4 feet below existing grade.

When removal of the pole and complete foundation removal is specified in the Plans completely remove each pole including the foundation and all accessories and attachments, such as pole keys, dead men, guying apparatus, conduit, anchor bolts, and reinforcing steel.

Disconnect span wires carefully at the pole, and salvage all usable hardware and attachment devices as determined by the Engineer. Remove all devices supported by the span wire (including wiring) prior to the removal of the span wire.

641-6 Method of Measurement.

641-6.1 General: Measurement for payment will be in accordance with the following work tasks.

641-6.2 Furnish and Install: The Contract unit price for prestressed concrete poles, furnish and install, will consist of the pole plus all labor, concrete for the foundation and other materials necessary for a complete and accepted installation as specified in the Contract Documents.

641-6.3 Pole Removal:

641-6.3.1 Pole Removal Partial: The quantity to be paid for will be the removal of each pole, including the foundation and all accessories and attachments, to a depth of not less than 4 feet below existing grade.

641-6.3.2 Pole Removal Complete: The quantity to be paid for will be the complete removal of the pole, foundation and all accessories and attachments.

641-7 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 641-	Prestressed Concrete Poles - each.
Item No. 641-	Concrete CCTV Pole - each.

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SECTION 646
ALUMINUM POLES, PEDESTALS, AND POSTS

646-1 Description.

The work in this Section consists of furnishing and installing aluminum poles, pedestals, and posts at the locations shown in the Plans and in accordance with the details shown in the Plans and Standard Plans, subject to a five-year warranty period as defined herein. The warranty period will apply only when aluminum poles, pedestals, and posts are painted as called for in the Contract Documents. An aluminum pedestal consists of a pole and a transformer base.

646-2 Materials.

Meet the following requirements:

Portland Cement Concrete* .....Section 346
Anchor Bolts and Shims .....Section 962
Poles and Posts.....Section 965
Transformer Base**.....Section 965
*Class II
**Use products listed on the Department's Approved Products List (APL)

646-2.1 Poles and Posts: Poles used with transformer bases must be threaded with No. 8 NPT threads. Sufficient threads are required to fully seat the pole into the hub of the pedestal base.

646-2.2 Anchor Bolts: Provide Grade 55 anchor bolts, 3/4-inch diameter, 18-inches long, with double nuts. For each bolt, provide two 3/4-inch heavy hex nuts and one 3/16-inch thick by 3-inch round plate washer or one Type 1 washer.

646-2.3 End Caps: Provide end caps sized for nominal 4-inch Schedule 40 4-1/2-inch outside diameter aluminum poles. The cap must be a minimum of 1/4-inch thick and tapped for at least two set screws. Set screws will be provided with the end cap.

646-2.4 Shims: Provide U-shaped galvanized steel shims 2-inches wide by 2-1/2 inches long, shaped to fit around a 3/4-inch anchor bolt.

646-3 Coatings.

646-3.1 Painting:

646-3.1.1 General: When required by the Contract Documents, provide painted aluminum poles, pedestals, and posts. Provide products that will meet specification requirements throughout the warranty period. Meet the color requirement as specified in the Contract Documents. Provide the Engineer with two metal sample coupons, a minimum of 2 inches by 4 inches, painted concurrently and with the same paint as was used on the first LOT of any aluminum poles, pedestals, and posts delivered to the jobsite. Submit sample coupons and manufacturer product data sheets to the Engineer along with the delivery of the first shipment of any painted aluminum poles, pedestals, and posts delivered to the jobsite. At the time of their delivery, the sample coupons described in this paragraph must match the color of the aluminum poles, pedestals, and posts to within 1ΔE measured as specified in 975-4. If the delivered sample coupons exhibit a difference in color from the poles, pedestals, and posts greater than 1ΔE then the sample coupons will be considered unacceptable and no payment shall be made for the materials which the sample coupons represent. Those materials shall not be accepted by the Department until acceptable representative sample coupons in accordance with the requirements of this Section have been submitted to the Engineer.

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646-3.1.2 Responsible Party Warranty: When the Contract Documents call for painted aluminum poles, pedestals, and posts, the Contractor shall designate a responsible party to accept responsibility. The responsible party designated by the Contractor must execute and submit to the Department a form, provided by the Department, prior to the first delivery to the jobsite of any painted aluminum poles, pedestals, and posts, stipulating that the responsible party accepts responsibility for ensuring the coating system adhesion and color retention requirements as specified in 975-4 are met for a period of five years after final acceptance in accordance with 5-11. The responsible party shall also bear the continued responsibility for performing all remedial work associated with repairs of any adhesion or color retention failure as defined in Section 975, as to which notice was provided to the responsible party within the five year warranty period. Failure to timely designate the responsible party will result in the Contractor being the responsible party unless otherwise agreed to in writing by the Department. The responsible party shall be either the Contractor or the supplier of the painted aluminum poles, pedestals, and posts. When the responsible party is the fabricator, the responsible party shall be one of the fabricators listed on the Prequalified Painted Galvanized Steel and Aluminum Products Fabricators List. This list may be viewed on the Department's website at the following URL: https://www.fdot.gov/construction/Engineers/PaintedPoleSuppliers.shtm.

Upon final acceptance of the Contract in accordance with 5-11, the Contractor's responsibility to ensure that the coating system adhesion and color retention requirements specified in 975-4 will terminate. The obligations of the responsible party set forth in this Section shall start at final acceptance of the Contract in accordance with 5-11 and continue thereafter until expiration of the five-year warranty period.

646-4 Remedial Work.

During the painting warranty period, the responsible party shall perform all painting remedial work necessary to meet the requirements of this Specification at no cost to the Department. Such remedial work shall be performed within 180 days of notification of a failure by the Department or by the determination of the Statewide Disputes Review Board. Failure to perform such remedial work within the time frame specified will result in the work being performed by other forces at the responsible party's cost.

If the responsible party is the fabricator, the fabricator will be removed from the Prequalified Painted Galvanized Steel and Aluminum Products Fabricators List for a minimum of six months or until payment in full for the correction of the deficiencies or defects has been made, whichever is longer.

If the responsible party is the Contractor, the Department will suspend, revoke, or deny the responsible party's certificate of qualification under the terms of Section 337.16(d)(2), Florida Statutes, for a minimum of six months or until payment in full for the correction of the deficiencies or defects has been made, whichever is longer.

646-5 Statewide Disputes Review Board.

The Statewide Disputes Review Board in effect for this Contract will resolve any and all disputes that may arise involving administration and enforcement of this Specification related to the painting remedial work performed during the warranty period. The Responsible Party and the Department acknowledge that use of the Statewide Disputes Review Board is required, and the determinations of the Statewide Disputes Review Board for disputes arising out of this Specification will be binding on both the Responsible Party and the Department, with no right of appeal by either party. Meet the requirements of 8-3.

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646-6 Installation.

646-6.1 General: Verify the length of the column supports in the field prior to fabrication to permit the appropriate sign or signal height.

646-6.2 Foundations: Construct foundations in accordance with the applicable Standard Plans.

The Contractor may use precast foundations in augered or excavated holes that are a minimum of 12 inches larger than each axis dimension of the precast foundation. The holes must be clean and without loose material. Obtain precast foundations from a manufacturing plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105. Fill the voids around precast foundations with flowable fill meeting the requirements of Section 121 or clean sand placed using hydraulic methods to a level of 6 inches below grade.

646-6.3 Setting Anchor Bolts: Set anchor bolts 90 degrees apart with a bolt circle diameter of 14 inches. Adjust anchor bolts to a plumb line and hold rigidly in position to prevent displacement while pouring concrete.

646-6.4 Installation: Do not erect poles until the concrete strength is at least 2500 psi. Plumb the poles after erection using shims if necessary to obtain precise alignment.

646-6.5 Grounding: Meet the requirements of Section 620 and the applicable Standard Plans.

646-7 Method of Measurement.

The Contract unit price per each for aluminum pedestals and posts, furnished and installed, will include all materials and equipment as specified in the Contract Documents, and all labor and materials necessary for a complete and accepted installation.

Payment for removal of aluminum poles will include the complete removal of the pole and foundation, pedestrian detector and pedestrian signal. Separate payment for the removal of the pedestrian detector and pedestrian signal will be made only when the pole/pedestal is to remain.

Payment for grounding will be incidental to the pedestal or post.

646-8 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 646- Aluminum Poles - per each.

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SECTION 649
GALVANIZED STEEL POLES, MAST ARMS, AND MONOTUBE ASSEMBLIES

649-1 Description.

The work in this Section consists of furnishing and installing galvanized steel strain poles, galvanized steel mast arms, galvanized steel monotube assemblies, and galvanized steel CCTV poles in accordance with the details shown in the Contract Documents, subject to a five year warranty period as defined herein. The warranty period will apply only when poles, mast arms or steel monotube assemblies are painted as called for in the Contract Documents.

649-2 Materials.

649-2.1 Pole Assembly: Use pole assemblies as shown in the Standard Plans when standard mast arm assemblies, standard strain pole assemblies, or standard steel CCTV pole assemblies are required by the Contract Documents.

Obtain poles, assemblies from a fabrication facility that is listed on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.

Obtain poles and mast arms from a fabrication facility that is approved in one of the following fabrication categories:

1. American Institute of Steel Construction, Highway Component Manufacturer
2. American Welding Society, Certified Welding Fabricator
3. Canadian Welding Bureau, Fusion Welding of Aluminum (W47.2)

Use coating products meeting the requirements of Section 975.

Use grouts meeting the requirements of Section 934 and listed on the Department's Approved Product List (APL).

Use water meeting the requirements of Section 923.

Use membrane curing compounds meeting the requirements of Section 925.

649-2.2 Camera Lowering Device: Meet the requirements of 641-2.2.

649-3 Fabrication.

Fabricate poles, mast arm, and monotube assemblies and miscellaneous hardware in accordance with the Contract Documents. Cut all materials to the final dimensions and complete all welding prior to galvanizing. Obtain all components for individual strain poles, mast arm and monotube assemblies from the same fabricator. Obtain the luminaire and bracket from other sources, when necessary.

All welds must be visually inspected for final approval by an actively certified welding inspector, qualified through the American Welding Society. A certifying statement from the welding inspector must be provided with the components. The document must identify the project information, date of inspection, welding inspector name, and inspector certification number.

Affix an aluminum identification tag which will be visible from the handhole or located inside the terminal box containing the information described in the Standard Plans.

Before shipping, assemble monotube assemblies to assure proper fit. Monotube assemblies may be separated for shipment.

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For mast arms, use adequate manufacturing controls to assure proper fit, ensuring dimensional tolerances are met and that mast arm to pole connections can achieve a snug-tight condition as defined in 649-7.

Ensure all components are protected from damage during shipping and handling by wrapping or other effective methods. Replace any component, which the Engineer determines is damaged beyond repair, at no additional cost to the Department. If components are wrapped for shipment, remove wrappings no later than five days after receipt of components or immediately if the wrappings become saturated. Post these instructions in brightly colored wording on the wrapper. Failure to comply with these instructions may lead to damage of the coating system and will be cause for the rejection of the component.

649-4 Coatings.

649-4.1 Galvanizing: Galvanize all components in accordance with ASTM A123, except galvanize all fastener assemblies in accordance with Section 962. Use galvanizing methods which provide surfaces suitable for painting.

649-4.2 Surface Preparation: Prepare all galvanized surfaces to be painted in accordance with ASTM D6386 and the manufacturer of the coating system's specifications. Provide a clean and suitable galvanized surface that maximizes coating system adhesion.

Measure the thickness of the zinc coating after completion of surface preparation using a magnetic thickness gage in accordance with ASTM A123. Ensure sufficient galvanizing remains on the substrate to meet the requirements of ASTM A123 and the Contract Documents. Correct any deficient areas to the satisfaction of the Engineer at no additional cost to the Department.

649-4.3 Painting:

649-4.3.1 General: When required by the Contract Documents, provide painted poles, mast arms and monotube assemblies. Provide products from a fabricator on the Department's list of Prequalified Painted Galvanized Steel and Aluminum Products Fabricators List. Provide products that will meet specification requirements throughout the warranty period. Meet the color requirement as specified in the Contract Documents. Provide the Engineer with two metal sample coupons, a minimum of 2 inches by 4 inches, painted concurrently and with the same paint as was used on the first LOT of any poles, mast arms and monotube assemblies delivered to the jobsite. Submit sample coupons and manufacturer product data sheets to the Engineer along with the delivery of the first shipment of any painted poles, mast arms or monotube assemblies delivered to the jobsite. At the time of their delivery, the sample coupons described in this paragraph shall match the color of the poles, mast arms and monotube assemblies to within 1ΔE when measured as specified in 975-4. The Engineer will perform a visual color comparison between the delivered products and sample coupons. The Engineer may evaluate and document any color difference by measuring as specified in 975-4. If the delivered sample coupons exhibit a difference in color from the poles, mast arms and monotube assemblies greater than 1ΔE then the sample coupons will be considered unacceptable and no payment shall be made for the materials which the sample coupons represent. Those materials shall not be accepted by the Department until acceptable representative sample coupons in accordance with the requirements of this Section have been submitted to the Engineer.

649-4.3.2 Responsible Party Warranty: When the Contract Documents call for painted galvanized steel poles, mast arms or monotube assemblies, the Contractor shall designate a responsible party to accept responsibility. The responsible party designated by the Contractor must execute and submit to the Department a form, provided by the Department, prior to the first

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delivery to the jobsite of any painted poles, mast arms or monotube assemblies, stipulating that the responsible party accepts responsibility for ensuring the coating system adhesion and color retention requirements as specified in 975-4 are met for a period of five years after final acceptance in accordance with 5-11. The responsible party shall also bear the continued responsibility for performing all remedial work associated with repairs of any adhesion or color retention failure as defined in Section 975, as to which notice was provided to the responsible party within the five-year warranty period. Failure to timely designate the responsible party will result in the Contractor being the responsible party unless otherwise agreed to in writing by the Department. The responsible party shall be either the Contractor or the fabricator. When the responsible party is the fabricator, the responsible party shall be one of the fabricators listed on the Prequalified Painted Galvanized Steel and Aluminum Products Fabricators List. This list may be viewed on the Department's website at the following URL:
https://www.fdot.gov/construction/Engineers/PaintedPoleSuppliers.shtm

Upon final acceptance of the Contract in accordance with 5-11, the Contractor's responsibility to ensure that the coating system adhesion and color retention requirements specified in 975-4 will terminate. The obligations of the responsible party set forth in this Section shall start at final acceptance of the Contract in accordance with 5-11 and continue thereafter until expiration of the five-year warranty period.

649-5 Remedial Work.

During the painting warranty period, the responsible party shall perform all painting remedial work necessary to meet the requirements of this Specification at no cost to the Department. Such remedial work shall be performed within 180 days of notification of a failure by the Department or by the determination of the Statewide Disputes Review Board. Failure to perform such remedial work within the time frame specified will result in the work being performed by other forces at the responsible party's cost.

If the responsible party is the fabricator, the fabricator will be removed from the Prequalified Painted Galvanized Steel Poles and Aluminum Products Fabricators List for a minimum of six months or until payment in full for the correction of the deficiencies or defects has been made, whichever is longer.

If the responsible party is the Contractor, the Department will suspend, revoke, or deny the responsible party's certificate of qualification under the terms of Section 337.16(d)(2), Florida Statutes, for a minimum of six months or until payment in full for the correction of the deficiencies or defects has been made, whichever is longer.

649-6 Statewide Disputes Review Board.

The Statewide Disputes Review Board in effect for this Contract will resolve any and all disputes that may arise involving administration and enforcement of this Specification related to the painting remedial work performed during the warranty period. The Responsible Party and the Department acknowledge that use of the Statewide Disputes Review Board is required, and the determinations of the Statewide Disputes Review Board for disputes arising out of this Specification will be binding on both the Responsible Party and the Department, with no right of appeal by either party. Meet the requirements of 8-3.

649-7 Installation.

Install foundations in accordance with Section 455. Do not install poles, mast arm poles, or monotubes until the foundation has achieved 70% of the specified 28-day concrete strength

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and verifying test results have been submitted to the Engineer. Determine concrete strength from tests on a minimum of two test cylinders prepared and tested in accordance with ASTM C31 and ASTM C39. Before erecting the pole, clean the top of the foundation of any laitance, oils, grease or any other deleterious materials. Erect strain poles in an orientation which considering the rake and the application, cable forces will produce a plumb pole. Erect monotubes plumb at the time of installation. Plumb the pole supporting mast arms after the mast arms, traffic signals or sign panels have been placed.

If the traffic signals and/or sign panels are not in place within two working days after the mast arm is erected, furnish and install a 3 foot x 2 foot blank sign panel on the bottom of each mast arm within 6 feet of the mast arm tip and plumb the pole. Re-plumb the pole supporting mast arms after installation of traffic signals and sign panels.

Install ASTM F3125, Grade A325 bolt, nut, and washer assemblies in accordance with the following. Use bolt, nut and washer assemblies that are free of rust and corrosion and are lubricated properly as demonstrated by being able to easily hand turn the nut on the bolt thread for its entire length. Tighten nuts to a snug-tight condition to bring the faying surfaces of the assembly into firm contact with plies solidly seated against each other, but not necessarily in continuous contact. Snug-tight is defined as the maximum nut rotation resulting from the full effort of a person using an ordinary spud wrench. Visually inspect the connection after snugging all bolts, ensuring firm contact has been achieved at a minimum between faying surfaces beneath bolts within one bolt diameter of bolt hole edges. Re-snug bolts in a connection where faying surfaces are not in firm contact. After bringing the faying surfaces to a snug-tight condition, tighten nuts in accordance with Table 460-7, Nut Rotation from the Snug-Tight Condition. Maintain as close to uniform contact pressure as possible on the faying surfaces during snugging and turn-of-nut process by utilizing suitable erection methods and a bolt tightening pattern that balances the clamping force of each bolt, as closely as possible, with the equal clamping force of a companion bolt.

For this Specification, the retainer nuts (half-height or full-height) are installed on top of the plate washers and below the anchor nuts (full-height). Base plate installation steps are as follows:

1. Clean and lubricate the exposed threads of all anchor bolts. Clean and lubricate the threads and bearing surfaces of all leveling nuts. Re-lubricate the exposed threads of the anchor bolts and the threads of the leveling nuts if more than 24 hours have elapsed since earlier lubrication, or if the anchor bolts and leveling nuts have become wet since they were first lubricated.

2. Verify that the nuts can be turned onto the bolts past the elevation corresponding to the bottom of each in-place leveling nut and be backed off by the effort of a person using an ordinary spud wrench, without employing a pipe extension on the wrench handle.

3. Turn the leveling nuts onto the anchor bolts and align the nuts to the same elevation less than or equal to one bolt diameter from the top of the foundation.

4. Place structural plate washers on top of the leveling nuts; one washer corresponding to each anchor bolt.

5. Install the base plate onto the leveling nut washers, place structural plate washers on top of the base plate; one washer corresponding to each anchor bolt and turn retainer nuts onto the anchor bolts.

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6. Tighten retainer nuts against the top of the base plate to a snug-tight condition in a star pattern. A star tightening pattern is one in which the nuts on opposite or near opposite sides of the bolt circle are successively tightened in a pattern resembling a star. For an 8 bolt circle with bolts sequentially numbered 1 to 8, tighten nuts in the following bolt order: (1, 5, 7, 3, 8, 4, 6, 2).

7. Tighten leveling nuts to a snug-tight condition in a star pattern. The distance from the bottom of the leveling nuts to the top of the concrete must not exceed one anchor bolt diameter after tightening.

8. Turn anchor nuts onto the anchor bolts and tighten each until it is in firm contact with the top surface of the retainer nut; then while preventing the retainer nut from rotating, tighten the anchor nut until it is snug-tight using a star pattern. Before final tightening of the anchor nuts, mark the reference position of each snug-tight retainer nut on one flat with a corresponding reference mark on the anchor nut and base plate on each bolt. Assure the retainer nut stays in this final position. Then while preventing the retainer nut from rotating, incrementally turn the anchor nuts using a star pattern until achieving the required nut rotation specified in Table 649-1. Turn the anchor nuts at least two full tightening cycles (passes). After tightening, verify the anchor nut rotation with respect to the retainer nut and verify the retainer nut has not rotated from its snug-tight condition with respect to the plate washer and base plate. Do not exceed the Table 649-1 value by more than 20 degrees. The final condition is a retaining nut that is snug-tight with respect to the plate washer, and an anchor nut that is rotated with respect to the reference mark on the retaining nut, plate washer, and base plate in accordance with Table 649-1.

9. Install a screen over the gap between the base plate and foundation concrete in accordance with 649-8, or place a structural grout pad in accordance with 649-9.

Table 649-1	
Anchor Bolt Diameter (inches)	Nut Rotation from Snug-Tight Condition
≤ 1-1/2	1/3 turn
> 1-1/2	1/6 turn

649-7.1 Camera Lowering Device Installation: Meet the requirements of 641-4.4.

649-8 Screen Installation.

On steel strain poles and steel monotube assemblies, install a screen that will prevent vermin and debris from entering the gap between the bottom of the base plate and the top of the concrete foundation. Cover the entire gap with a wire screen, the bottom horizontal wire of which shall be in full contact with the surface of the concrete foundation and the top horizontal wire of which shall not extend beyond the top surface of the base plate. For the screen, use standard grade plain weave galvanized steel wire cloth with 1/2 inch x 1/2 inch mesh and 0.063 inch diameter wires. Vertical screen wires shall not extend beyond the top and bottom horizontal wires of the screen. Use one continuous section of screen with only one overlapping splice where the ends come together and overlap the layers 3 inches minimum. Attach the screen to the vertical side of the base plate with self-tapping stainless steel screws (No. 8, 1/2 inch long) with stainless steel washers (1/4 inch inside diameter). Drill pilot holes into the base plate to facilitate screw installation. Install screws on 9 inch centers maximum and at least one screw shall be installed through the overlapping splice to clamp the layers together. Also clamp the

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overlapping splice layers together just above the concrete foundation with an all stainless steel fastener assembly consisting of a machine screw (No. 8, 5/8 inch long), nut and two flat washers (1/4 inch inside diameter) and lock washer. Tightly clamp the screen layers between the flat washers.

649-9 Structural Grout Pads.

On mast arm support structures, install a structural grout pad in accordance with the Standard Plans and manufacturer's instructions. Prior to grout placement, flush the top of the foundation with water to remove any dirt and debris.

Mix grout to a fluid state in accordance with the manufacturer's recommendations. Test the grout fluidity using ASTM C939 Flow Cone Method. Discard any grout with an unacceptable efflux time.

Do not use mechanical means to push or vibrate the grout. Clean any excess grout from the base plate. Verify that water inside the pole will drain freely through the installed drain hole.

649-10 Method of Measurement.

The Contract unit price each for poles, mast arms, and monotube assemblies, furnished and installed, will include all materials specified in the Contract Documents, including the foundation, cover plates, caps, clamps, blank sign panel, luminaire bracket, all labor, equipment, miscellaneous materials and hardware necessary for a complete and acceptable installation.

The Contract unit price for removal of poles, mast arms, and monotube assemblies will include the removal of all attachments (arms, vehicle signals, light fixtures, pedestrian signals, pedestrian detectors and other incidentals).

When removal of the pole and partial foundation removal is called for, remove the pole, foundation, and all accessories or attachments (including pole keys, dead men, guying apparatus, conduit, anchor bolts and reinforcing steel) to a minimum depth of four feet below existing grade.

When removal of the pole and complete foundation removal is called for, completely remove the pole including the foundation and all accessories or attachments as listed above.

649-11 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section. Sign panels and signal assemblies will be paid for separately.

Payment will be made under:

Item No. 649-	Steel Mast Arm Assembly - each.
Item No. 649-	Steel Monotube Assembly - each.
Item No. 649-	Steel Strain Pole - each.
Item No. 649-	Steel CCTV Pole - each.

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SECTION 650
VEHICULAR TRAFFIC SIGNAL ASSEMBLIES

650-1 Description.

Furnish and install vehicular traffic signal assemblies as shown in the Plans and Standard Plans. For additional requirements related to mounting and attaching the assemblies, see Section 659.

650-2 Materials.

Use vehicular signal assemblies that meet the requirements of Section 995 and are listed on the Department's Approved Product List (APL). Vehicular traffic signal assemblies must meet the requirements of Section 603 and the Institute of Transportation Engineers (ITE) Standard for Vehicle Traffic Control Signal Heads.

Provide vehicular traffic signal assemblies as a complete and functioning unit. Components include, but are not limited to, signal housing, light emitting diode (LED) signal modules, visors, backplates, and assembly hardware.

All sections of multi-section assemblies must be from the same manufacturer.

650-3 Installation.

650-3.1 Preassembly: Pre-assemble the signal heads when more than one signal section is required prior to installation at the site. Furnish signal heads with LED modules, backplates, and visors. Use tunnel visors unless otherwise specified in the Contract Documents. Install the LED circular module in the door so that the UP arrow or the word UP or TOP is in the up orientation of the signal housing. Install the LED arrow modules in the signal housing door in the direction of the intended use.

650-3.2 Positioning of Signals: Consider the locations of the installed signals as shown in the Plans as sufficiently flexible as to allow for unanticipated field conditions at the site. The Engineer will direct any variations from the locations shown. Position adjacent signal faces no closer than 8 feet apart measured horizontally at 90 degrees to the traffic flow between centers of faces.

Regardless of the results of any scaled dimensions, consider the location shown in the Plans to be approximate. Position a signal face mounted on a span wire or mast arm as near as practical to the line of the driver's normal view.

Ensure that all sections are of the same manufacturer and the section assemblies are uniform in appearance and alignment.

650-3.3 Clearances: Unless directed otherwise by the Engineer for unusual circumstances at the site, provide a vertical clearance of not less than 17 feet-6 inches and not more than 19 feet for traffic signals placed over the roadway. Measure such clearance for each span directly under the most critical signal assembly (in regards to clearance) for that span. Place signal assemblies on each span as near as practical to the same elevation as the critical signal assembly.

Ensure that the lowest point on pedestal-mounted and side-mounted signal heads is 12 feet above finished grade at the point of their installation.

650-3.4 Aiming of Signal Indication: For proper lateral orientation, aim signals after installing and before locking them in position.

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650-3.5 Wiring Connections: Do not splice signal cable. Connect the proper signal cable to the terminals in each signal head in order to provide the proper signal indication display when the cables are connected to the signal controller. Wire a separate neutral circuit and return it to the controller cabinet from each vehicular movement as shown in the Contract Documents.

650-3.6 Special Installation Requirements for Optically Programmed Signals: Install, direct (aim), and conceal optically programmed signals in strict accordance with the instructions of the manufacturer, using the materials furnished by the signal manufacturer, and with the direction of the Engineer.

Position the signals for maximum performance in accordance with the requirements shown in the Plans, and install them with rigid mounting assemblies, using elbows and plumbizers of such type as will provide for stability of the position of the signals. Do not use clevises in the supporting attachments.

Seal the cable routing to the signals to provide permanent water tightness.

650-3.7 Vertically Mounted Plastic Signal Head Assemblies: The top section of all multi-section (5-section, 3-section), vertically mounted, plastic signal assemblies must be constructed of die cast aluminum, unless the entire 3 (or more)-section plastic signal assembly is specifically approved and listed on the APL as a 12 inch plastic 3 (or more)-section vehicle assembly.

Single section signals may be constructed of die cast aluminum or plastic.

650-3.8 Backplates: Install backplates on all signal head assemblies.

650-3.9 Sealing Installed Signal Head Assembly: Ensure that the installed signal head assembly is sealed to exclude dust and moisture. Drill two, 1/4 inch drain holes in the bottom of the installed signal head assembly.

650-3.10 Concealing Signals Not in Use: Where traffic signals are installed and not put into service immediately, or placed out-of-service temporarily, conceal the signal head assembly by securely placing burlap bags or other covering approved by the Engineer over a weather resistant covering of non-transparent material open at the bottom to prevent condensation buildup.

650-3.11 Installation Sequence: Install all traffic signal assemblies at any intersection as a single operation unless a staged operation is approved by the Engineer.

650-3.12 Emergency Signal Heads: For new emergency fire stations signals, install 12 inch signal heads for all three indications. For existing 8 inch emergency fire station signals, retrofit with 8 inch LED modules. The 8 inch LED optical unit must conform to the requirements of the ITE's Performance Specification, Vehicle Traffic Control Signal Heads - Light Emitting Diode (LED) Circular Signal Supplement, dated June 27, 2005.

650-3.13 Transit Signal Heads: For transit signal priority at signalized intersections with bus queue jumper lanes, install 12 inch two-lens signal head assembly per the MUTCD, Figure 8C-3. The 12 inch LED optical unit indications must comply with the MUTCD, Section 8C.11 and as illustrated in Figure 8C-3. The 12 inch LED optical unit must conform to the requirements of the ITE's Performance Specification, Vehicle Traffic Control Signal Heads-Light Emitting Diode (LED) Circular Signal Supplement, dated June 27, 2005, regarding environmental requirements, transient protection, operating voltage range, and electronic noise. The indication (bar symbol) must measure 1-1/2 inches wide by 9 inches long. The indication must be capable of being displayed in any angle of orientation from horizontal to vertical.

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650-4 Warranty.

Ensure that the signal housings, backplates, and any other signal assembly components have a manufacturer's warranty covering defects for a minimum of three years from the date of final acceptance in accordance with 5-11 and Section 608. Ensure the warranty includes providing replacements, within 30 calendar days of notification, for defective parts and equipment during the warranty period at no cost to the Department or the maintaining agency.

Ensure that the LED signal modules have a manufacturer's warranty covering defects for a minimum of five years from the date of final acceptance in accordance with 5-11 and 608. Ensure that the warranty includes providing replacements, within 30 calendar days of notification, for any defective parts and equipment (including falling below minimum intensity levels) during the warranty period at no cost to the Department or the maintaining agency.

650-5 Method of Measurement.

The Contract unit price per assembly for vehicular traffic signal, furnished and installed, will consist of the traffic signal and all components necessary to make a complete unit, including mounting assemblies, backplates, visors, LED modules, labor, and materials necessary for a complete and accepted installation.

Separate payment for backplates will only be made for retrofitting existing signal heads, when called for in the Contract Documents.

650-6 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 650-	1-	Vehicular Traffic Signal - per assembly.
Item No. 650-	2-	Vehicular Signal Auxiliaries - per each.

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SECTION 653
PEDESTRIAN SIGNAL ASSEMBLIES

653-1 Description.

Furnish and install pedestrian signal assemblies as shown in the Plans and Standard Plans, Index 653-001. Meet the requirements of Section 603.

653-2 Materials.

Use pedestrian signals that meet the requirements of Section 995 and are listed on the Department's Approved Product List (APL). Pedestrian signal assemblies must meet the requirements of the latest edition of the Federal Highway Administration's (FHWA) Manual on Uniform Traffic Control Devices (MUTCD) and the Institute of Transportation Engineers (ITE) standard for Pedestrian Traffic Control Signal Indications.

653-3 Installation.

653-3.1 General: Use pedestrian signal assemblies capable of being maintained, adjusted, and disassembled with ordinary hand tools. Pre-assemble the pedestrian signal, with the exception of mounting hardware, prior to installation at the site. Construct the pedestrian signal assembly (including the mounting hardware) to be a weather-tight unit. Conceal all conductors.

653-3.2 Placement: Position pedestrian signals and all mounting assembly members as either plumb or level, and symmetrically arranged. Align signals in the line of the pedestrian's vision for the crosswalk being used.

653-3.3 Installation Sequence: Install all pedestrian signal assemblies at any intersection as a single operation unless a staged operation is approved by the Engineer. Do not install signals at any intersection until all other signal equipment, including the controller, and pedestrian detectors are in place and ready for operation, unless completely covered in accordance with 650-3.10.

653-4 Method of Measurement.

The Contract unit price per assembly for pedestrian signal assembly, furnished and installed, (including mounting hardware but not including poles or pedestals) will include all materials and equipment as specified in the Contract Documents, and all labor and materials necessary for a complete and accepted installation.

Payment for removal of pedestrian signal assemblies will be made only when the pole/pedestal is to remain. Otherwise, the removal of pedestrian signal assemblies are included in the removal of the pole or pedestal.

653-5 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 653- Pedestrian Signal - per assembly.

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SECTION 654
MIDBLOCK CROSSWALK ENHANCEMENT ASSEMBLIES

654-1 Description.

Furnish and install midblock crosswalk enhancement assemblies.

654-2 Materials.

Use In-roadway light assemblies and rectangular rapid flashing beacon (RRFB) assemblies that meet the requirements of Section 995 and are listed on the Department's Approved Product List (APL). Use hardware that meets the requirements of Section 603.

Pedestrian hybrid beacon assemblies must meet the physical and operational requirements of the latest edition of the MUTCD, Chapter 4F. The cabinet, signals, controller, pedestrian detectors, and other traffic control devices used to create a pedestrian hybrid beacon assembly must be listed on the APL.

654-3 Installation Requirements.

Restore any areas impacted by the installation of the crosswalk enhancement assembly to original condition unless otherwise shown in the Plans. Install crosswalk enhancement assembly in accordance with the Americans with Disabilities Act Standards for Transportation Facilities.

Install post mounted RRFB assemblies in accordance with Standard Plans, Index 654-001. Use sign panel attachment hardware in accordance with Standard Plans, Index 700-010.

Follow manufacturer recommendations on the number of RRFB units that are connected to the timer's output driver. The outside edges of RRFB indications, including any housings, shall not project beyond the outside edges of the associated warning sign.

If installed with highlighted signs or flashing yellow beacons, in-roadway light assemblies shall operate in unison and with an identical flash rate as the signs or beacons.

654-4 Warranty.

Ensure the midblock crosswalk enhancement assembly has a manufacturer's warranty covering defects for two years from the date of final acceptance in accordance with 5-11 and Section 608. Ensure the warranty includes providing replacements within 10 calendar days of notification for defective parts and equipment during the warranty period at no cost to the Department or the maintaining agency.

654-5 Method of Measurement.

654-5.1 General: All midblock crosswalk assemblies will include all materials, equipment, and labor necessary for a complete and accepted installation.

654-5.2 In-Roadway Light Assembly: The in-roadway light assembly includes in-roadway lights, signs, sign support structures, cabinet, electronics, wiring, and pedestrian detectors for a complete crossing. Include solar panels in the cost of the assembly when shown in the Plans.

654-5.3 Rectangular Rapid Flashing Beacon (RRFB) Assembly: Assemblies mounted in accordance with Standard Plan 654-001 includes rectangular beacons and signs for each approach, sign support structure, mounting brackets, attachment hardware, cabinet, electronics, wiring, and pedestrian detector. Include solar panels in the cost of the assembly when shown in the Plans.

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654-5.4 Pedestrian Hybrid Beacon Assembly: The Contract unit price for each pedestrian hybrid beacon assembly will consist of all labor and materials necessary for a complete and accepted installation. The assembly includes the 3-section signal, hardware, and backplate. Pedestrian signals, cabinet, signs, mast arms, strain poles or other support structures, and signal cable will be paid under the applicable sections for each item.

654-6 Basis of Payment.

Price and Payment will be full compensation for all work specified in this Section. Payment will be made under:

Item No. 654- 1	Midblock Crosswalk - In-Roadway Light Assembly - per assembly.
Item No. 654- 2	Midblock Crosswalk - Rectangular Rapid Flashing Beacon Assembly - per assembly.
Item No. 654- 3	Midblock Crosswalk - Pedestrian Hybrid Beacon Assembly - per assembly.

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SECTION 659
MAST ARM, SPAN WIRE, AND POLE MOUNTING ASSEMBLIES

659-1 Description.

Furnish and install mounting assemblies for vehicular and pedestrian traffic signals, signs, cameras, detectors, and other devices in accordance with the Contract Documents.

659-2 Materials.

659-2.1 General: Use mounting assemblies that meet the requirements of Section 995 and are listed on the Department's Approved Product List (APL). Meet the requirements of Section 603.

Fastening hardware such as bolts, nuts, washers, set screws, studs, u-bolts, cable and cable swags, must be provided by the mounting assembly manufacturer, must be SAE Type 316 or 304 stainless steel. Hardware (studs, bolts and u-bolts) must be a minimum of 5/16 inch diameter unless otherwise specified in this Section. SAE Grade 8 bolts and nuts are also acceptable.

659-2.2 Mast Arm Mounting Assemblies: Mast arm mounting assemblies must include the following components: mast arm saddle, swivel, attachment cables (with cable clamp mechanism) or bands, support tube, and top and bottom support arms.

659-2.3 Span Wire Mounting Assemblies: Span wire mounting assemblies must include a span wire clamp, a hanging device such as a drop pipe, adjustable hanger, or adjustable pivotal hanger with extension bar, messenger clamp, disconnect hanger, and multi-brackets.

659-3 Installation.

Install all mounting assemblies and torque all fastening hardware in accordance with the manufacturer's recommendations.

When connecting the extension bar to the top and bottom parts of the adjustable hanger, use maximum overlap of the two pieces and use a minimum of two bolts to connect the top and bottom portion of the hanger to the extension bar, separated with one hole between the top and bottom.

659-4 Warranty.

Ensure mounting assemblies have a manufacturer's warranty covering defects for a minimum of three years from the date of final acceptance in accordance with 5-11 and Section 608. The warranty must include providing replacements, within 10 calendar days of notification, for defective parts and equipment during the warranty period at no cost to the Department or the maintaining agency.

659-5 Method of Measurement.

The Contract unit price per assembly for each mounting assembly, furnished and installed, will include all materials specified in the Contract Documents and all labor, equipment, and miscellaneous items necessary for a complete and acceptable installation.

No separate payment will be made for mounting assemblies for new installations. All incidentals required by the Plans for new installations, including mounting hardware, will be included in cost of the new signal, sign, camera, detector, or other traffic control device.

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659-6 Basis of Payment.

Price and Payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 659- 1	Mast Arm, Span Wire and Pole Mounting Assemblies - each.

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SECTION 660
VEHICLE DETECTION SYSTEM

660-1 Description.

Furnish and install a vehicle detection system in accordance with the Contract Documents and this Section. Meet the requirements of Section 603.

660-2 Materials.

660-2.1 General: Meet the following requirements:

Traffic Data Detection System- Microwave*	Section 995
Vehicle Detector- Microwave*	995-2.4
Traffic Data Detection System- Video*	Section 995
Vehicle Detector- Video*	995-2.3
Traffic Data Detection System- LiDAR*	Section 995
Vehicle Detector- LiDAR*	Section 995
Vehicle Loop Detector*	995-2.2
Wireless Magnetometer Assembly*	995-2.5
Automatic Vehicle Identification*	995-2.6
Wrong Way Vehicle Detection Systems*	995-2.7
Loop Sealant*	995-3
Highlighted Signs*	995-15
Hardware and Fittings	603-2.4
Galvanizing	962-11

*Use products listed on the Department's APL.

660-2.2 Classification of Types: Vehicle detection and data collection systems are classified by the type of function they perform and the type of technology that they employ.

660-2.2.1 Functional Types: Provide the functional type detailed in the Plans.

660-2.2.1.1 Vehicle Presence Detection Systems: Vehicle presence detection systems produce a corresponding output any time that a vehicle occupies the physical or virtual area of the detector.

660-2.2.1.2 Traffic Data Detection Systems: Traffic data detection systems provide presence, volume, occupancy, and speed data for the lanes they are configured to monitor.

660-2.2.1.3 Probe Data Detection Systems: Probe data detection systems provide speed data and travel times for a road segment. Probe data detectors use automatic vehicle identification (AVI) technologies to establish a unique identifier for each vehicle they detect. This identifier is then transmitted to a central site where it can be matched to past or future detections of the same vehicle at different detector locations.

660-2.2.1.4 Wrong Way Vehicle Detection Systems: Wrong way vehicle detection systems produce an alarm output when a vehicle is detected traveling in the wrong direction and may consist of more than one detection zone and may use any of the technology types. For both mainline and ramp installations, the detection system must monitor all lanes for one direction, including shoulders. The wrong way detection system must not interfere with other vehicle presence or traffic data detection systems.

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660-2.2.2 Technology Types: Provide the detection technology type detailed in the Plans. Detection technology types include inductive loop, video, thermal, microwave, wireless magnetometer, and AVI systems.

660-2.2.2.1 Inductive Loop: An inductive loop detection system uses a minimum of one inductive loop and loop detector. The system operates by energizing and monitoring wire embedded in the road surface to detect vehicle presence and provide an output to traffic controllers or other devices that can generate volume, occupancy, and speed data (detection output).

660-2.2.2.1.1 Loop Wire: Use No. 12 AWG or No. 14 AWG stranded copper wire with Type XHHW cross-linked polyethylene insulation and an additional outer sleeve composed of polyvinylchloride or polyethylene insulation that meets the requirements of International Municipal Signal Association (IMSA) 51-7.

660-2.2.2.1.2 Shielded Lead-in Cable: Use No. 14 AWG two conductor, stranded copper wire with shield and polyethylene insulation, meeting the requirements for IMSA 50-2.

660-2.2.2.1.3 Splicing Material: Butt-end connectors may be used for splicing the loop wire to the lead-in cable. Butt-end connectors must be non-insulated. Use resin-core solder for soldered splices. Splicing tape must be self-fusing silicone rubber. Ensure insulated tubing used to cover splice is heat-shrinkable, cross-linked polyethylene with a silicon sealant inside the tubing and an insulation rating of at least 600 V.

660-2.2.2.2 Video: A video vehicle detection system (VVDS) uses one or more cameras recommended by the manufacturer or an integrated thermal sensor and video analytics hardware and software to detect vehicle presence, provides a detection output, or generates volume, occupancy, and speed data.

660-2.2.2.3 Microwave: A microwave vehicle detection system (MVDS) transmits, receives, and analyzes a FCC-certified, low-power microwave radar signal to detect vehicle presence, provide a detection output, or generate volume, occupancy, and speed data.

660-2.2.2.4 Wireless Magnetometer: A wireless magnetometer detection system (WMDS) uses one or more battery-powered wireless sensors embedded in the road surface, which communicates data by radio to a roadside receiver. Wireless magnetometer systems detect vehicle presence and provide a detection output to traffic controllers or other devices that can generate volume, occupancy, and speed data.

660-2.2.2.5 Automatic Vehicle Identification (AVI): An AVI detection system uses one or more different methods to collect information that can be used to establish a unique identifier for each vehicle detected and the time and location that the vehicle was detected. AVI detection systems collect data using radio-frequency identification (RFID), optical character recognition, magnetic signature analysis, laser profiling, Bluetooth®, or other methods to establish vehicle identifier, time, and location.

660-2.2.2.6 Light Detection and Ranging: A light detection and ranging (LiDAR) detection system uses one or more LiDAR sensors and perception hardware and software to detect vehicle presence, provide a detection output, or generate volume, occupancy, and speed data.

660-3 Installation Requirements.

660-3.1 Installation Requirements for all Detectors: Install, configure, and demonstrate a fully functional vehicle detection system as shown in the Plans. Connect all field equipment to the existing communication network, and provide all materials specified in the

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Contract Documents. Install all equipment in accordance with this Section and the manufacturer's recommendations.

Install above-ground detectors on poles or sign structures, as shown in the Plans. Furnish and install the power cable and the communication cables in accordance with the manufacturer's recommendation. Ensure that the cables comply with NEC sizing requirements and meet all other applicable standards, specifications, and local code requirements.

Do not install communication cables in the same conduit or pull boxes as power cables carrying voltage greater than 24 V_{DC}/V_{AC} or current in excess of 1.5 amps.

Cut all wires to their proper length before assembly. Do not double back any wire to take up slack. Neatly lace wires into cables with nylon lacing or plastic straps. Secure cables with clamps and provide service loops at all connections. Label all field wiring cables in the cabinet.

In the event that power to the vehicle detection system or a subcomponent thereof is interrupted, ensure that the equipment automatically recovers after power is restored. Ensure that all programmable system settings return to their previous configurations and the system resumes proper operation.

660-3.2 Inductive Loop Detector Installation: Install vehicle loops in accordance with the Contract Documents, the manufacturer's instructions, and Standard Plans, Index 660-001.

660-3.2.1 Inductive Loop-Detector Units: Adjust the operating frequency of each detector unit, if required, to prevent crosstalk of the units.

660-3.2.2 Saw Cuts: Use a chalk line or equivalent method to outline the perimeter of the loop on the pavement and routes for lead-in cables. Do not allow the saw cut in the pavement to deviate by more than 1 inch from the chalked line. Ensure that all saw cuts are free of any dust, dirt, or other debris and completely dry prior to installation of the loop wire, loop wire twisted pair lead, or lead-in cable.

Ensure that the top conductor of the loop wire or lead-in cable is a minimum of 1 inch below the final surface of the roadway.

660-3.2.3 Loop Wire: Ensure that all loops are wound in a clockwise manner and the first turn of the loop wire is placed in the bottom of the saw cut, with each subsequent turn placed on top of the preceding turn. Push the loop wire to the bottom of the saw cut with a non-metallic tool which will not damage the insulation.

Tag and identify the clockwise "lead" of each loop.

Use alternate polarity on adjacent loops.

Ensure that the hold down material is non-metallic, is placed in the saw slot using segments 1 to 2 inches long, spaced 12 inches apart, and that the distance from the top of the hold down material to the final surface of the roadway is not less than 1-1/2 inches.

660-3.2.4 Loop Wire Twisted Pair Lead: Create a loop wire twisted pair lead by twisting the loop wire pair a minimum of 10 turns per foot to form a loop wire twisted pair lead from the edge of the loop to the pull box located adjacent to the roadway. Place only one loop wire twisted pair lead in a saw cut. Ensure that the distance between a twisted loop wire pair lead within the roadway is a minimum of 6 inches from any other twisted loop wire pair lead or loop, until they are within 1 foot of the edge of pavement or curb, at which point they may be placed closer together.

Provide a minimum of 3 feet of twisted loop wire pair lead in the pull box located adjacent to the roadway. Do not route twisted loop wire pair lead directly through conduits to the cabinet, unless otherwise shown in the Plans.

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660-3.2.5 Loop Sealant: Do not use expired products. Prepare and apply loop sealant in accordance with the manufacturer's instructions. Ensure that the loop sealant has cured completely before allowing vehicular traffic to travel over the sealant.

660-3.2.6 Shielded Lead-in Cable: Place the lead-in cable in the bottom of the saw cut. Do not damage the insulation.

Install no more than four lead-in cables in a saw cut. Ensure that the hold down material is no longer than 1 inch and that the distance from the top of the hold down material to the final surface of the roadway is not less than 1-1/2 inches.

660-3.2.7 Splicing: Perform the splicing in a pull box located off the roadway, not in the roadway itself.

Splice the black conductor of the lead-in cable to the clockwise "lead" of the loop.

Ensure that the ends of the cable jackets, twisted pair, and lead-in are encased in the loop splice material.

Ensure that each loop has an individual return to the cabinet and series splicing is performed on a separate terminal block in the cabinet.

660-3.2.8 Terminations: Using insulated terminal lugs, terminate lead-in cables or twisted pair loop wire on a terminal strip, which is located in the controller or detector cabinet. Use a calibrated ratchet type crimping tool to attach the lugs to the conductors of the lead-in cable or twisted loop wire.

660-3.2.9 Loop Assembly Identification: Identify and tag each loop assembly in the controller or detector cabinet by lane and movement number.

660-3.2.10 Inductive Loop Detector Testing and Turn-on:

660-3.2.10.1 Series Resistance: Obtain Department of Transportation Traffic Signal Resistance Measurement Data Sheets from the Engineer. Measure and record the series resistance of each loop assembly on these data sheets. Leave a copy in the controller cabinet.

If the series resistance of a loop assembly is greater than 10 Ω, inspect the loop assembly to find the cause of the excessive resistance. Correct the cause of the excessive resistance at no additional cost to the Department.

660-3.2.10.2 Insulation Resistance: Measure and record the insulation resistance of each loop assembly and verify that the resistance is greater than 100 MΩ. Use a 500 V_{DC} insulation tester to measure the resistance. Reference all measurements to a good earth ground (ground rod, metallic water pipe, etc.). Disconnect the transient suppression devices from the loop assemblies before taking any measurements. If the insulation resistance is less than 100 MΩ, determine if the lead-in cable or the loop wire is causing the problem, and replace the defective cable or loop wire at no additional cost to the Department.

660-3.2.10.3 Loop Detector Turn-on: Connect the loop assemblies to the appropriate inductive loop vehicle detectors and tune the detectors in accordance with the manufacturer's instructions. Separate the operating frequencies of vehicle detectors, in adjacent lanes, by at least 2 kHz.

660-3.3 Video Detector Installation: Install cameras and configure detection zones and settings in accordance with the Contract Documents, manufacturer's recommendations, and as directed by the Engineer. Submit configuration settings (including, but not limited to, detector names, communication settings, and output assignments) and configuration file backups to the Engineer. Submit a graphical depiction of each camera site, its pole location, mounting height,

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the ratio of distance away from the camera versus the mounting height, the camera's mounting type (i.e., pole or structure), camera aiming procedures, and the placement of the proposed detection zone for each lane.

Do not use coaxial cable runs in excess of 500 feet. Mount and aim cameras in a manner that eliminates as much environmentally generated glare as possible.

660-3.4 Microwave Detector Installation: Install detector and configure detection zones and settings in accordance with the Contract Documents, manufacturer's recommendations, and as directed by the Engineer. Submit configuration settings (including, but not limited to, detector names, communication settings, and output assignments) and configuration file backups to the Engineer.

660-3.5 Wireless Magnetometer Installation: Install in accordance with the Contract Documents, manufacturer's recommendations, and as directed by the Engineer. Ensure that materials used for the installation of magnetometers in the road surface have cured completely before allowing vehicular traffic to travel over them.

660-3.6 AVI Detector Installation: Install in accordance with the Contract Documents, manufacturer's recommendations, and as directed by the Engineer.

660-3.7 Wrong Way Vehicle Detection Systems (WWVDS) Installation: Install in accordance with the Contract Documents, manufacturer's recommendations, and as directed by the Engineer.

660-3.8 LiDAR Detection System Installation: Install in accordance with the Contract Documents, manufacturer's recommendations, and as directed by the Engineer.

660-4 Acceptance Testing.

660-4.1 Vehicle Presence Detection System:

660-4.1.1 Performance Requirements: Ensure presence detectors provide a minimum detection accuracy of 98%.

660-4.1.2 Field Acceptance Testing: Verify presence detection accuracy at installed field sites using a reduced method in accordance with 995-2.9. Compare sample data collected from the detection system with ground truth data collected by human observation. For site acceptance tests, collect samples and ground truth data for each site for a minimum of five minutes during a peak period and five minutes during an off-peak period. For presence detection at intersections, ensure there are a minimum of three detections for each signal phase. Perform site acceptance tests in the presence of the Engineer.

660-4.2 Traffic Data Detection System:

660-4.2.1 Performance Requirements: Provide a vehicle detection system capable of meeting the minimum total roadway segment accuracy levels of 95% for volume, 90% for occupancy, and 90% for speed for all lanes, up to the maximum number of lanes that the device can monitor as specified by the manufacturer.

660-4.2.2 Field Acceptance Testing: Conduct field acceptance testing in accordance with Section 611.

660-4.3 Probe Data Detection System:

660-4.3.1 Performance Requirements: Ensure that probe data detectors establish a unique and consistent identifier for each vehicle detected and the time and location that the vehicle was detected. Ensure probe data detection systems that match upstream and downstream detection of the same vehicle provide a minimum match rate of 5%. Ensure probe data detection systems meet a minimum total roadway segment speed and travel time accuracy

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level of 90%. Verify system performance over several time periods under a variety of traffic conditions as described in 995-2.9.1.

660-4.3.2 Calculation of Speed and Travel Time Accuracy: Verify detector accuracy at installed field sites using a reduced method in accordance with 995-2.11. Calculate speed and travel time accuracy by comparing the speeds and travel times reported by the system against ground truth collected through human observation or another method approved by the Engineer.

660-4.4 Wrong Way Vehicle (WWVDS) Detection System: Submit a test plan for the field acceptance test (FAT) to the Engineer a minimum of 30 calendar days before commencement of testing for review and approval; tests cannot commence or be scheduled until test plans are approved by the Engineer. For each testing phase, test plans must include descriptions of test procedures; test form with areas for test result recording, test conductor, and witness signatures; pass/fail criteria; and test schedule.

Conduct a field acceptance test for each ramp being monitored by a WWVDS. Test all local system functions using the installed WWVDS equipment as detailed in the Plans and as approved by the Engineer. Testing must demonstrate that:

1. All wiring and local configurations are correct.
2. The WWVDS is detecting vehicles driving the wrong way, in all ramp travel lanes and any paved shoulders 8 feet or wider, while ignoring vehicles traveling in the correct direction. A true positive rate of 95% or greater must be achieved. A false positive rate of 1% or less must be achieved.
3. The WWVDS is activating all wrong way highlighted signs on the ramp upon detection of a vehicle traveling in the wrong direction and sign activation occurs before the vehicle reaches the sign.

If any WWVDS fails to pass its field acceptance test, correct the unit, or substitute another unit in its place, then repeat the test.

If a unit has been modified due to a field acceptance test failure, prepare a report describing the nature of the failure and the corrective action taken and submit it to the Engineer prior to re-testing. If a failure pattern develops, the Engineer may direct that design and construction modification be made to all units without additional cost to the Department or extension of the Contract Time.

660-4.4.1 True Positive Testing: Conduct this test on a closed ramp using Contractor-provided test vehicles. Test each lane and paved shoulder 8 feet or wider by driving two types of test vehicles traveling at two travel speed ranges the wrong direction. For this testing, the small vehicle shall be a FHWA Class Group 2 (passenger car) vehicle, and the large vehicle shall be a FHWA Class Group 3 (pick-ups and vans) or Class Group 5 (two-axle truck) vehicle.

Each ramp lane shall be subjected to the following test vehicle runs; each ramp paved shoulder 8 feet or wider must only undergo test runs described in #1 and #2.

1. Five runs of a small vehicle traveling between 10 and 15 miles per hour.
2. Five runs of a large vehicle traveling between 10 and 15 miles per hour.
3. Five runs of a small vehicle traveling 35 miles per hour or greater.
4. Five runs of a large vehicle traveling 35 miles per hour or greater.

Calculate the true positive rate using the following formula:

$$TPR = {}^{TP}/_{N} * 100$$

Where *TPR* = True positive rate %.

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TP = Cumulatively for all test runs, the total number of times the WWVDS correctly detected the wrong way vehicle and activated the highlighted signs.

N = Total number of test vehicle runs.

660-4.4.2 False Positive Testing: Conduct this test on a ramp open to the traveling public. Test the WWVDS by monitoring a minimum of 300 total vehicles traveling in the correct direction of travel passing through the WWVDS detection zones. At least 150 vehicles shall be monitored during daylight hours and at least 150 vehicles shall be monitored at night. The Engineer may reduce minimum volume requirements under low volume conditions if necessary.

Calculate the false positive rate using the following formula:

$$FPR = {}^{FP}/_{N} * 100$$

Where:

FPR = False positive rate %.

FP = Total number of times the WWVDS activated for a vehicle traveling in the correct direction.

N = Total number of vehicles traveling in the correct direction.

660-5 Warranty.

Ensure that the detection system has a manufacturer's warranty covering defects for a minimum of 1 year from the date of final acceptance by the Engineer in accordance with 5-11 and Section 608.

Ensure the warranty includes providing replacements, within 10 calendar days of notification, for defective parts and equipment during the warranty period at no cost to the Department or the maintaining agency.

660-6 Method of Measurement.

The quantity to be paid will be the plan quantity for each inductive loop detector and per assembly for loop assembly completed and accepted.

The quantity to be paid will be the plan quantity for each MVDS, VVDS, WMDS, AVI, WWVDS, or LiDAR VDS completed and accepted.

The highlighted signs for a WWVDS will be paid for in accordance with Section 700. Only one WWVDS will be paid per exit ramp, regardless of the number of signs.

660-7 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section including furnishing, placement, and testing of all materials and equipment, and for all tools, labor, equipment, hardware, operational software packages and firmware, supplies, support, personnel training, shop drawings, warranty documentation, and incidentals necessary for a complete and accepted installation.

Payment will be made under:

Item No. 660-1	Inductive Loop Detector - each.
Item No. 660-2	Loop Assembly – per assembly.
Item No. 660-3	Vehicle Detection System - Microwave - each.
Item No. 660-4	Vehicle Detection System - Video - each.
Item No. 660-5	Vehicle Detection System - Wireless Magnetometer - each.
Item No. 660-6	Vehicle Detection System - AVI - each.

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Item No. 660-7	Vehicle Detection System - WWVDS - each.
Item No. 660-8	Traffic Data Detection System - Microwave - each.
Item No. 660-9	Traffic Data Detection System - Video - each.
Item No. 660-10	Vehicle Detection System – LiDAR – each.
Item No. 660-11	Traffic Data Detection System – LiDAR – each.

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SECTION 663
SIGNAL PRIORITY AND PREEMPTION SYSTEMS

663-1 Description.

Furnish and install a signal priority and preemption system as shown in the Plans. The signal preemption system must recognize and respond to the priority of each user. Meet the requirements of Section 603.

663-2 Materials.

Use signal priority and preemption system equipment that meet the requirements of Section 995 and are listed on the Department's Approved Product List (APL). Ensure that all materials furnished, assembled, fabricated, or installed are new products.

Signal priority and preemption system equipment may utilize optical, GPS, and radio frequency based technologies.

Ensure that in-vehicle equipment operates without requiring any action from the vehicle operator or occupants once power is applied.

663-3 Installation.

Installation of materials must be in accordance with the manufacturer's instructions. Install the emergency preemption system including installation of detectors with all necessary hardware and software, mounting hardware, cabling, and all other associated electronics in cabinet necessary to create a fully functional emergency preemption system.

Ensure that status indicators remain unobstructed and visible.

663-4 Field Testing.

Subject the system to field acceptance tests (FATs). Develop and submit a test plan for FATs to the Engineer for approval. The Engineer reserves the right to witness all FATs.

663-5 Warranty.

Ensure that the priority and preemption system has a manufacturer's warranty covering defects for 5 years from the date of final acceptance. Ensure that the manufacturer will furnish replacements for any part or equipment found to be defective during the warranty period at no cost to the Department or the maintaining agency within 10 calendar days of notification.

663-6 Method of Measurement.

The Contract unit price for each signal priority and preemption system, furnished and installed, will include furnishing, placement, and testing of all equipment and materials, and for all tools, labor, hardware, operational software packages and firmware, supplies, support, personnel training, shop drawings, documentation, and incidentals necessary to complete the work.

663-7 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 663- 1- Signal Priority and Preemption System

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SECTION 665
PEDESTRIAN DETECTION SYSTEM

665-1 Description.

Install a pedestrian detection system as shown in the Plans. Pedestrian detection systems are classified into three categories: Standard Pedestrian Pushbutton Detectors, Accessible (Audible/Tactile) Pedestrian Pushbutton Detectors, and Passive Detectors. The components of the pedestrian detection system include pushbuttons, pedestrian actuation signs, electronics, wiring, and mounting hardware.

665-2 Materials.

Use pedestrian detection systems that meet the requirements of Section 995 and are listed on the Department's Approved Product List (APL). For the pedestrian actuation sign, use Type XI retroreflective sign sheeting meeting the requirements of Section 994 and the Standard Plans, Index 700-102.

665-3 Warranty.

Ensure that pedestrian detection systems have a manufacturer's warranty covering defects for a minimum of 5 years from the date of final acceptance by the Engineer in accordance with 5-11 and Section 608. Ensure the warranty includes providing replacements, within 10 calendar days of notification, for defective parts and equipment during the warranty period at no cost to the Department or the maintaining agency.

665-4 Installation.

Install pedestrian detectors at the locations and in a manner as shown in the Plans and Standard Plans, Index 665-001. Ensure all detectors are the same manufacturer and model.

Pushbuttons mounted on wood poles must be serviced by a conduit riser. Pushbuttons mounted on steel or aluminum (poles, pedestals, or posts) must be serviced by wiring inside the pole. Pushbuttons mounted on existing concrete poles may be serviced by a conduit riser. Pushbuttons mounted on new concrete poles or pedestals must be serviced by wiring on the inside.

A pedestrian actuation sign must be included with each pushbutton assembly. Install pedestrian actuation sign in accordance with the sheeting manufacturer's recommendations. Tactile arrows of accessible pedestrian pushbuttons must align parallel with the direction of the crossing.

When mounting, place the detector housing or saddle in complete contact with the pole or controller cabinet. When a post is required in the installation of the pedestrian detector, restore the area around the post to its original condition or as required by the Plans.

665-5 Method of Measurement.

The Contract unit price for pedestrian detectors, will be paid per each, and will include the pedestrian actuation sign, all mounting hardware, wiring, materials and equipment, and all labor and miscellaneous materials necessary for a complete and accepted installation.

Payment for poles, pedestals, and posts will be made under their respective pay item numbers.

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665-6 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 665- 1- Pedestrian Detector - each.

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SECTION 670
TRAFFIC CONTROLLER ASSEMBLIES

670-1 Description.

Furnish and install a traffic controller assembly or flashing intersection control beacon controller assembly as shown in the Plans. Meet the requirements of Section 603.

670-2 Materials.

Use only controller components listed on the Department's Approved Product List (APL). Traffic controller assemblies and intersection control beacon controller assemblies must be permanently marked with manufacturer name or trademark, part number and serial number. Markings must be visible after installation.

Provide a traffic controller assembly consisting of a traffic controller, traffic controller accessories (including monitors, load switches, flasher, flash transfer relay, power supplies), and other equipment wired into a controller cabinet to make a complete and operational assembly. All traffic controller assemblies must provide functionality that meets or exceeds operational characteristics, including NTCIP support, as described in NEMA TS-2-2003.

670-2.1 Traffic Controller: Meet the requirements of Section 671.

670-2.2 Traffic Controller Accessories: Meet the requirements of Section 678.

670-2.3 Controller Cabinet: Meet the requirements of Section 676.

670-2.4 Flashing Intersection Control Beacon Controller Assembly: A flashing intersection control beacon controller assembly must consist of a Type 3 flasher wired into a Type 1 controller cabinet to make a complete and operational assembly.

670-3 Installation Requirements.

670-3.1 Controller Cabinets: Meet the requirements of Section 676.

670-3.2 Field Wiring: Meet the requirements of Sections 632 and 676.

670-3.3 Grounding: Meet the requirements of Sections 620 and 676.

670-3.4 Equipment Placement: Install all equipment in the cabinet in accordance with the manufacturer's recommendations.

670-4 Method of Measurement.

The Contract unit price per assembly for traffic controller assembly or intersection control beacon controller assembly will include all labor, equipment, and miscellaneous materials necessary for a complete and accepted installation.

No separate payment will be made under this item for wiring, programming, signal operating plan, or other modifications needed to complete the installation of new signal cables or auxiliary equipment.

670-5 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 670-	4-	Intersection Control Beacon Controller Assembly - per assembly.
Item No. 670-	5-	Traffic Controller Assembly - per assembly.

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SECTION 671
TRAFFIC CONTROLLERS

671-1 Description.

Furnish and install a traffic controller unit as shown in the Plans. Meet the requirements of Section 603.

671-2 Materials.

Use traffic controllers that meet the requirements of Section 995 and are listed on the Department's Approved Product List (APL).

If shown in the Plans, new installations must include controllers that will deactivate the dimming circuit of LED street lighting during pedestrian activations. Pedestrian detector diagnostics must be activated when this feature is used.

671-3 Installation Requirements.

Install and configure traffic controllers in accordance with the Plans and the manufacturer's recommendations.

671-4 Method of Measurement.

The Contract unit price each for traffic controller, furnished and installed, will include all materials specified in the Contract Documents, and all labor, equipment, and miscellaneous materials necessary for a complete and acceptable installation.

No separate payment will be made for a traffic controller when included with the Traffic Controller Assembly per Section 670.

671-5 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item 671- 2- Traffic Controller - each

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SECTION 676
TRAFFIC CABINETS

676-1 Description.

Furnish and install traffic cabinets as shown in the Plans. Meet the requirements of Section 603.

676-2 Materials.

676-2.1 General: Use traffic signal controller cabinets, ITS cabinets, and small equipment enclosures that meet the requirements of Section 995-11 and are listed on the Department's Approved Product List (APL). Provide the cabinet with an automatic transfer switch if shown in the Plans. New signal installations must include controller cabinets that will interface with the dimming circuit of LED street lighting with an auxiliary relay if shown in the Plans. Provide cabinets with No. 2 locks unless otherwise shown in the Plans.

676-3 Installation Requirements.

676-3.1 General: Ground all cabinets in accordance with the requirements of Section 620. Keep the ground wire from the cabinet ground busbar to the ground rod assembly or array as short as possible. Ensure the ground wire is not in contact with any other part of the cabinet. All field drilled conduit entrance holes or other holes must be reamed and free of burrs. All conduit connections to cabinets and small equipment enclosures must be weatherproof. Ensure cabinet doors do not pinch or damage interior cables or displace equipment when doors are open, closed, or in motion.

Construct cabinet bases and maintenance service slabs as shown in Standard Plan 676-010 unless otherwise shown in the Plans. Construct cabinet bases and maintenance service slabs without risers using concrete in accordance with Section 347. Construct cabinet bases and maintenance service slabs with risers using concrete in accordance with Section 346. Make the concrete base and maintenance service slab level, free of honeycombs, and with a broomed finish. Temporarily seal the end of conduit risers located in the base before placing the concrete. Ensure conduit remains clear of debris. Position the end of the conduit risers a minimum of 2 inches above the finished surface of the concrete base.

676-3.2 Controller Cabinet Installation: Install traffic signal controller cabinets and concrete risers in accordance with Standard Plans, Index 676-010. Wire controller cabinets in accordance with the signal operating plan specified in the Contract Documents. If phases are omitted for future use, the cabinet must be wired for these future phases. Load switches for the future phases do not have to be furnished.

676-3.2.1 Pole Mounted Cabinets:

(a) Fasten the pole mounted hardware furnished with the cabinet to the cabinet using bolts no less than 1/2 inch threaded diameter. Ensure all connections are watertight.

(b) Use stainless steel bands for mounting cabinets onto steel strain poles.

(c) Use stainless steel bands or lead anchors (or equivalent) for mounting cabinets onto concrete strain poles.

(d) Use stainless steel bands or lag bolts for mounting cabinets onto wood poles.

676-3.2.2 Ground Mounted Cabinets:

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(a) Use anchor bolts to fasten ground mounted cabinets to the concrete base.

(b) Seal the joint between the bottom of the cabinet and the concrete base (inside and outside of cabinet) with a clear silicone rubber sealant.

676-3.2.3 Field Wiring:

(a) Terminate signal cable, interconnect cable, and loop lead-in wires on the appropriate terminal strips in the controller cabinet with insulated terminal lugs. Use a calibrated ratchet type crimping tool to install the insulated terminal lugs onto the field wires.

(b) Label spare circuits of the signal and interconnect cables and connect them to the cabinet ground busbar.

(c) Neatly bundle and identify all field wiring cables in the controller cabinet.

676-3.3 Intelligent Transportation System Cabinet Installation: Mount the cabinet as shown in the Plans and provide the cabinet with the necessary base or pole mount hardware. Ensure that pole and structure-mounted field cabinets have mounting brackets on the side so that both cabinet doors are fully functional. Provide an adapter bracket for pole mounted cabinets that is designed to allow banding straps to be installed without obstructing pole handholes.

Make provisions for all data, control, and confirmation connections between the ITS device and field cabinet and for any required wiring harnesses and connectors.

Place a heavy-duty resealable plastic bag on the backside of the main cabinet door for storing a list of terminal block connections and other cabinet documentation.

Place all equipment in the cabinet according to the recommendations of the manufacturer. Maintain a minimum clearance of 6 inches between the top of the cabinet and the top of any equipment placed on the top shelf of the cabinet and a minimum clearance of 2 inches between each side of the cabinet and any equipment placed on the cabinet shelves.

676-3.4 Small Enclosure Installation: Mount the enclosure on a pole or support structure as shown in the Plans and provide any hardware necessary for a complete and accepted installation.

676-4 Warranty.

Ensure cabinets, enclosures, and risers have a manufacturer's warranty covering defects for a minimum of 2 years from the date of final acceptance. The warranty must include providing replacements, within 10 calendar days of notification, for defective parts and equipment during the warranty period at no cost to the Department or maintaining agency.

676-5 Method of Measurement.

The Contract unit price each for cabinet, enclosure, or riser, furnished and installed, will include all materials specified in the Contract Documents, and all labor, equipment, and miscellaneous materials necessary for a complete and acceptable installation.

No separate payment will be made for a traffic signal controller cabinet when included with the controller assembly as per Section 670.

676-6 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 676- 1- Traffic Signal Controller Cabinet - each.

Item No. 676- 2- ITS Cabinet - each.

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Item No. 676- 3- Small Equipment Enclosure - each.

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SECTION 677
EQUIPMENT SHELTER

677-1 Description.

Furnish and install an equipment shelter as shown in the Plans. Ensure that all materials furnished, assembled, fabricated, or installed are new products.

677-2 Materials.

677-2.1 General: Ensure that the shelter includes a secure door; power distribution panels; a heating, ventilation, and air conditioning (HVAC) system; lightning protection, grounding, and any other components necessary for a completely integrated communication building. Ensure that the shelter is constructed and installed according to local building codes.

Provide a shelter designed for the following loads: wind: 170 MPH; floor: 200 pounds per square foot; slab: 200 pounds per square foot; roof: 100 pounds per square foot. Submit design drawings that meet all minimum standards and are signed and sealed by a registered Professional Engineer in the State of Florida.

The shelter's exterior shall have an exposed concrete aggregate finish. The shelter must have a bullet-resistant exterior surface in accordance with UL 752. The shelter's exterior color is to be earth tone. Alternative exterior finishes or colors may be approved by the Engineer.

677-2.2 Shelter Floor and Foundation: The floor is to be constructed of concrete or concrete composite material.

The foundation is a monolithic slab with appropriate footings and the final top of slab elevation is set a minimum of 2 feet above final grade, or as shown in the Plans. Concrete is to be Class II for extremely aggressive environments and in accordance with Section 346. Perform concrete structures work in accordance with Section 400.

The equipment shelter must not bend or break during moving, towing, or hoisting.

The equipment room's interior floor covering is to be industrial-grade vinyl flooring fastened to the shelter floor with waterproof adhesive. Provide an air gap between the equipment shelter floor and the foundation slab, or alternatively, construct the foundation slab with a vapor barrier to prevent moisture penetration. Insulate the floor to provide a minimum insulating factor of R-11.

677-2.3 Door: The exterior door is to be 36 inches wide by 78 inches tall, insulated, bullet-resistant, corrosion-resistant steel door with a door check and doorstop secured with a mortised deadbolt security lock keyed as directed. The door is to have a lever type handle on both the inside and outside. Provide the Department with four keys to each door lock.

677-2.4 Walls: Vapor shield the walls to prevent moisture penetration and install rigid board insulation for a minimum insulating factor of R-14. Attach the vapor shield and insulation directly to the concrete wall avoiding any air gap. Interior surfaces are to have a white textured finish wall covering with molding on all corners. All floor and wall intersections are to have 4 inch vinyl baseboards installed using waterproof adhesive.

677-2.5 Ceiling and Roof: The interior room height is to be no less than 9 feet above the floor and capable of supporting the proposed electrical fixtures and cable trays. The roof section shall have a 1/8 inch per foot minimum pitch for drainage. Fill all voids between the ceiling and roof with a vapor shield and install rigid board insulation for a minimum Type insulating factor of R-21 insulation. Attach the vapor shield and insulation directly to the concrete ceiling avoiding any air gap.

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677-2.6 Entrance: The entrance steps shall be concrete with ADA approved hand rail. The maximum distance from the final grade or final step to the shelter floor must not exceed 8 inches.

677-2.7 Lighting: Fluorescent light fixtures are to provide a uniform initial light level of 125 to 150 foot candles at 4 feet above the floor with a 3:1 ratio of maximum to minimum light levels as measured throughout the shelter's interior. Mount a light switch inside the shelter, adjacent to the entry door, for the interior lighting.

Install one 2250 lumen floodlight that is vandal resistant and mounted on the outside near the entrance door with a photocell and interior light switch. Install an auxiliary powered interior emergency light that illuminates when primary power fails.

677-2.8 HVAC System: Install appropriately sized exterior wall-mounted air conditioners. Ensure the system has a dry contact closure alarm output for failure monitoring and has an installed adjustable start time delay, initially set to 5 minutes.

The HVAC unit must be capable of operating when the outside temperature falls below 60ºF and have sufficient capacity to cool from a 95ºF ambient temperature to 75ºF, including the equipment heat load, providing continuous interior equipment cooling and dehumidification. The unit shall have a device installed to reduce the starting current required during a cold start or under high-head pressure conditions.

Provide an IP addressable thermostat which provides a secure web based interface that displays the current thermostat settings and allows remote adjustments.

677-2.9 Cable Trays: Cable trays are to be 12 inches wide capable of supporting the transmission lines, control and data wires, and alarm wires associated with communication equipment. Use cable trays constructed of aluminum or painted steel fabricated in an open ladder type arrangement that are suspended from the ceiling. Electrically bond by mechanical means, on non-painted surface areas, all rack and cable tray units together. After bonding all rack and cable tray units, cover these areas with an antioxidant compound. Cable trays and rack frames are to be connected to the shelter interior ground.

The clearance height between the floor and bottom of the cable tray is to be no less than 86 inches.

Equip the cable trays with overhead receptacles as shown in the Plans.

677-2.10 Equipment Rack: Include at least one standard 19 inch EIA/TIA equipment rack capable of mounting and supporting all devices indicated in the Plans. Include provisions for vertical and horizontal cable management and for power strips. Secure the top of each rack to the cable tray above using C channel or J hook hardware and to the floor in the location shown in the Plans or as directed by the Engineer.

677-2.11 Fire/Smoke Detection and Suppression: Install at least one smoke detector that operates on alternating current. Mount the smoke detector on the ceiling 1 foot clear of all obstructions and ensure that it includes a dry contact closure that will activate during prescribed conditions.

Where the equipment shelter is to be furnished with an automatic fire protection system, it is to be an FM-200 waterless, residue-free fire suppression system that conforms to NFPA and ISO 14520 standards.

Mount a hand-held carbon dioxide ABC fire extinguisher on the wall near the door. Verify that the extinguisher has a valid inspection tag and is rechargeable.

677-2.12 Alarm Specification: Wire, label and terminate all alarms on a Type 66 block. Provide the following shelter alarms:

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1. A magnetic dry contact door alarm.
2. A dry contact air conditioner failure alarm for each installed unit.
3. Dry contact fire alarms.
4. Dry contact high- and low-temperature alarms with thresholds adjustable between 50 and 90ºF.
5. A power failure alarm that is wired from a dedicated circuit breaker.
6. A main fuse alarm that is wired from the main fuse disconnect.

Provide provisions on each exterior side of the shelter that can be used for installation of security cameras. Provide these weatherproof conduit entries at locations near the corner of the shelter just below the roofline to allow wiring for cameras and other security devices to pass into the shelter.

677-2.13 Electrical: The standard electrical configuration is single-phase 120/240 V_{AC} at 60 Hz with a 150 A minimum service and a 42 circuit distribution panel. Provide power service drop and site-specific power needs in accordance with Section 639.

677-2.13.1 Primary AC Surge Protective Device: Install a primary AC surge protective device (SPD) that meets the requirements of Section 620, wired to protect the system while utilizing either utility or emergency power.

677-2.13.2 SPDs at Point of Use: Install SPDs that meet the requirements in Section 620 so that all outlets are protected.

677-2.14 Communication Cable Wall Entry: Install four, 4 inch diameter exterior wall penetrations with weather-sealed boots as shown in the Plans.

677-2.15 Circuit Termination Backboard: Install a backboard for the termination of communication circuits of 3/4 inch AC-grade plywood no less than 48 inches square and painted with two coats of gray, flame-retardant paint. All ground wires and conductors are to be insulated from the backboard, which must be securely mounted to the wall and capable of supporting the hardware fastened to it.

677-2.16 Warranty: The equipment shelter, its components, and hardware must have a manufacturer's warranty covering defects for a minimum of one year.

677-3 Installation Requirements.

677-3.1 General: Provide and detail the equipment shelter installation, including site layout, fencing, and all other features. Submit this drawing for approval prior to the start of construction.

Concrete is to be Class II in accordance with Section 346. Perform concrete structures work in accordance with Section 400. Obtain precast products from a plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105. Submit to the Engineer all permit documents for approval prior to starting the work.

Complete construction of the shelter foundation prior to delivery of the equipment shelter. Provide primary electrical power service, or generator power, to the site prior to delivery of the equipment shelter.

Begin shelter installation on the foundation within two days of shelter delivery to the jobsite. Complete the grounding and electrical connections to the shelter.

Upon completion of shelter installation dehumidify the shelter. Keep the shelter door closed for a period of 15 minutes and cycle the heat with the HVAC thermostat set on 85°F. The vendor shall return the HVAC units to normal operation mode once the dehumidification process is complete.

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In the event that shelter installation and primary or back up power connections to the shelter are delayed, then a portable dehumidifier shall be installed and operated until the shelter installation and power connection is complete. Install the portable dehumidifier with minimum performance capability, at 80°F and 60% relative humidity, of 30 pints per day water removal rate. Install a drain to route water away from the shelter.

677-3.2 Electrical: Install and connect electrical power to the equipment shelter and install all wires and cables in a neat, orderly fashion. Provide underground power service unless otherwise specified in the Plans.

Make all electrical connections from the service drop to the equipment shelter's receptacles. Use a minimum of No. 12 AWG copper wires to install the receptacles, switches, and light fixtures. Run all wire in a minimum 0.75 inch inside diameter electrical metallic conduit. Divide the electrical loads among as many load centers as necessary to contain the quantity of circuit breakers required to protect the equipment shelter facility.

Load centers must contain separate, appropriately sized circuit breakers for the HVAC units, each major branch as is necessary, each receptacle, and each remaining location in the 42 circuit panel. Each interior side of the four walls will have a duplex receptacle 18 inches above the floor, or as shown in the Plans. Protect receptacles with an individual 20 A circuit breaker. Install a separate 20 A single-pole circuit breaker to protect the lighting circuits.

677-3.3 Provision for Backup Power: The equipment shelter must be capable of utilizing a mobile emergency generator during power outages. The emergency generator connection shall allow Department personnel to power the site from a portable generator in the event that both the utility power and emergency power is lost.

Install a primary power switch to allow for the disconnection of commercial power at the main power entrance that is interconnected to an automatic transfer switch to facilitate a switch to emergency generator power in the event utility power is lost. Emergency generator power must route through a manual power switch on the outside of the shelter prior to connection to the automatic transfer switch panel.

677-3.4 Grounding: Meet the requirements of Section 620.

677-3.5 Site Preparation: Meet the requirements of Section 110. Coordinate the extent and schedule for all land clearing activities with the Engineer.

677-3.6 Fencing: Furnish Type B chain-link perimeter fencing and gates according to the requirements of Section 550 and Standard Plans, Index 550-002 with barbed wire attachment. Install the fence to form a rectangle or square shape, unless otherwise specified in the Plans. Allow for a minimum clearance of 5 feet between the fence and any enclosed item.

Construct sliding gates in accordance with Standard Plans, Index 550-003 with barbed wire, configure as shown in the Plans. Provide a hardened, four digit combination gate lock with the combination set as directed.

677-3.7 Weed Prevention: As necessary, treat the fenced area with a Department-approved herbicide used in accordance with 7-1. Install a woven plastic weed barrier in accordance with manufacturer's recommendations prior to gravel installation with a minimum 10% overlap for each barrier section and secure the edges of the mat with stakes.

677-3.8 Compound Gravel: Place gravel or crushed rock covering all unimproved areas within the limits of the fenced area to a depth of 6 inches. Gravel or crushed rock shall not exceed 3 inches in diameter.

677-3.9 Site Restoration: Provide performance turf in accordance with Section 570.

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677-4 Inspection and Verification.

677-4.1 General: The Department may perform an inspection witnessed by the Engineer at completion of the work. Notify the Engineer at least 10 days prior to completion of the installation to schedule the inspection. The inspection will verify that all equipment is correctly installed and functional.

Submit all test results in a format approved by the Engineer prior to testing. All recorded test report data shall be signed and dated, witnessed, and validated by signature from a Department representative. Remedy all noted deficiencies at no cost to the Department.

677-4.2 Mechanical Inspection: Test all equipment associated with the shelter. Test and verify the HVAC system performance for heating, cooling, and dehumidification. Inspect the building for the proper sealing of all wall penetrations. Correct any deficiencies at no cost to the Department.

677-4.3 Electrical Inspection: Verify and submit a report to the Engineer prior to acceptance that all shelter lights and smoke detectors operate properly, and proper electrical power load balances are realized. Correct any deficiencies at no cost to the Department.

677-4.4 Site Inspection: The site is to be free of debris and all excavations backfilled and restored to natural grade conditions.

677-4.5 Performance Period: Following the completion of all acceptance testing and inspections, subject the installed site to a minimum 20 day performance period, or alternately, the operational test period for the project, whichever is greater.

For the purpose of a successful performance period, failure of operation is defined as the failure of a major site component (i.e., HVAC systems, lighting, alarms, fire or smoke detection, etc.). Conduct the performance verification inspection with the Engineer present.

Complete performance testing within 45 days of shelter installation and inspection.

677-5 Method of Measurement.

The Contract unit price for each equipment shelter, furnished and installed, will include furnishing, placement, and testing of the shelter, all its materials and equipment, and for all tools, labor, equipment, hardware, site preparation, site restoration, fencing, supplies, shop drawings, permit documents, utility connections, documentation, and incidentals necessary to complete the work.

677-6 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 677- 1 Equipment Shelter, per each.

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SECTION 678
TRAFFIC CONTROLLER ACCESSORIES

678-1 Description.

Furnish and install traffic controller accessories as shown in the Plans. Meet the requirements of Section 603.

678-2 Materials.

Meet the following requirements:

Conflict Monitor*	Section 995
Malfunction Management Unit*	Section 995
Power Supply*	Section 995
Load Switch*	Section 995
Flasher*	Section 995
Flash Transfer Relay	NEMA TS2-2021, Section 6.4
Model 206L Power Supply Unit*	Section 995
Model 208 Monitor Unit*	Section 995
Model 210 Monitor Unit*	Section 995
Power Distribution Assembly*	Section 995
Input File*	Section 995
Model 430 Flash Transfer Relay	CALTRANS TEES 2020, 6.4.5.1.5
Time Switch*	Section 995

*Use products listed on the Department's APL.

678-3 Installation Requirements.

678.3.1 General: Install all traffic controller accessories in accordance with the manufacturer's recommendations. Terminate wires on the appropriate terminal strips in the controller cabinet with insulated terminal lugs. Neatly bundle, secure, and identify all wiring and cables.

678-3.2 Time Switch: Mount time switches on the inside wall of the controller cabinet to allow easy access for programming the switch. Ensure that the load current on the output circuits of the time switch does not exceed 3 A at 115 $V_{AC.}$ Whenever time switches are used for transferring a controller assembly to and from flashing operation, wire the controller cabinet for uniform code flashing as specified in Section 676.

678-4 Basis of Payment.

No separate payment will be made for traffic controller accessories. Include the cost in the Contract unit price for the traffic controller assembly.

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SECTION 680
SYSTEM CONTROL EQUIPMENT

680-1 Description.

Furnish and install system control equipment as shown in the Plans. Meet the requirements of Section 603.

680-2 Materials.

680-2.1 General: Use system control equipment and components listed on the Department's Approved Product List (APL).

680-3 Installation.

Install all system control equipment in accordance with the manufacturer's recommendations. Terminate wires on the appropriate terminal strips in the controller cabinet with insulated terminal lugs. Neatly bundle, secure, and identify all wiring and cables.

680-4 Warranty.

Ensure system control equipment has a manufacturer's warranty covering defects for a minimum of 3 years from the date of final acceptance. The warranty must include provisions for providing replacements within 10 calendar days of notification for defective parts and equipment during the warranty period at no cost to the Department or the maintaining agency.

680-5 Method of Measurement.

The Contract unit price for system control equipment, furnished and installed, will include all materials, equipment, hardware labor and miscellaneous materials necessary for a complete and accepted installation.

680-6 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 680	1	System Control Equipment - each.

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SECTION 682
VIDEO EQUIPMENT

682-1 CCTV Camera.

682-1.1 Description: Furnish and install a closed-circuit television (CCTV) camera at the locations shown in the Plans. The installed equipment must provide video images of the roadway, traffic, and other current conditions around a roadside CCTV field site; respond to camera control signals from the operator; and transmit video images to remote locations for observation.

682-1.2 Materials: All equipment shall be permanently marked with manufacturer name or trademark, part number, and date of manufacture or serial number. Meet the requirements of Section 603. Provide a CCTV camera that is compatible with any camera operating software indicated in the Contract Documents. Cameras are classified by camera type and video type. Provide the appropriate type for the locations shown in the Plans. Use only equipment and components that meet the requirements of Section 996 and are listed on the Department's Approved Product List (APL).

All CCTV cameras must support the communication links shown in the Plans. Unshielded twisted pair/shielded twisted pair network cables must be compliant with the TIA-568 Standard.

682-1.3 Installation: Install the CCTV camera on a pole in accordance with Standard Plans, Indexes 641-020, 649-020, and 659-020, and as shown in the Plans.

Furnish and install the power supplies and any other camera-related field electronic equipment and transient voltage surge suppressors within a pole- or base-mounted lockable cabinet. The cabinet must meet the requirements of Section 676.

Furnish and install all power, video, and data cables necessary to provide connection points for camera video and PTZ control signals within the cabinet. Furnish and install any and all ancillary equipment required to provide a complete and fully operational CCTV camera. Verify that all wiring meets National Electric Code (NEC) requirements where applicable.

Route the data and video cables from the pole or support structure to the camera inside the mounting hardware and protect from exposure to the outside environment.

Coat the exterior of the dome-type enclosure's lower half with a clear, rain repellant product prior to final acceptance.

682-1.4 Field Acceptance Testing: Conduct field acceptance testing in accordance with Section 611.

Perform local field inspection at each local CCTV field site to verify and confirm the following:

1. Physical construction has been completed as specified in the Plans and all existing and proposed lanes are clearly visible with no line of site obstructions.
2. The quality and tightness of ground and surge protector connections.
3. Proper voltages for all power supplies and related power circuits.
4. All connections, including correct installation of communication and power cables.

682-2 Video Display Equipment.

682-2.1 Description: Furnish and install video display equipment as shown in the Plans.

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682-2.2 Materials: Video display equipment must have the capability to display analog, digital, and other images associated with the operation of the transportation management center (TMC).

Provide equipment, mounting hardware, cabling, and other video display components that are compatible with each other. All equipment and materials furnished and installed must be reviewed and approved by the Engineer.

682-2.2.1 Video Display Control System: Furnish a video display control system that meets the requirements of Section 996.

Provide the video display control system with a minimum configuration of 4 composite video inputs, 4 component (red, green, and blue (RGB)) video inputs, and 4 DVI inputs as well as network connections, decoders, and associated hardware and software required to display 32 inputs simultaneously at a minimum resolution of 720 pixels x 480 pixels and a frame rate of 30 fps, or as shown in the Plans.

Provide the video display control system with a minimum configuration of 4 composite video outputs, 2 component (RGB video outputs), and 4 DVI outputs, or as shown in the Plans. If the projection device requires an analog signal, then breakout cables may be used to convert the DVI output connector to a HD15 analog RGB connector.

682-2.2.2 Video Wall Display: Furnish and install a video wall display consisting of display devices described below arranged in a wall, as shown in the Plans, together with a video display control system.

The video wall display must produce, at a minimum, a large-scale, high-resolution video image having accurate color rendition, sufficient image brightness, and a high contrast ratio, as described in 682-2.2.8. The display system must provide access to serviceable components for repair and replacement of electronics, lamps, and optical components without removing the device from service for a period longer than 30 minutes.

Integrate the individual display units in a single, seamless display that provides a continuous image across the entire active display area provided, under the complete control of the TMC operators from their individual shared workstations.

Source all major wall display components from a single provider or manufacturer to ensure that the various devices are compatible with each other and able to function together as an integrated display.

The individual video images must exhibit a uniformity of color quality across the multiple displays. Colors must be displayed evenly across the video wall and the video wall must maintain uniform brightness characteristics from one video display unit to the next in the tiled display, with no degradation in color or brightness uniformity over time. The video wall display must provide features that allow physical and electronic alignment of the separate high-resolution display units that comprise the wall.

682-2.2.3 Video Wall Support Structure: Furnish and install an aluminum or steel-frame structure that supports the video display units as mounted and stacked to form the matrix for the video wall display. The support structure must consist of stackable display units that maintain a consistent maximum horizontal and vertical spacing of 0.04 inches between adjacent display units in the video wall matrix.

Fabricate the support structure specifically to ensure that a continuous, accurate image is provided on the screens without any distortion or unused screen space and that no observable distortions are present in the installed video wall display due to normal building

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vibration. Each completed structure must be enclosed such that there is no ambient light effect on the screen from behind the display.

Ensure that the components of the individual video displays can be serviced without disturbing the integrity of the entire video wall display.

682-2.2.4 Rear Projection Video Display: Use rear projection video displays that are suitable for digital video wall applications in mission-critical TMCs where video wall image quality, operational reliability, and serviceability objectives as stated in this Specification can be achieved.

Use rear projection video displays that display a minimum of a single or quad-split, four-paned CCTV camera video image. Each video display must be able to be independently controlled from any of the central operator or shift supervisor workstations, and that each video display can be integrated with additional video units to form a single video display, or a virtual desktop where video windows can be positioned and resized by the operator.

Ensure that the rear projection video display facilitates lamp replacement without the need to readjust the image being projected on the screen.

The rear projection video display intensity must be sufficient for effective and comfortable viewing by TMC operations personnel under normal lighting conditions, subject to approval by the Department. The unit's display engine must produce a minimum light output of 550 ANSI lumens.

The rear projection video units must have the following minimum features and characteristics:

1. Screen brightness achieved by a combination of projection techniques and screen materials, so that the video display has a minimum brightness measurement of 130 candelas per square meter (cd/m2) across the outside viewing surface of the projection screen.

2. Brightness uniformity that meets or exceeds 80 percent across the display unit, as measured using a photometer.

3. A multi-lamp optical engine must be provided for rear projection video units that do not use light-emitting diodes (LEDs) for illumination. Multi-lamp optical engines must provide a failover feature whereby a second lamp can be automatically activated when the first lamp fails. Ensure displays with multi-lamp optical engines provide indication of lamp status.

4. Multi-lamp optical engines must include both a "hot standby" mode in which failover to the second lamp takes no more than two seconds and a "cold standby" mode in which failover and the time for the display to return to full light output does not exceed 30 seconds.

5. A display module that uses modular component architecture to permit service or replacement of serviceable parts without removing the projection engine.

6. Each unit must be completely enclosed and light tight, with fixed panels for access to the lamp, power supply, and projection engine.

682-2.2.5 Flat Panel Display: Furnish and install a flat panel display unit to reproduce video and computer graphics information. The device must display, at a minimum, a high-resolution, distortion-free image and maintain a consistent level of illumination across the entire screen area. Ensure that it has the following minimum features and characteristics:

1. Dimensions of 24 inches high by 41 inches wide by 4 inches deep, or as shown in the Plans.

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2. Ability to be installed on the face of a standard wall or flush mounted within the wall system.

682-2.2.6 Cabling: Furnish each video display component with all required appurtenances, including all the necessary cables, with proper length and connectors for power and communication, as defined by the manufacturer. Ensure that cabling conforms to applicable EIA/TIA standards. Size the power cables to meet NEC requirements. Provide communication cables from each video display component to the network communication devices that are appropriate for and compatible with the technology employed (e.g., fiber optic, twisted pair, or coaxial), and meet the minimum size and bandwidth specifications the manufacturer requires.

Provide all cabling of adequate length, along with the compatible connectors and any ancillary equipment necessary to fully interconnect the video components and display control systems needed to achieve the functions required. Label all cables at both ends, as approved by the Engineer.

682-2.2.7 Electrical: Provide equipment that operates on 120 V_{AC} at a frequency of 60 Hz. Furnish a transformer or other necessary means of power conversion for any device that requires another voltage or frequency.

Conduct TMC field reviews to examine the electrical distribution panels allocated for various equipment items and the electrical schedules for each. Make any changes, additions, or corrections to the electrical panels, wiring, outlets, and connectors that may be deemed necessary to adequately power all of the equipment proposed for a video display project at the intended location, subject to the approval of the Engineer. Make any changes to the building's electrical wiring in accordance with applicable codes and permits, and with the NEC. Modifications to an existing building's wiring or the video wall electrical wiring plans must be signed and sealed by a Specialty Engineer, and submitted for approval.

682-2.2.8 Performance: Use only display devices meeting the following minimum requirements.

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Table 682-1 Minimum Requirements for Display Devices				
	Flat Panel Display			Rear Projection Video Display
Type	Direct View LCD			DLP or LCD
Size	(dependent on TMC design, as shown in the Plans)			
Aspect Ratio	(dependent on TMC design, as shown in the Plans)			
Resolution	1600 x 1200 / 1280 x 768 pixels; 16.7 million colors			1024 x 768 pixels
Viewing Angle	170 degrees horizontally and vertically	160 degrees horizontally and vertically		160 degrees horizontally and vertically
Half Gain Angle	—	—		±40 degrees horizontally and vertically
Contrast Ratio	500:1	600:1		600:1
Screen Brightness *	250 cd/m2	450 cd/m2		130 cd/m2
Lamp Life	—	—		8,000 hrs. (avg.)
Video Inputs	Analog/digital via 15-pin D-sub (HD-15) connector; DVI-D connector.	Composite video (NTSC) on RCA connector; analog/digital via 15-pin D-sub (HD-15) connector; DVI-I connector; HDMI.		Composite video (NTSC) on BNC; RGB via 15-pin D-sub (HD-15) connector; DVI-D connector.
Operating Temperature and Humidity	32° to 95°F. 20 to 80%.	32° to 95°F. 20 to 80%.		32° to 95°F. 20 to 80%.
Power Requirements	120 V_{AC} at 60 Hz	120 V_{AC} at 60 Hz		120 V_{AC} at 60 Hz
* Measured using a photometer.				

682-2.3 Installation: Do not proceed with any part of the procurement, construction, or installation of the video display equipment until the construction plans and materials are approved by the Engineer. Submit to the Engineer documentation, including the manufacturers' product specification sheets and a detailed description of each item's function as well as a compliance matrix that confirms all equipment meets or exceeds the requirements of these Specifications.

Configure each video display unit to provide individual, independent control from each operator workstation.

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Create the video wall display by arranging individual video display units in a framework or apparatus that creates the video wall configuration as shown in the Plans. The finished video wall must provide a single, apparently seamless display area. The adjacent individual display units must be aligned physically and electronically so that image content stretched across multiple monitors align within plus or minus 2 lines of horizontal and vertical resolution.

All rear projection video unit controls must be accessible at all times when the devices are permanently installed. Ensure that installation and positioning does not conceal or limit access to any display unit controls at any time during active use.

Follow proper ventilation and cooling procedures for the equipment installed, as determined by the equipment manufacturers. Provide electrical requirements and power distribution units and power supplies for the video display components as-needed.

682-2.4 Testing: Submit a detailed system acceptance test plan to the Engineer for review and approval. Prepare a test plan that covers all areas of system function described in this Section, and that is developed according to the various equipment manufacturers' recommendations.

Check and test the satisfactory operation of all video display components upon completion of the equipment's installation. At minimum, include in the video display system test the testing of each color video monitor type, each secondary display output at workstations, each rear projection video display unit, and the video wall display's image alignment and control functions.

Subject the video wall display to a 90 day operational observation period. During this time, perform any and all maintenance, recalibration, system checking, and display modifications required by the Engineer. The Engineer has the option to require a restart of the observation period if a major system flaw or failure occurs.

682-3 Warranty.

Ensure that CCTV cameras and video display equipment have a manufacturer's warranty covering defects for a minimum of one year from the date of final acceptance. Ensure that the warranty requires the manufacturer to furnish replacements for any part or equipment found to be defective during the warranty period at no cost to the Department or the maintaining agency within 10 calendar days of notification.

Warranty repairs of the video display control system and related TMC display equipment must commence within 24 hours after notification by the Department.

682-4 Method of Measurement.

The Contract unit price for each CCTV camera or video display device or system, furnished and installed, will include furnishing, placement, and testing of all equipment and materials, and for all tools, labor, operational software packages and firmware, supplies, support, personnel training, shop drawings, documentation, and incidentals necessary to complete the work. The cabinet will be paid for in accordance with Section 676.

The video display equipment will be measured as each major system component is furnished, installed, made fully operational, and tested in accordance with this Specification or as directed by the Engineer.

682-5 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

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Payment will be made under:

Item No. 682- 1- CCTV Camera - each.

Item No. 682- 2- Video Display Equipment - each.

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SECTION 684
NETWORK DEVICES

684-1 Description.

Furnish and install network devices as shown in the Plans. Meet the requirements of Section 603.

684-2 Materials.

684-2.1 General: Meet the following requirements:

Managed Field Ethernet Switch*	Section 996
Managed Hub Ethernet Switch	Section 996
Device Server*	Section 996
Digital Video Encoder*	Section 996
Digital Video Decoder*	Section 996
Media Converter*	Section 996

*Use products listed on the Department's APL.

684-2.2 Managed Field Ethernet Switch: Ensure that the managed field Ethernet switch (MFES) provides Ethernet connectivity between devices, systems, and locations as required by the Contract Documents.

Ensure that the ITS network administrator will be able to manage each MFES individually and as a group for switch configuration, performance monitoring, and troubleshooting.

Ensure that the MFES is fully compatible and interoperable with connected Ethernet devices and the traffic control system network.

Ensure the MFES provides a switched Ethernet connection for each connected device and at least one open RJ45 Ethernet port for technician access.

684-2.2.1 Optical Ports: Ensure that all fiber optic link ports operate at 1,310 or 1,550 nanometers in single mode. Ensure that the optical ports are Type ST, SC, LC, or FC only, as specified in the Plans or by the Engineer. Do not use mechanical transfer registered jack (MTRJ) type connectors.

Provide an MFES having a minimum of two optical 100 Base FX ports capable of transmitting data at 100 megabits per second unless otherwise shown in the Plans. Ensure the MFES is configured with the number and type of ports detailed in the Contract Documents. Provide optical ports designed for use with a pair of fibers; one fiber will transmit (TX) data and one fiber will receive (RX) data. The optical ports must have an optical power budget of at least 15 dB, or as detailed in the Contract Documents.

684-2.2.2 Copper Ports: Provide an MFES that includes a minimum of four copper ports unless otherwise shown in the Plans.

Ethernet over very high speed digital subscriber line (EoVDSL) ports are permitted for use in applications where fiber optic cable is not available.

684-2.3 Managed Hub Ethernet Switch: Ensure that the managed hub Ethernet switch (MHES) provides wire-speed Ethernet connectivity at transmission rates of up to ten gigabits per second to and from adjacent MHES within the traffic control network.

Ensure that the ITS network administrator will be able to manage each MHES individually and as a group for switch configuration, performance monitoring, and troubleshooting.

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Ensure that the MHES is fully compatible and interoperable with field devices and the traffic control system network.

Ensure the MHES includes any license(s) required to utilize all Layer 3 features.

Ensure the MHES provides a switched Ethernet connection for each connected device and at least one open RJ45 Ethernet port for technician access.

684-2.3.1 Optical Ports: Ensure that all fiber optic link ports are modular SFP/SFP+ ports that operate at 1310 or 1550 nanometers in single mode and support 100Base-FX, 1000Base-X, and 10GBase-X. Ensure that the optical ports are Type LC unless otherwise shown in the Plans. Do not use mechanical transfer registered jack (MTRJ) type connectors.

Provide an MHES having a minimum of six optical Gigabit Ethernet ports as required to interface adjacent network devices. Optical ports must be capable of 100M, 1G, and 10Gbps data rates unless otherwise shown in the Plans. Ensure the MHES is configured with the number and type of ports detailed in the Contract Documents. Furnish hot-swappable fiber optical transceivers. Provide optical ports designed for use with a pair of fibers; one fiber will transmit (TX) data and one fiber will receive (RX) data. The optical ports must have an optical power budget of at least 15 dB, or as detailed in the Contract Documents.

684-2.3.2 Copper Ports: Provide an MHES that includes a minimum of twelve gigabit Ethernet copper ports unless otherwise shown in the Plans. All copper ports must be Type RJ-45 and auto-negotiate speed (e.g., 10/100/1000 Base) and duplex (i.e., full or half).

684-2.4 Device Server: Ensure that the device server provides Ethernet connectivity to devices with serial data interfaces as required by the Contract Documents. The device server must operate using a nominal input voltage of 120 V_{AC}. If the device requires nominal input voltage of less than 120 V_{AC}, furnish the appropriate voltage converter.

684-2.5 Digital Video Encoder and Decoder: Ensure that the complete video and data transmission system, defined as the combination of digital video encoder (DVE) and digital video decoder (DVD) hardware together with the existing or planned network infrastructure, simultaneously transports video and data from multiple remote field locations to multiple monitoring locations for roadway surveillance and traffic management.

Provide a software decoding and control package that allows the viewing of any video source connected to the network through a DVE, and which allows the pan-tilt-zoom (PTZ) control of any PTZ camera on the network, the discovery of DVE and DVD devices on the network, and the control and adjustment of programmable parameters in the DVE and DVD equipment, including the network addresses of these devices, at no additional cost.

684-2.5.1 Digital Video Decoder: Provide a DVD that is either a hardware-based network device or a software application that resides on a workstation PC. Ensure that the software application provides PC desktop display of IP network video streams.

Provide all setup, control programs, and diagnostic software related to the DVE or DVD.

Provide all equipment licenses, where required for any software or hardware in the system.

Ensure that any software-based decoder applications do not interfere with SunGuide® software operating when installed and used together on a shared hardware platform. Ensure that the software-based decoder offers an open Application Programming Interface (API) and software development kit available to the Department at no cost for integration with third party software and systems.

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684-2.5.2 Interoperability: Provide DVE and DVD devices and software that are interoperable and interchangeable with DVE and DVD devices and software from other manufacturers.

684-2.5.3 Network Interface: Ensure that fiber ports are single mode with a minimum link budget of 30 dB or the type and power detailed in the Contract Documents.

684-2.6 Media Converter: The media converter must allow transition between the transmission media shown in the Plans or required to construct a functional system, such as conversion from twisted pair to optical fiber or from twisted pair to coaxial cable.

Ensure that fiber ports are single mode with a minimum link budget of 30 dB or the type and power detailed in the Contract Documents.

Media converters must operate on a nominal voltage of 120 V_{AC} if POE is unavailable. Supply an appropriate voltage converter for devices that require operating voltages of less than 120 V_{AC}.

684-3 Installation.

684-3.1 General: Install network devices at the locations shown in the Plans. Ensure that network devices are mounted securely and are fully accessible by field technicians. Ensure that all unshielded twisted pair/shielded twisted pair Ethernet network cables are compliant with the EIA/TIA-568-B standard.

684-4 Field Acceptance Testing.

684-4.1 General: Conduct field acceptance testing in accordance Section 611.

684-4.2 MFES Field Acceptance Testing: Conduct inspection and testing at the installed equipment location according to the approved test plan. Perform the following:

1. Verify that physical construction has been completed as detailed in the Plans.
2. Inspect the quality and tightness of ground and surge protector connections.
3. Verify proper voltages for all power supplies and related power circuits.
4. Connect devices to the power sources.
5. Verify all connections, including correct installation of communication and power cables.
6. Verify network connection and MFES configuration using a laptop PC.

684-4.3 MHES Field Acceptance Testing: Conduct inspection and testing at the installed equipment location according to the approved test plan. Perform the following:

1. Verify that physical construction has been completed as detailed in the Plans.
2. Inspect the quality and tightness of ground and surge protector connections.
3. Verify proper voltages for all power supplies and related power circuits.
4. Connect devices to the power sources.
5. Verify all connections, including correct installation of communication and power cables.
6. Verify network connection and MHES configuration using a laptop PC.

684-4.4 Device Server Field Acceptance Testing: Conduct inspection and testing at the installed equipment location according to the approved test plan. Perform the following:

1. Verify that physical construction has been completed as specified in the Plans.
2. Verify the quality and tightness of ground and surge protector connections.
3. Verify proper voltages for all power supplies and related power circuits.
4. Connect devices to the power sources.

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5. Verify all connections, including correct installation of communication and power cables.

6. Verify network connection and device server configuration using a laptop PC.

7. Verify serial data transmission through the device server.

684-4.5 DVE and DVD Field Acceptance Testing: Conduct inspection and testing at the installed equipment location according to the approved test plan. Perform the following:

1. Verify that physical construction has been completed as detailed in the Plans.
2. Inspect the quality and tightness of ground and surge protector connections.
3. Verify proper voltages for all power supplies and related power circuits.
4. Connect devices to the power sources.
5. Verify all connections, including correct installation of communication and power cables.
6. Verify video image is present and free from oversaturation and any other image defect in both color and monochrome mode.
7. Verify network connection to the DVE and DVD through ping and telnet session from a remote PC.
8. Verify serial data transmission through the DVE and DVD serial ports.
9. Verify support of unicast, multicast, and SAP.

684-5 Warranty.

684-5.1 General: Ensure that network devices have a manufacturer's warranty covering defects for 1 year from the date of final acceptance. Ensure that the manufacturer will furnish replacements for any part or equipment found to be defective during the warranty period at no cost to the Department or the maintaining agency within 10 calendar days of notification.

684-6 Method of Measurement.

The Contract unit price for each network device, furnished and installed, will include furnishing, placement, and testing of all equipment and materials, and for all tools, labor, hardware, operational software packages and firmware, supplies, support, personnel training, shop drawings, documentation, and incidentals necessary to complete the work.

Provide software-based decoders at no additional cost when furnished in conjunction with DVEs.

A software-based DVD provided individually must be paid under the pay item below.

684-7 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 684- 1-	Managed Field Ethernet Switch-each.
Item No. 684- 2-	Device Server-each.
Item No. 684- 3-	Digital Video Encoder with Software Decoder-each.
Item No. 684- 4-	Digital Video Decoder-each.
Item No. 684- 5-	Media Converter-each.
Item No. 684- 7-	Managed Hub Ethernet Switch-each

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SECTION 685
TRAFFIC CONTROL SYSTEM AUXILIARIES

685-1 Description.

Furnish and install traffic control system auxiliaries as shown in the Plans.

685-2 Materials.

685-2.1: General: Meet the following requirements:

Uninterruptible Power Supply* .....Section 996
Remote Power Management Unit* .....Section 996
*Use products listed on the Department's APL.

685-2.2 Uninterruptible Power Supply (UPS): Use a line interactive or online/double-conversion UPS as shown in the Plans. UPS assemblies must be designed for installation in a roadside NEMA 3R enclosure to provide battery backup functionality for traffic control systems, including traffic signal and intelligent transportation system (ITS) devices. UPS assemblies must include batteries provided by the UPS manufacturer or in accordance with manufacturer's requirements. Batteries must be sealed and require no maintenance, cause no corrosion, and be capable of maintaining 80% of original capacity and performance for a minimum of five years.

Loss of utility power, transfer from utility power to battery power, and transfer back to utility power must not interfere with normal operation of connected equipment. In the event of UPS failure or battery depletion, connected equipment must be energized automatically upon restoration of utility power.

Removal and replacement of the UPS must not disrupt the operation of the equipment being protected.

All harnesses necessary to connect and operate the system must be included.

685-2.2.1 Electrical: UPS assemblies used to provide backup power in an ITS cabinet must provide a minimum of 350 watts (at 120 V_{AC}) of continuous backup power for a minimum of two hours unless otherwise shown in the Plans.

UPS assemblies used to provide backup power in a traffic signal controller cabinet must provide a minimum 400 watts (at 120 V_{AC}) of continuous power for a minimum of 6.5 hours unless otherwise shown in the Plans.

685-2.2.2 Traffic Signal UPS Cabinet: Cabinets used to house traffic signal UPS assemblies must be designed to be mounted to the side of a traffic cabinet or base mounted. Cabinets must meet the requirements of Section 676 and must include shelves and rack rails to house all UPS system components including the UPS, batteries, harnesses, switches, surge protective device, power terminal block and a generator hookup with transfer switch. The UPS cabinet must allow a maintenance technician to safely insert power for traffic signal operation while the UPS or associated equipment is serviced or replaced.

A surge protective device must be installed where the supply circuit enters the cabinet in accordance with 620-2.7.1.

685-2.2.2.1 Transfer Switch and Generator Access Panel: The cabinet must include an automatic transfer switch and generator access panel in accordance with Section 676. The generator access door must not protrude more than 1 inch when closed.

685-2.3 Remote Power Management Unit (RPMU): Use a RPMU as shown in the Plans. The RPMU must be designed for installation in a roadside Traffic Cabinet to provide remote control of electrical receptacles.

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685-3 Installation.

Install UPS assemblies in accordance with the manufacturer's recommendations. All equipment used to keep the intersection signalized must be backed up and protected by the UPS. Include a UPS operation and maintenance manual in the cabinet where the UPS is installed that includes cabinet wiring schematics, electrical interconnection drawings, parts layout and parts lists.

Install the RPMU in accordance with the manufacturer's recommendations. Include a RPMU operation and maintenance manual in the cabinet where the RPMU is installed that includes cabinet wiring schematics, electrical interconnection drawings, parts layout and parts lists.

685-4 Testing.

Provide a field acceptance test plan to the Engineer for approval at least 14 days prior to commencement of testing. After approval of the acceptance test plan, perform testing of the installed UPS and RPMU equipment. Furnish all equipment, software, and supplies necessary for conducting the test.

685-5 Warranty.

Ensure the UPS includes a manufacturer's warranty covering defects for a minimum of 3 years (5 years for the batteries in accordance with 685-2.2) from the date of final acceptance in accordance with 5-11 and Section 608. The warranty must include provisions for providing a replacement UPS within 10 calendar days of notification for any UPS found to be defective during the warranty period at no cost to the FDOT or the maintaining agency.

Ensure the RPMU includes a manufacturer's warranty covering defects for a minimum of 3 years from the date of final acceptance in accordance with 5-11 and Section 608.

685-6 Method of Measurement.

The Contract unit price for each UPS or RPMU, will include furnishing, placement, and testing of all equipment and materials as specified in the Contract Documents, and all tools, labor, operational software packages and firmware, supplies, support, documentation (including the field acceptance test plan), and incidentals necessary for a complete and accepted installation.

685-7 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 685- 1-	Uninterruptible Power Supply - each
Item No. 685- 2-	Remote Power Management Unit - each

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SECTION 695
TRAFFIC MONITORING SITE EQUIPMENT

695-1 Description.

Furnish or furnish and install a complete, operable traffic monitoring site (TMS) as shown in the Plans and Standard Plans. The Department uses TMS to monitor the volume, speed, number of axles, weight of wheels, axles or vehicles, or vehicular axle classification types.

695-2 General.

695-2.1 Materials: Meet the following requirements:

Poles	Section 646
Transformer Base*	Section 646
Wire for Inductive Loop*	Section 997
Class II Piezoelectric Axle Sensor*	Section 997
TMS Vehicle Non-Weight Axle Sensors*	Section 997
TMS Vehicle Microwave Radar Vehicle Sensors*	Section 997
TMS Vehicle Video Sensors*	Section 997
TMS Vehicle Strain Gauge Sensors*	Section 997
TMS Vehicle Quartz Piezoelectric Sensors*	Section 997
TMS Non-Motorized Axle Sensor*	Section 997
TMS Non-Motorized Infrared Sensor*	Section 997
TMS Non-Motorized Video Sensor*	Section 997
TMS Solar Power Unit For Vehicle Data Collection*	Section 997
TMS Solar Power Unit For Non-Motorized Data*	Section 997
TMS System Communications Modem*	Section 997
TMS Modem Antenna*	Section 997
TMS Vehicle Speed/Classification Unit*	Section 997
TMS Vehicle Weigh-In-Motion (WIM) Unit*	Section 997
TMS Non-Motorized Data Collection Unit*	Section 997
Adhesive Bonding Agent*	Section 997
Loop Sealant*	Section 997
TMS Cabinets*	Section 997
TMS Suppression Devices (power, sensor)*	Section 997
TMS Managed Field Ethernet Switch*	Section 997
Patch Panel	Section 633

*Use products listed on the Department's APL.

695-2.2 Traffic Monitoring Site Component Approval: Submit forms in accordance with 603-5. Any electronics unit or software submitted for approval must be compatible with or convert the data into a format compatible with the Department's polling and processing software and be compatible with the existing and new equipment. Remove and replace any new equipment that fails the operational test at no cost to the Department.

695-2.3 Notification: Notify the Engineer 10 working days prior to beginning work in the area of the TMS to coordinate the removal of existing TMS equipment.

A TMS Inspector must be onsite during TMS installation. Notify the Engineer 10 working days prior to installation of the TMS to coordinate the scheduling of a TMS Inspector.

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For the Weigh-In-Motion (WIM) electronics sensor and unit, notify the Engineer for final acceptance inspection after the completion of a 30 day operational period with no deficiencies. For all other equipment, notify the Engineer for final acceptance inspection after the completion of a 14 day operational period with no deficiencies.

695-2.4 Poles: Install the weather head in accordance with Standard Plans, Index 695-001. Ground the pole in accordance with Section 620.

695-2.5 Manufacturer's Warranty : Ensure that the terms and conditions of warranties are documented when submitting equipment submittal for approval. Furnish replacements within 10 calendar days of notification for any part or equipment found to be defective during the manufacturer's warranty period at no cost to the Department. Transfer warranties upon final acceptance in accordance with 5-11. Document all warranties and warranty transfers and submit to the Engineer.

Leave a copy of the warranty in the cabinet once it is installed and submit the warranty to the Engineer. The Engineer will submit warranty forms received from the Contractor to the TDA TMS Manager.

695-3 Vehicle Sensor (Non-Weight) Applications.

695-3.1 General: The vehicle classification site consists of axle sensors and inductive loop sensors. Furnish and install TMS vehicle sensors of the type and at the location shown in the Plans.

695-3.2 Axle Sensor:

Section, Contract Documents, and Standard Plans, Index 695-001. Ensure axle sensors are installed in the roadway and secured using an adhesive bonding agent as listed on the APL.

Allow newly applied friction course to cure for a minimum of 30 days prior to the installation of in-road sensors.

Install axle sensors in the right-hand wheel-path midway between the leading and trailing loops as detailed in Standard Plans, Index 695-001. Install axles sensors in the left-hand wheel-path when no paved shoulder exists and sensor lead exit windows are installed at the right-hand edge of the roadway surface or in a lane which is to the left of and adjacent to an open lane of traffic.

Install the axle sensor such that the cable end is closest to the pull box to which the sensor lead cable will be routed. Install the end of the sensor mid-way into the edge line stripe or lane line stripe. Ensure that the axle sensor being installed has lead-in cables of sufficient length to reach the cabinet without splicing. Do not splice axle sensor lead-in cables.

Route the sensor leads to the pull box then to the TMS cabinet. Mark the sensor leads at the pull box and at termination in the cabinet. Submit lane numbering information as specified in Standard Plans, Index 695-001.

Cut the slot the length of the sensor plus an additional 3 to 4 inches. Ensure the depth and width of the slot is installed as recommended by the sensor manufacturer, typically 0.75 inch wide by 1.5 to 2 inches deep.

Use clips or jigs provided by the manufacturer to suspend the sensor at a uniform depth in the slot. Mix and apply the adhesive bonding agent ensuring the slot is completely full with no voids beneath the sensor.

695-3.2.2 Test Requirements: Perform the manufacturer's recommended on-site pre-installation test to determine the sensor's condition using an Inductive Capacitance Resistance meter. Replace any sensors that fail the pre-installation test.

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Record all test results by lane on the warranty form provided by the manufacturer and leave a copy in the cabinet.

Repeat the test at the termination point in the cabinet after installation. Use an oscilloscope to view and record typical waveforms and signal intensity measurements for the axles of passenger cars and large trucks. Remove and replace any sensor that fails the test at no additional charge to the Department.

Perform an operational test to meet final acceptance requirements. The operational test requires the equipment to operate without deficiencies for a minimum of 14 days prior to final acceptance. The sensor shall be operating without deficiencies at the time of final acceptance. Remove and replace any sensor that fails the operation test at no additional charge to the Department. Final inspection will be completed by FDOT TDA staff for final acceptance.

695-3.3 Non-Intrusive Vehicle Sensors:

695-3.3.1 General: Install motorized (radar, microwave, or video) vehicle sensors on a pole as shown in the Plans, Contract Documents, and Standard Plans, Index 695-001.

695-3.3.2 Installation Requirements: Install the sensor on a pole perpendicular to the target lanes of traffic with room to perform horizontal and vertical aiming adjustments.

Ensure that the wireless vehicle sensor has sufficient cable length to reach the cabinet without splicing. Fasten the cable to the pole so wind does not move it or route the cable within the pole cavity to the cabinet termination point. Provide 18 to 24 inches of slack in the cable at the connections to the sensor and in the cabinet to ensure the cable is stress-free. Include the appropriate mounting hardware and the manufacturer's recommended surge suppression as a part of the installation.

Set up the lane detection zones using the manufacturer's instructions and software and verify that the sensor's orientation is perpendicular to the roadway.

Configure the wireless vehicle sensor for vehicle volume unless otherwise specified in the Plans.

695-3.3.3 Test Requirements: Conduct a visual test to determine that all detection zones are being counted accurately.

Connect a personal computer (PC) to the electronics unit and observe traffic in every lane, verifying that each vehicle is displayed on-screen. A minimum of 20 vehicles should be observed for each lane of traffic with all vehicles counted; assuming a clear line of sight between the sensor and the vehicle being observed is maintained.

If any vehicles are not counted, reconfigure the wireless vehicle sensor and repeat the visual observation test until all lanes count correctly. If the sensor fails to provide accurate counts after three test attempts, it must be replaced with a new unit at no expense to the Department.

Submit a 48 hour verification (class, speed and volume) report for all TMS to the Engineer and leave a copy in the cabinet.

Perform an operational test to meet final acceptance requirements. The operational test requires the equipment to operate without deficiencies for a minimum of 14 days prior to final acceptance. The sensor shall be operating without deficiencies at the time of final acceptance. Final inspection will be completed by FDOT TDA staff for final acceptance.

695-4 Vehicle Speed/Classification Unit.

695-4.1 General: Furnish and install TMS vehicle speed/classification unit (electronics unit) in the TMS cabinet at the locations shown in the Plans.

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Ensure that the vehicle speed/classification unit and equipment cables are compatible and constructed in accordance with the Standard Plans.

Ensure that the vehicle speed/classification unit markings are visible after installation.

695-4.2 Installation Requirements: Furnish and install the electronics unit and equipment cables in accordance with the manufacturer's recommended installation procedure, Standard Plans, Index 695-001, and the Contract Documents.

Ensure that the cables are properly terminated for the prescribed use without further modification by the Department.

Furnish one serial port cable for interconnecting each electronics unit with a PC.

695-4.3 Test Requirements: The electronics unit must collect and distribute vehicle speed and classification data during the 14 day operational testing period and at final acceptance.

695-5 Weigh-In-Motion Electronic Unit.

695-5.1 General: Furnish and install the vehicle weigh-in-motion (WIM) unit in the TMS cabinet at the locations shown in the Plans.

Ensure that the WIM unit and equipment cables are compatible and constructed in accordance with the Standard Plans.

Ensure that the WIM unit markings are visible after installation.

695-5.2 Installation Requirements: Furnish and install the electronics unit and equipment cables in accordance with the manufacturer's recommended installation procedure, Standard Plans, Index 695-001, and the Contract Documents.

Ensure that the cables are properly terminated for the prescribed use without further modification by the Department.

695-5.3 Test Requirements: The electronics unit must collect and distribute weigh-in-motion data during the 30 day operational testing period and at final acceptance.

695-6 Non-Motorized Data Collection Unit.

695-6.1 General: Furnish and install the non-motorized data collection unit in the TMS cabinet at the locations shown in the Plans.

Ensure that the non-motorized data collection unit and equipment cables are compatible and constructed in accordance with the Standard Plans.

Ensure that the data collection unit markings are visible after installation.

695-6.2 Installation Requirements: Furnish and install the electronics unit and equipment cables in accordance with the manufacturer's recommended installation procedure, Standard Plans, Index 695-001, and the Contract Documents.

Ensure that the cables are properly terminated for the prescribed use without further modification by the Department.

695-6.3 Test Requirements: The electronics unit must collect and distribute non-motorized data during the 14 day operational testing period and at final acceptance.

695-7 Weigh-In-Motion Electronic Sensor.

695-7.1 General: The weigh-in-motion (WIM) lane consists of WIM sensors and inductive loops sensors. The first type of WIM sensor, strain gauge sensor, is described in 695-7.3. The second type of WIM sensor, quartz piezoelectric weigh-in-motion sensor, is described in 695-7.4. The inductive loop assembly is described in 695-10. Furnish and install the Traffic

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Monitoring Site (TMS) Weigh-In-Motion Electronic Sensor in the configuration shown on the Standard Plans, Index 695-001. Install in accordance with Manufacturer's instructions.

695-7.2 Installation Requirements: The installer must have a valid certification from the manufacturer for installing the Weigh-In-Motion Electronics Sensors. Use a chalk line or equivalent method to outline the perimeter of the sensor on the pavement and routes for lead-in cables. Do not allow the saw cut in the pavement to deviate more than 1.0 inch from the chalk line. Ensure that all saw cuts are free of any dust, dirt, or other debris and completely dry prior to the installation.

695-7.3 Strain Gauge Sensor: Install two strain gauge sensors in line with each other in each wheel path to cover a 12-foot lane in the roadway. Connect the strain gauge sensors to an interface processor.

Install the strain gauge sensor frames into concrete slabs of 6 inches or more without constructing a special foundation socket. The frames, including strain gauge sensor embedded in it, have an average depth of 1.5 inches.

If the concrete slab is less than 6 inches or if the roadway material is asphaltic concrete, install a special foundation socket of concrete under the frame, just as wide as the frame. Bore 1-inch diameter anchors to a minimum of 8 inches into the base course.

Install the manufacturer provided drain pipe from lower side of the foundation frame towards the slope into the drain water shaft. Ensure that water does not accumulate in the frame and properly drains the frame.

Install the strain gauge sensors in accordance with the manufacturer's installation procedures and in the presence of the manufacturer's representative. Ensure that the procedures are approved by the Engineer.

695-7.4 Quartz Piezoelectric Weigh-In-Motion Sensor: Install two quartz piezoelectric sensors in line with each other in each wheel path to cover a 12-foot lane in the roadway.

Install the quartz piezoelectric sensor by sawing slots into the pavement perpendicular to the flow of traffic, equal to the length of the sensor plus 1 inch, by 2.875 inches wide, and by 2.125 inches deep. Sawcut a 1 inch wide by 2 inches deep cable run slot from the end of the sensor slot to the edge of the pavement shoulder.

Install the quartz piezoelectric sensor into the slot, properly aligned and positioned using specially constructed installation and leveling beams. Pour the manufacturer recommended adhesive bonding agent into the cavity until it is at the proper height above the road surface and allow it to set. After the adhesive bonding agent hardens, grind it to be level with the road surface. The top of the sensor must not deviate more than 1/24 inch above the height of the pavement surface over the length of the sensor.

Route the sensor lead-in cables to the pull box and through the conduit to the traffic monitoring site cabinet. Mark the sensor lead-in cables at the pull boxes and at the point of termination within the traffic monitoring site cabinet, in accordance with Standard Plans, Index 695-001. Connect the cable to the interface card installed in the traffic monitoring cabinet.

695-7.5 Weigh-In-Motion Electronics Sensor Test Requirements: Perform the manufacturer's recommended on-site pre-installation test to determine the Weigh-In-Motion electronics sensor's condition. Install only those Weigh-In-Motion electronics sensors that pass the pre-installation test.

Repeat the test, following installation, at the lead-in point of connection in the traffic monitoring site cabinet. Remove and replace any Weigh-In-Motion electronics sensor which fails the test at no additional cost to the Department. Prior to post-installation acceptance,

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the Contractor shall demonstrate in the presence of the Engineer that the equipment supplied and installed for the system is in full compliance with the Plans and Specification herein.

The Department will operate the complete system for 30 consecutive days without failures prior to Final Acceptance. The Department will poll the site and statistically check data from historical data, field collected data and field observations. In the event of failures, the Contractor shall correct the problem(s) and restart the 30-day test. Any equipment or labor that is found to be defective during the operation test and prior to Final Acceptance shall be replaced or corrected at no expense to the Department. Final Acceptance will be made upon the successful completion of the 30-day test.

Place a copy of the final test results, including the date of installation, manufacturer's name, model number for each Weigh-In-Motion electronics sensor, laboratory calibration sheet provided by the manufacturer, and type of adhesive bonding agent used in a waterproof package in the cabinet and furnish one copy to the Engineer.

695-8 Non-Motorized Sensor Applications.

695-8.1 General: The non-motorized site uses axle sensors, inductive loops sensors, and infrared sensors. The inductive loop assembly is described in 695-10. Furnish and install TMS non-motorized sensors of the type and at the location shown in the Plans and Index 695-001.

695-8.2 Non-motorized Axle Sensor:

695-8.2.1 Installation Requirements: Allow newly applied friction course to cure for a minimum of 30 days prior to the installation of in-path sensors.

Ensure axle sensors are installed in the pathway and secured using an adhesive bonding agent as listed on the APL.

Cut the slot the length of the axle sensor plus an additional 3 to 4 inches. Ensure the depth and width of the slot is installed as recommended by the sensor manufacturer. Ensure that all saw cuts are free of any dust, dirt, or other debris and completely dry prior to the installation.

Use clips or jigs provided by the manufacturer to suspend the sensor at a uniform depth in the slot. Mix and apply the adhesive bonding agent ensuring the slot is completely full with no voids beneath the sensor. Once cured, grind down excess adhesive bonding agent to be level with the road surface, sidewalk, side path, or shared-use path.

695-8.2.2 Test Requirements: Perform the manufacturer's recommended on-site pre-installation test to determine the sensor's condition using an Inductive Capacitance Resistance meter. Install only those sensors that pass the pre-installation test. Record all test results on the warranty form provided by the manufacturer and leave a copy in the cabinet.

Repeat the test at the termination point in the cabinet after installation. Use an oscilloscope to view and record typical waveforms and signal intensity measurements for the axles of non-motorized vehicles.

Connect a personal computer (PC) to the electronics unit and observe bicycles and pedestrians in the pathway, verifying the detection of each non-motorized vehicle on-screen. A minimum of 20 non-motorized vehicles shall be observed with all non-motorized vehicle manually counted.

If any non-motorized vehicles are not counted by the sensor, reconfigure the sensor and repeat the visual observation test until all are counted correctly. If the sensor fails to provide accurate counts after 3 test attempts, it must be replaced with a new unit at no expense to the Department.

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The sensor shall operate without any deficiencies for two weeks after installation and at final acceptance. Remove and replace any sensor that fails the 14 day operation test at no additional charge to the Department.

Submit all documents to the Engineer and leave a copy of the report in the cabinet.

695-8.3 Infrared Sensors:

695-8.3.1 Installation Requirements: For grade level applications, install the sensor perpendicular to the pathway and pointed parallel to the ground. The sensor shall not point towards the vehicular traffic lane, reflective surfaces, direct sunlight exposure, or moving infrastructure. Ensure that the sensor has sufficient cable length to reach the cabinet without splicing.

For overhead applications, route the cable within the pole cavity or conduit to the cabinet termination point. Provide 18 to 24 inches of slack in the cable at the connections to the sensor and in the cabinet to ensure the cable is stress-free. Include the appropriate mounting hardware as a part of the installation.

Set up the detection zones using the manufacturer's instructions and software and verify that the sensor's orientation is perpendicular to the pathway.

Configure the sensor for pedestrian and bicycle traffic.

695-8.3.2 Test Requirements: Conduct a visual test to determine that all detection zones are being counted accurately.

Connect a personal computer (PC) to the electronics unit and observe traffic in the pathway, verifying that each non-motorized vehicle or pedestrian is displayed on-screen. A minimum of 20 non-motorized vehicles and 20 pedestrians shall be observed with all non-motorized vehicles and pedestrians counted.

If any non-motorized vehicles or pedestrians are not counted, reconfigure the infrared sensor and repeat the visual observation test until all are counted correctly. If the sensor fails to provide accurate counts after 3 test attempts, it must be replaced with a new unit at no expense to the Department.

The sensor shall operate without any deficiencies for two weeks after installation and at final acceptance. Remove and replace any sensor that fails the 14 day operation test at no additional charge to the Department.

Submit all documents to the Engineer and leave a copy of the report in the cabinet.

695-9 TMS Solar Power Unit.

695-9.1 General: Furnish and install TMS solar power units at the locations and as shown in the Plans and Standard Plans. Solar power units are used to power TMS that collect vehicular data and non-motorized data on a continuous basis. The solar power unit consists of the following components: solar panel(s) and mounting hardware; 12 V storage battery; and voltage regulator with wiring and associated mounting hardware.

695-9.2 Testing Requirements: Solar panels must be tested by setting the multi-meter to volts setting and connecting the positive lead to the solar panel's positive wire. Then connect the multi-meter's negative lead to the solar panel's negative wire. The volt reading on the multi-meter should be no less than 20 volts. If the volts are less, then there is a problem with the solar panel output. Go back and check all connections of the solar panel and check for cracks in the solar cells. Next test the solar panel for amperage by setting the multi-meter to amps setting and follow the above-mentioned steps. The amp reading should be no less than 4.25 amps. If the

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amperage is less, then there is a problem with the solar panel output. Go back and check all the connections of the solar panel and check for cracks in the solar cells.

The panels shall operate without any deficiencies for two weeks after installation and at final acceptance. Remove and replace any panels that fail the 14 day operation test at no additional charge to the Department.

Submit all documents to the Engineer and leave a copy of the report in the cabinet.

695-10 Inductive Loop Assembly.

695-10.1 General: Install TMS motorized inductive loop assembly and non-motorized inductive loop assembly at the locations shown in the Plans. Ensure that all materials furnished, assembled, or installed are new products.

Install loop wire in accordance with Standard Plans, Index 695-001. Install the inductive loops such that the loop leads reach the cabinet. Do not splice loop leads.

695-10.2 Installation Requirements:

695-10.2.1 Saw Cuts: Perform saw cuts across concrete pavement expansion joints as detailed in Standard Plans, Index 695-001.

For pavement thickness greater than or equal to 2 inches deep, make saw cuts deep enough to allow 1 to 1-1/2 inch of sealant cover over the installed loop wire.

For pavement thickness less than 2 inches, make the saw cut depth to 1 inch.

695-10.2.2 Loop Wire: Ensure that all motorized vehicular loops have four complete turns of wire and all non-motorized vehicle loops have eight complete turns of No. 14 AWG stranded copper wire that meet the requirements of International Municipal Signal Association (IMSA) 51-7, wound in a clockwise manner. Do not damage the insulation.

For roadways, ensure that the hold down material is non-metallic; placed in the saw slot using segments 1 to 2 inches long, spaced 12 inches apart; and the distance from the top of the hold down material to the final roadway surface is not less than 1-1/2 inches.

For sidewalks, side paths, or shared use paths, the distance from the top of the non-metallic hold down material to final surface elevation must be 1/2 inch or greater.

Install inductive loops in the pathway and secure using loop sealant listed on the APL. Avoid installation of inductive loops in areas that have electromagnetic interference from power lines (overhead or underground) or buried telecommunication equipment or in the proximity of other inductive loops.

695-10.2.3 Loop Wire Twisted Pair Lead: For motorized vehicular loops, create a loop wire twisted pair lead by twisting the loop wire pair a minimum of 8 to 16 twists per foot from the edge of the loop to the termination point in the cabinet. Provide a minimum of 3 feet of twisted loop wire pair lead in the pull box located adjacent to the roadway. For non-motorized vehicle loops, create a loop wire twisted pair lead by twisting the loop wire pair 10 twists per foot from the edge of the loop to the termination point. Splicing of the loop wire is not permitted.

695-10.2.4 Loop Sealant: Use loop sealant in accordance with Section 997. Prepare and apply the sealant in accordance with the manufacturer’s instructions. Remove excess sealant from the roadway surface. Ensure that the loop sealant has cured completely before allowing vehicular traffic to travel over the sealant.

695-10.3 Testing: Conduct all testing with the leads disconnected from the backplane. The loops shall operate without any deficiencies for two weeks after installation. Remove and

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replace any loop that fails the 14 day operation test at no additional charge to the Department. Submit all documents to the Engineer and leave a copy of the report in the cabinet.

695-10.3.1 Motorized Vehicular Loop Resistance: Ensure new loops have a resistance reading of 3.0 Ω or less.

695-10.3.2 Motorized Vehicular Loop Inductance: Ensure new loops have a minimum inductance reading of 100 μH.

695-10.3.3 Motorized Vehicular Loop Insulation Resistance (Megging): Ensure new loops have a minimum reading of 200 MΩ at 500 V.

695-10.3.4 Non-Motorized Vehicular Loop Resistance: Ensure new loops have a resistance reading of 3.0 Ω or less.

695-10.3.5 Non-Motorized Vehicular Loop Inductance: Ensure new loops have an inductance reading of 100 to 150 μH.

695-10.3.6 Non-Motorized Vehicular Loop Insulation Resistance (Megging): Ensure new loops have a minimum reading of 200 MΩ at 500 V.

695-11 TMS Cabinet.

695-11.1 General: Furnish and install Type III, IV or V TMS cabinets in accordance with Section 676 and Standard Plans, Index 695-001.

695-11.2 Materials:

695-11.2.1 General: Only use TMS cabinets and components currently listed on the Department's APL. Ensure that the cabinet and components are compatible with the other components installed at the location.

695-11.2.2 Shelf: Ensure that the cabinet has an adjustable shelf, constructed of 0.08 inch thick aluminum, that is adjustable to within 15 inches of the top of the cabinet and to within 26 inches of the bottom of the cabinet in 2 inch increments.

695-11.2.3 Backplane and Cabinet Cable: Furnish and install as specified in the Standard Plans, Index 695-001.

695-11.2.4 Suppression Devices: Furnish and install suppression devices per manufacturers recommendation.

695-11.3 Installation Requirements: Install the TMS cabinet in accordance with the Plans, Standard Plans and manufacturer's recommended installation procedure. Ensure that all conduit entrance holes or field drilled holes are reamed and free of burrs. Use clear silicone rubber sealant to make all conduit connections to the cabinet watertight. Perform all excavation and backfill in accordance with 125-4 and 125-8.2.

695-11.3.1 Pole Mounted Traffic Monitoring Site Cabinets (Types III and IV): Install pole mounted traffic monitoring site cabinets in accordance with Standard Plans, Index 676-001 and 695-001.

695-11.3.2 Base Mounted (Type IV and V) and Pedestal Mounted (Type III) Traffic Monitoring Site Cabinets: Install base and pedestal mounted traffic monitoring site cabinets in accordance with Standard Plans, Index 676-001 and 695-001.

Ensure that the end of the conduit riser is a minimum of 2 inches above the finished surface of the concrete base.

695-12 TMS System Communications Modem.

695-12.1 General: Furnish and install the TMS modem and antenna in the cabinet at the TMS location shown in the Plans.

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Furnish and install all cables required to connect the modem to the electronics unit. Furnish and install all antenna cables.

695-12.2 Commercial Software Registration: Ensure that the Department is registered as the end-user of software installed on the system communications.

695-12.3 Installation Requirements: Install the TMS modem and antenna in accordance with the manufacturer's recommended installation procedure.

695-12.4 Test Requirements: The modem and antenna shall operate without any deficiencies for two weeks after installation. The modem and antenna must transmit and receive TMS data during the 14 day operational testing period and at final acceptance. Remove and replace any modem and antenna that fails the operation test at no additional charge to the Department. Submit all documents to the Engineer and leave a copy of the report in the cabinet.

695-13 TMS Managed Field Ethernet Switch.

695-13.1 General: Furnish and install the Managed Field Ethernet Switch (MFES) in the cabinet at the TMS location shown in the Plans. Furnish and install all cables required to connect the MFES to the cabinet equipment. Furnish and install all fiber optic jumpers required to connect the MFES to the patch panel.

695-13.2 Installation Requirements: Install the MFES in accordance with the manufacturer's recommended installation procedure.

695-13.3 Test Requirements: The MFES must transmit and receive TMS data over the Department's fiber network. The MFES shall communicate with the TMS central data repository. The MFES must operate within the TMS solar site power and battery backup system constraints. All MFES functions shall be operational during the operational testing period and at final acceptance.

The MFES shall operate without any deficiencies for two weeks after installation. The MFES must transmit and receive TMS data during the 14 day operational testing period and at final acceptance. Remove and replace any MFES that fails the operation test at no additional charge to the Department. Submit all documents to the Engineer and leave a copy of the report in the cabinet.

695-14 Method of Measurement.

The Contract unit price for each vehicle axle sensor will include the vehicle sensor, lead-in cables, adhesive bonding agent; and all equipment, materials, testing and labor necessary for a complete and accepted installation.

The Contract unit price for each non-intrusive vehicle sensor will include the vehicle sensor, cables, conduit, conduit accessories such as the weatherhead and couplings; and all equipment, materials, testing and labor necessary for a complete and accepted installation.

The Contract unit price per assembly for the vehicle speed/classification unit includes the electronics unit and equipment cable, all equipment, materials and labor necessary for a complete and accepted installation.

The Contract unit price per assembly for the weigh-in-motion unit includes the electronics unit and equipment cable, all equipment, materials and labor necessary for a complete and accepted installation.

The Contract unit price per assembly for the non-motorized data collection unit includes the electronics unit and equipment cable, all equipment, materials and labor necessary for a complete and accepted installation.

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The Contract unit price for each Weigh-In-Motion Electronics Sensor, furnished and installed, will consist of the Weigh-In-Motion sensor, lead-in cable(s), adhesive bonding agent, loop sealant, all equipment, materials, and labor necessary for a complete and accepted installation.

The Contract unit price for each non-motorized axle sensor will include the sensor, lead-in cables, adhesive bonding agent, loop sealant; and all equipment, materials, testing and labor necessary for a complete and accepted installation.

The Contract unit price for each non-motorized infrared sensor will include the infrared sensor, mounting hardware, cabling; and all equipment, materials, testing and labor necessary for a complete and accepted installation.

The Contract unit price for each solar power unit includes the solar power unit as specified in the Contract Documents, all equipment, materials (weatherhead, conduit, conduit accessories), and labor necessary for a complete and accepted installation.

The Contract unit price for each inductive loop assembly includes loop wire, loop sealant, all equipment, materials, testing, and labor necessary for a complete and accepted installation.

The Contract unit price for each TMS cabinet includes the TMS cabinet, shelf, suppression device, and backplane components as specified in the Contract Documents, all equipment, materials, and labor necessary for a complete and accepted installation. The cost of the base or pedestal, as shown in the Standard Plans, is included in the cost of the cabinet. The cost of the pole for pole mounts will be paid in accordance with Section 646.

The Contract unit price for each TMS modem will include the modem and all equipment, materials, and labor necessary for a complete and accepted installation.

The Contract unit price for each TMS antenna will include the antenna and all equipment, materials, and labor necessary for a complete and accepted installation.

The Contract unit price for each TMS Managed Field Ethernet Switch (MFES) will include the MFES and all equipment, materials, and labor necessary for a complete and accepted installation.

695-15 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 695- 1-	TMS Vehicle Axle Sensor - Non-Weight Applications- each.
Item No. 695- 2-	TMS Vehicle Non-Intrusive – Non-Weight Applications – each.
Item No. 695- 3-	TMS Vehicle Speed/Classification Unit - per assembly.
Item No. 695- 5-	TMS Solar Power Unit - each.
Item No. 695- 6-	TMS Inductive Loop Assembly – each.
Item No. 695- 7-	TMS Cabinet - each.
Item No. 695- 8-	TMS System Communications Modem – each.
Item No. 695- 9-	TMS Weigh-In-Motion Axle Sensor – each.
Item No. 695- 10-	TMS Weigh-In-Motion Unit – per assembly.
Item No. 695- 11-	TMS Non-Motorized Data Collection Unit – per assembly.
Item No. 695- 12-	TMS Non-Motorized Axle Sensor – each.
Item No. 695- 13-	TMS Non-Motorized Infrared Sensor – each.
Item No. 695- 14-	TMS Non-Motorized Inductive Loop Assembly – each.
Item No. 695- 15-	TMS Non-Motorized Solar Power Unit – each.

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Item No. 695- 16- TMS Surge Suppressor – each.
Item No. 695- 17- TMS Patch Panel – each.
Item No. 695- 18- TMS Managed Field Ethernet Switch – each.

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SECTION 700
HIGHWAY SIGNING

700-1 Description.

Furnish and install roadway signs in accordance with the details in the Standard Plans and as shown in the Plans.

Erect ground traffic signs as signs on the shoulders, slopes, or medians. Signs are classified as single column(post), multi-column, or In-Street signs.

Erect overhead traffic signs partially or completely over the traveled roadway or mounted on bridges. Overhead traffic signs are classified as span wire mounted, mast arm mounted, overhead cantilever structure, or overhead span structure traffic signs.

The sign face(s) may be a single or combination of static sign panels, illuminated sign panels, dynamic message signs, or electronic display signs.

Fabricate standard sign panel messages in accordance with details included in the Standard Highway Signs (SHS) manual published by the U.S. Department of Transportation, the Plans, or Standard Plans. Submit shop drawings to the Department for approval, as specified in Section 5.

All Traffic Control Signals and Devices must meet the requirements of Section 603.

700-2 Materials.

700-2.1 General Requirements: Meet the following requirements:

Flowable Fill for precast foundation.....Section 121
Structural Concrete .....Section 346
Non-Structural Concrete .....Section 347
Reinforcing Steel .....Section 415
Structural Steel Welding.....Section 460
Repair of Galvanized Surfaces.....Section 562
Transformer Base.....Section 965
Structural Steel and Miscellaneous Metal Items
(other than aluminum).....Section 962
Aluminum Items .....Section 965
Retroreflective Sign Sheeting* .....Section 994
Sign Panel Fabrication .....Section 994
Internally Illuminated Signs*..... Section 995-14
Highlighted Signs*..... Section 995-15
Dynamic Message Signs* ..... Section 995-16
Electronic Display Signs
(ERS, ESFS, BOS)*..... Section 995-17
Sign Beacon* ..... Section 995-18
In-street Sign* ..... Section 995-19

*Use products listed on the Department's Approved Products List (APL).

700-2.2 Static Sign Assembly Requirements:

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700-2.2.1 Static Sign Panels: Provide aluminum sheets for sign panels meeting the requirements of Section 965 and Section 994. Meet the minimum thickness requirements of Table 700-1.

For flip signs, use continuous hinges constructed of ANSI grade 316 stainless steel.

For In-Street signs, see 700-7.

Table 700-1 Static Sign Panel Requirements	
Type	Minimum Thickness
Single column ground sign	0.08 inch
All other sign panels	0.125 inch

700-2.2.2 Sign Panel Mounting Hardware: Provide aluminum materials (plates, bars, shapes, bolts, nuts, and washers) in accordance with Section 965. Stainless steel mounting hardware meeting Table 962-6 (ASTM F593 for bolts and ASTM F594 for nuts) may be substituted. Steel plates, shapes and hardware must meet Section 962.

700-2.2.3 Retroreflective Sign Sheeting: Sign sheeting must meet the requirements of Section 994 and Table 700-2.

Table 700-2 Retroreflective Sign Sheeting*		
Application	Sheeting System Type	Notes
All signs and retroreflective strips, except as otherwise noted below	Type XI	
School: S1-1, S3-1, S3-2, S4-5, S4-5a, S5-1 (SCHOOL portion) Bicycle: W11-1 Pedestrian: R1 6, R1 6a, R1 6b, R1 6c, R1 9, R1 9a, R10 15, W11 2 Shared Use Path (trail): W11 15, W11 15a	Type XI fluorescent yellow green sheeting**	Includes supplemental panels
* All digitally printed signs and red silkscreen inks require a clear overlay for UV protection. **Do not mix signs having fluorescent yellow green sheeting with signs having yellow retroreflective sheeting.		

700-2.3 Galvanized Bolt Assemblies (Bolts, Nuts, Washers): Provide galvanized bolt assemblies meeting Section 962 for high-strength steel fastener assemblies. Provide galvanized anchor rods, plate washers, U-bolts, and shims meeting the requirements of Section 962 for hardware not designated as high strength.

700-2.4 Sign Support Structure:

700-2.4.1 Single Column Ground Signs and Single Post Barrier Mounted Signs: Use aluminum tubing meeting the requirements of Section 965. For top-mounted single post barrier mounted signs use galvanized steel pipe meeting the requirements of Section 962. Steel shapes and welding must meet 962-10.

700-2.4.2 Multi-Column Ground Signs: Multi-column signs must be galvanized steel W or S beams steel columns meeting Section 962.

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700-2.4.3 Overhead Signs: Obtain overhead sign structures from a facility that is listed on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.

Meet the requirements for overhead signs in accordance with Section 962.

Repair galvanized surfaces in accordance with Section 562. Galvanizing materials used for repair must meet the requirements of Section 975.

700-2.4.4 Enhanced Highway Sign Assemblies: Use aluminum pedestal posts, transformer bases, anchors, caps, and shims meeting the requirements of Section 646.

700-2.5 Storage, Handling and Labeling: If signs are stored prior to installation, store them in accordance with the manufacturer's recommendations. Properly package signs to protect them during storage, shipment and handling to prevent damage to the sign face and panel.

Install a label on all permanent roadway signs on the back bottom edge with the date of installation, APL number of the base sheeting, and Name of Fabricator. Make the labels unobtrusive, but legible enough to be easily read by an observer on the ground when the sign is in its final position. Apply the label in a manner that is at least as durable as the sign face.

700-2.6 Acceptance of Signs:

700-2.6.1 Sign Inspection: Submit certification that the sign assembly meets the material and installation requirements of the Contract Documents. The Engineer will inspect the signs upon delivery to the storage or project site and again at the final construction inspection. Repair and replace damaged signs at no expense to the Department.

700-2.6.2 Imperfections and Repairs: Repair or replace signs containing imperfections or damage regardless of the kind, type, or cause of the imperfections or damage. For sign panels exceeding 30 square feet, the Contractor may make one patch, if necessary, to each sign panel not to exceed two square inches. Make repairs according to the manufacturer's recommendations. Ensure that completed repairs provide a level of quality necessary to maintain the service life of the sign and are satisfactory in appearance to the Engineer.

700-3 Static Signs.

700-3.1 Single Column and Multi-Column Ground Sign Assemblies: Furnish and install single column and multi-column ground signs in accordance with the Plans and Standard Plans, Indexes 700-010, 700-011, and 700-020.

700-3.1.1 Foundation: Construct foundations in accordance with the applicable Standard Plans. The Contractor may use precast foundations in augured or excavated holes a minimum of 12 inches larger than each axis dimension of the precast foundation. Obtain precast foundations from a plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.The holes must be clean and without loose material. Temporary casing will be required if the soil is unstable. Fill the void around the precast foundation with flowable fill meeting the requirements of Section 121 or use clean sand placed using hydraulic methods.

700-3.1.2 Breakaway Support Mechanisms for Ground Traffic Signs:

700-3.1.2.1 Frangible Supports: Provide support posts for all frangible sign assemblies consisting of aluminum tubes up to 3-1/2 inches outside diameter with 3/16-inch wall thickness in accordance with the requirements in the Standard Plans.

700-3.1.2.2 Slip Bases: Slip base assemblies for single column signs will use aluminum sleeves and base plates. The slip base stub (the lower base plate assembly) may be galvanized steel in accordance with the Standard Plans.

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Slip base assemblies for multi-column signs will use galvanized steel bases. All slip bases must be fabricated in accordance with the requirements of the Standard Plans.

700-3.1.3 Fabrication: Fabricate the supports and wind beams in accordance with the Standard Plans. Weld joints in accordance with Section 460.

Drill or sub-punch and ream holes in multi-column fuse plates and hinge plates.

Hot dip galvanize after fabrication. Remove all drips, runs or beads on base plate within washer contact areas (including saw cuts).

700-3.1.4 Installation: Verify the length of the column supports in the field prior to fabrication to permit the appropriate sign mounting height. Columns must be plumb and panels must be level with the proper orientation.

700-3.1.5 Retroreflective Strips for Signs: Use with static Wrong-Way Signs in accordance with Standard Plans, Index 700-101 and on other signs where retroreflective strip is called for in the Plans. The retroreflective strip must be 2 inches in width and 5 feet in height for all signs, except for signs mounted at a height of 4 feet, then use a retroreflective strip 2 feet in height. For the back of Railroad Crossbuck signs, the retroreflective strip will be 2 inches wide for the full length of the blade. Match the color of the retroreflective strip to the background color of the sign (per the SHS), except for YIELD signs and DO NOT ENTER signs, where the color must be red. Install retroreflective strips directly to a panel attached to the column in accordance with the manufacturer's instructions. Use a 0.040-inch minimum aluminum plate or other material approved by the sheeting manufacturer. Use stainless steel attachment hardware for the installation. Install retroreflective strips in a manner that does not require drilling holes through the column (post). A set screw no larger than 1/4 inch may be used with band attachments

700-3.1.6 Flip Signs: Install in accordance with the Plans and Standard Plans Index 700-010.

700-3.2 Single Post Barrier Mounted Signs: Meet the requirements of the Standard Plans, Indexes 700-012 and 700-013. Snap-in post cap is UV and weather-resistant glass-filled polyester cap.

700-3.3 Overhead Signs: Meet the requirements of the Plans and Standard Plans for overhead sign structures, including those for walk-in dynamic message signs (DMS).

700-3.3.1 Fabrication: Weld joints in accordance with Section 460.

Structural bolt hole diameters: Bolt diameter plus 1/16 inch.

Anchor bolt hole diameters: Bolt diameter plus 1/2 inch.

Upright splices are not allowed. Sign trusses may be fabricated in sections that fit into available galvanizing vats. Provide magnetic particle testing on 100% of upright fillet welds after galvanizing.

Shop assemble the entire structure after galvanizing to validate proper fit for all bolted connections. Complete necessary repairs prior to shipping. Assemblies may be separated for shipment.

700-3.3.2 Foundations: Meet the requirements of Section 455. Use Class IV concrete for spread footings and IV (Drilled Shaft) for drilled shaft foundations.

700-3.3.3 Installation: Install nuts on anchor bolts in accordance with Section 649 with the following exception. For cantilever overhead sign structures, after placement of the upright and prior to installation of the truss, adjust the leveling nuts beneath the

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base plate to achieve the back rake shown on the Camber Diagram. If the top surface of the base plate has a slope that exceeds 1:40, use beveled washers under the top nuts. Split-lock washers are not permitted.

Install screens or grout pads in accordance with the Standard Plans, and as required by Section 649.

Install ASTM F3125, Grade A325 bolt, nut and washer assemblies in accordance with 460-5, except that 460-5.4.2 Preparation of Faying Surfaces is not required.

700-3.3.4 Erection of Signs and Sign Supports: Do not erect overhead sign supports until the concrete strength in the support footing is at least 2,500 psi. Determine concrete strength from tests on a minimum of two test cylinders sampled and tested in accordance with ASTM C31 and ASTM C39 and verifying test results have been submitted to the Engineer.

Erect the signs and sign structures in accordance with the details shown in the Plans. Re-galvanize damaged parts as specified in Section 562. Record the as-built anchor locations and submit to the Engineer prior to erecting the sign supports. Place backfill above spread footings prior to installation of the sign panels. Do not remove or reduce backfill without prior approval of the Engineer.

700-4 Enhanced Highway Sign Assemblies.

700-4.1 Description: Furnish and install enhanced highway sign assemblies in accordance with the Plans and Standard Plans, Index 700-120.

700-4.2 Materials: Use flashing beacons, highlighted signs, electronic display signs (EDS), and associated mounting hardware that meet the requirements of Section 995 and are listed on the APL. EDS are specialized electronic signs that include dynamic display components. The term EDS refers to a general category of electronically enhanced road signs (ERS) with warning regulatory, or guide legends; electronic speed feedback signs (ESFS); and blank-out signs (BOS).

For new roadside sign assemblies, provide support structure in accordance with Section 646. Meet all static sign requirements for the static portion of the highlighted sign (i.e., sign panel, reflective sheeting, etc.).

700-4.2.1 Warranty: Ensure that beacons, highlighted signs, and EDS have a manufacturer’s warranty covering defects for three years from the date of final acceptance by the Engineer in accordance with 5-11 and Section 608.

700-4.3 Foundations: Construct foundations in accordance with the Standard Plans and Specification 646.

700-4.4 Installation: Install sign assembles based on Alpha-Numeric Type designation shown in the Plans. Assembly Type is based on Power Configuration “Alpha” Identification and Numerical Identification shown in Standard Plans, Index 700-120. Install sign panel and wind beam meeting the requirements of this Section and Standard Plans, Index 700-110. For roadside sign assemblies, construct foundation and install support structure in accordance with 646-3 and the Standard Plans, Index 700-120. Install enhanced highway sign assembly components in accordance with the manufacturer’s recommendations.

700-5 Internally Illuminated Signs.

700-5.1 Description: Furnish and install internally illuminated signs in accordance with the details specified in the Contract Documents.

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700-5.2 Materials: Use internally illuminated signs and associated mounting hardware listed on the Department's Approved Product List (APL).

Use clamp-on cantilever arms for internally illuminated signs which meet all design and wind loading requirements as specified in the Contract Documents. Ensure the clamp is adjustable to accommodate various size poles.

700-5.2.1 Acceptance of Internally Illuminated Signs: Certify that signs and clamp-on cantilever arms provided meet the criteria in this Section and Section 995.

700-5.2.2 Warranty: Ensure that internally illuminated signs have a manufacturer's warranty covering defects for five years from the date of final acceptance by the Engineer in accordance with 5-11 and Section 608.

700-5.3 Installation of Internally Illuminated Signs: Secure the brackets to the sign housing in accordance with the manufacturer's instructions.

700-5.3.1 Double Sided Sign Assembly: Use a free swinging mounting method.

700-5.3.2 Two Point Support Assembly: Use a two point support assembly when the sign assembly is attached to a mast arm that is perpendicular to the street on which the sign is viewed.

Use a two point mast arm mounting assembly consisting of the following:

1. Stainless steel band or cable type clamp,
2. Clevis,
3. Span wire adapter,
4. Tri-stud hanger body.

Ensure one of the hangers has a mechanism for the horizontal adjustment of the sign.

700-5.3.3 One Point Support Assembly: Use a one point support assembly consisting of an articulated horizontal stainless steel band or cable type mast arm clamp, sign bracket and mounting hardware, when the sign assembly is attached to a mast arm that is diagonal to the street on which the sign is viewed. Do not use a one point support assembly for internally illuminated sign assemblies exceeding four feet in width.

Ensure the band or cable clamp is capable of horizontal rotation of 360 degrees.

700-5.3.4 Clamp-On Cantilever Arm: Attach the arm perpendicular to the street on which the sign assembly is viewed. Use a clamp and arm that are galvanized in accordance with ASTM A123 unless otherwise shown in the Plans. Ensure the arm has a cap secured in place.

700-5.3.5 Electrical Wiring: Unless otherwise shown in the Plans, install dedicated 14 AWG conductors to supply power to the sign and connect the conductors to a dedicated 15 amp circuit breaker located either inside the controller cabinet or inside the electrical service disconnect. Using the same conduit system for both signal cables and internally illuminated sign conductors is permitted, unless otherwise shown in the Plans.

Install conductors in such a manner as to prevent damage to conductors or conductor insulation. Remove and replace all damaged conductors /insulation at no additional cost to the Department.

Ensure drilled holes through which conductors pass through are fitted with a weather tight rubber grommet fitting.

Install continuous lengths of conductors between the dedicated circuit breaker and internally illuminated signs.

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Do not splice conductors unless otherwise shown in the Plans.

Provide one photoelectric cell for all internally illuminated signs at each intersection. Use an L bracket to mount the photoelectric cell as specified in the Contract Documents. Connect the photoelectric cell to a contactor assembly inside the controller cabinet to provide switching of the internally illuminated signs.

700-6 Dynamic Message Signs.

700-6.1 General: Provide monochrome, tri-color, or full-color signs as shown in the Plans.

700-6.2 Sign Housing Requirements for all DMS: Ensure that the sign housing design and appearance is approved by the Engineer.

700-6.3 Characters, Fonts, and Color: Submit a list of the character fonts to the Engineer for approval.

700-6.4 Main Power Supply and Energy Distribution Specifications: Provide Type XHHW power cables sized as required by the NEC for acceptable voltage drops while supplying alternating current to the sign.

700-6.5 Uninterruptible Power Supply (UPS): The UPS system must be capable of displaying the current messages on a sign when a power outage occurs. Signs with an UPS must be able to operate on battery power and display text messages for a minimum of two hours.

700-6.6 Operational Support Supplies: Furnish the operational support supplies listed in Table 700-3. Promptly replace any of the supplies used to perform a warranty repair prior to final acceptance.

For every group of 10 or fewer DMSs provided or required, provide one set of supplies as follows:

Table 700-3
DMS Operational Support Supplies

1 each	Sign controller and I/O board(s)
1 per DMS	LED display modules
1 each	Display power supply
1 each	Uninterruptible power supply
2 each	Surge suppression sets
1 each	Fan assembly

700-6.7 Message and Status Monitoring: Ensure that the sign can perform the following functions:

1. Control Selection – Ensure that local or remote sign control can be selected.
2. Message Selection – Ensure that the sign controller can select a blank message or any one of the messages stored in the sign controller's nonvolatile memory when the control mode is set to local.
3. Message Implementation – Ensure that the sign controller can activate the selected message.

Ensure that each font may be customized, and modifications to a font may be downloaded to the sign controller from the TMC or a laptop computer at any time without any software or hardware modifications.

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Ensure that there is no perceivable flicker or ghosting of the pixels during sign erasure and writing periods.

700-6.8 TMC Communication Specification for all DMS:

Provide communications line circuits that are point-to-point or multipoint, and that provide full duplex asynchronous data transmissions at the rate shown in the Contract Documents or directed by the Engineer.

Assign each sign controller a unique address.

700-6.9 Sign Control Software: Ensure that the laptop computer and sign can communicate when connected directly by an EIA-232 cable and via Ethernet. Ensure that the software allows communication between multiple users and multiple signs across the same communication network.

700-6.10 Sign Support Structure: Meet the requirements of 700-2.3.

700-6.11 Installation Requirements: Provide a walk-in DMS for locations over interstate travel lanes. Verify that any ventilation system incorporated within the sign is operational per the manufacturer's recommendations.

Install the DMS in accordance with the manufacturer's recommendations and Standard Plans, Index 700-090.

Ensure that the location of the lifting eyebolts, left in place or removed, is sealed to prevent water entry after installation.

Load the initial message libraries on both the sign control software and the sign controller. The Engineer will furnish the messages to be placed in these libraries.

700-6.12 Documentation: Submit documentation for electronic equipment in accordance with 603-6.

700-6.13 Licensing: Ensure that the manufacturer grants the Department a license that allows the Department to use and internally distribute any and all sign communications protocols, operating systems, drivers, and documentation.

700-6.14 Technical Assistance: Ensure that a manufacturer's representative is available to assist the Contractor's technical personnel during pre-installation testing and installation.

Do not provide initial power to the signs without the permission of the manufacturer's representative.

700-6.15 Pre-installation Field Testing: Conduct pre-installation tests on all units at a Contractor-provided facility within the appropriate District. Perform the tests on each unit supplied to verify that no damage was done to any sign during the shipment and delivery process. Notify the Engineer a minimum of 10 calendar days before the start of any tests. Conduct all tests according to the approved test procedures detailed in this Section. Each DMS must pass the individual tests detailed below prior to installation.

700-6.15.1 Material Inspection: Examine each DMS carefully to verify that the materials, design, construction, markings, and workmanship comply with all applicable standards, specifications, and requirements.

700-6.15.2 Operational Test: Operate each DMS long enough to permit equipment temperature stabilization, and to check and record an adequate number of performance characteristics to ensure compliance with applicable standards, specifications, and requirements.

700-6.15.3 Pre-Installation Test Failure Consequence: If any unit fails, the unit shall be corrected or another unit substituted in its place and the test repeated.

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If a unit has been modified as a result of a failure, a report shall be prepared and submitted to the Engineer. The report shall describe the nature of the failure and the corrective action taken.

If a failure pattern develops, the Engineer may direct that design and construction modifications be made to all units without additional cost to the Department or an extension of the Contract Time.

700-6.16 Installed Site Tests: Conduct Intelligent Transportation System Device Installation testing in accordance with Section 611.

700-6.17 System Testing: Conduct Intelligent Transportation System Device Installation testing in accordance with Section 611.

700-7 In-Street Sign Assemblies.

700-7.1 Description: In-Street signs consist of the R1-6a or R1-6c In-Street Pedestrian Crossing Sign assemblies including the sign base.

700-7.2 Fabrication of Panel Messages: Fabricate standard sign panel messages in accordance with the Standard Plans. Sign panels of 9 inches in width x 27 inches in height or 12 inches x 36 inches are acceptable. See Standard Plans Section 700-102.

700-7.3 Installation: Install a fixed base connection in accordance with the manufacturer's instructions. Install portable base connections only for temporary applications at school crossings where a crossing guard is present during school arrival and departure times or when children are present.

700-8 Warranty.

Refer to Section 608 for Contractor Requirements. Transfer all warranties from the Manufacturer to the Department.

700-9 Method of Measurement.

700-9.1 Single Column Ground Sign Assembly: Measurement will be made per each and will consist of all signs mounted on a single column (post). Area measurement for an assembly will include the total sheeting area, excluding any reflective sign strips.

700-9.2 Multi-Column Ground Sign Assembly: Measurement will be made per each and will consist of all sign panels and columns for a multi-column ground sign. Area measurement for an assembly will include the total sheeting area, excluding any reflective sign strips.

700-9.3 Sign Panel: Measurement for each sign panel will be the width times height of the sheeting area. No separate payment will be made for any panels on a new sign assembly.

700-9.4 Overhead Static Sign Structure: Sign panels will be paid separately from the overhead static support structures. For signs mounted on a span wire or mast arm, payment for the structure will be paid under the applicable items in Section 634 or Section 649. Measurement for all other overhead static sign structures will be made per each.

700-9.5 Enhanced Highway Sign Assembly: Measurement for Enhanced Highway Sign Assembly will be made per each.

700-9.5.1 Sign Beacon: No separate measurement will be made for a sign beacon mounted on a new Enhanced Sign Assembly. Separate measurement for retrofit, per each sign beacon, will be made for installation on an existing sign panel or sign assembly.

Separate payment for removal will be made only when the sign panel or sign assembly is to remain.

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700-9.5.2 Highlighted Signs: No separate measurement will be made for a highlighted sign as part of a new Enhanced Sign Assembly. Separate measurement for retrofit, per each highlighted sign, will be made for installation on an existing post or other structure. Measurement for Highlighted Sign will be made per each sign completed.

700-9.5.3 Electronic Display Sign: No separate measurement will be made for an EDS as part of a new Enhanced Sign Assembly. Separate measurement for retrofit, per each EDS, will be made for installation on an existing post or other structure. Measurement for EDS will be made per each sign completed.

700-9.6 Internally Illuminated Signs: Measurement for Internally Illuminated Sign will be made per each completed sign, regardless of whether the sign has one or more illuminated faces.

700-9.7 Embedded Dynamic Message Sign: Measurement for Embedded Dynamic Message Sign will be made for each completed sign, regardless of the number of embedded sign messages or housings mounted on a single or multi-post foundation.

700-9.8 Front Access Dynamic Message Sign: Measurement for Front Access Dynamic Message Sign will be made for each completed sign, regardless of the number of sign messages or housings mounted on a single or multi-post foundation.

700-9.9 Walk-in Dynamic Message Sign: Measurement for Embedded Dynamic Message Sign will be made for each completed sign.

700-9.10 Dynamic Message Sign Support Structure: Measurement for Dynamic Message Sign Support Structure will be made for each completed sign structure, regardless of the number of static and/or dynamic message signs supported.

700-9.11 Retroreflective Strip: Measurement for the retroreflective sign strip will be per each.

700-9.12 In Street Sign Assembly: Measurement will be made per each.

700-9.13 Removal and Relocation Operations: Measurement for removal or relocation operations of single column and multi-column signs will be made per each. Measurement for overhead sign structure will be made per each.

Measurement, per each, for removal of sign panels will only be made for signs not on an assembly.

700-10 Basis of Payment.

700-10.1 Single Column Ground Sign Assembly: The Contract unit price per each for single column ground mounted signs will include the sign panels, sheeting, support structure, foundation, hardware, and labor necessary for a complete and accepted installation. For flip-up signs, the assembly includes the hinge and any additional hardware.

700-10.2 Multi-Column Ground Sign Assembly: The Contract unit price per each for multi-column ground mounted signs will include the sign panels, support structure, foundation, hardware, and labor necessary for a complete and accepted installation.

700-10.3 Sign Panel: The Contract unit price per each sign panel will include the aluminum panel, sheeting, support structure, foundation, hardware, and labor necessary for a complete and accepted installation.

700-10.4 Overhead Static Sign Structure: The Contract unit price for each overhead static sign structure will include the support structure, foundation, hardware, and labor necessary for a complete and accepted installation.

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700-10.5 Enhanced Highway Sign Assembly: The Contract unit price per each will include sign, electronics, cabinet, support structure, foundation, hardware, power system, and labor necessary for a complete and accepted installation.

700-10.5.1 Sign Beacon: The Contract unit price per each for sign beacon will consist of the flashing beacons, cabinet, housing, controller, hardware, and labor necessary for a complete and accepted installation. Signal cable from the cabinet to the signs will be paid separately under the applicable item for signal cable.

When solar power is specified in the Contract Documents, the Contract unit price will include the solar panel, auxiliary pole, batteries, and electronics.

700-10.5.2 Highlighted Signs: The Contract unit price per each for highlighted signs, furnished and installed, will include furnishing the sign, electronics, cabinet, support structure, foundation, hardware, and labor necessary for a complete and accepted installation. When solar power is specified in the Contract Documents, the Contract unit price will include the solar panel, auxiliary pole, batteries, and electronics.

Highlighted Signs used for Wrong Way sign installations do not include the Wrong Way Detection System; measurement and payment for the detection system will be made in accordance with Section 660.

700-10.5.3 Electronic Display Sign: The Contract unit price per each for electronic display sign will include static sign panels as required, electronic display, support structure, foundation, housing, cabinet, controller, speed detector, hardware, electrical connection, and labor necessary for a complete and accepted installation.

When the electronic display sign is ground mounted, the Contract price will include the support structure and foundation. All other mounting will include the hardware necessary to complete the attachment to the support structure; the span wire, monotube, or mast arm structure will be paid separately.

When solar power is specified in the Contract Documents, the Contract unit price will include the solar panel, auxiliary pole, and batteries.

700-10.6 Internally Illuminated Signs: The Contract unit price for each Internally Illuminated Sign will include the sign, housing, hardware, electrical connection, and labor necessary for a complete and accepted installation. All other mounting will include the hardware necessary to complete the attachment to the support structure; the span wire, monotube, or mast arm structure will be paid separately.

700-10.7 Embedded Dynamic Message Sign: The Contract unit price per each for Embedded DMS will include the sign, all hardware and software, testing, and warranty for a completed installation.

700-10.8 Front Access Dynamic Message Sign: The Contract unit price per each for Front Access DMS will include the sign, all hardware and software, testing, and warranty for a completed installation.

700-10.9 Walk-in Dynamic Message Sign: The Contract unit price per each for Walk-in DMS will include the sign, all hardware and software, testing, and warranty for a completed installation. When shown in the Contract Documents, payment for the Walk-in DMS will also include the Uninterruptible Power Supply.

700-10.10 Dynamic Message Sign Support Structure: The Contract unit price for each support structure will include posts and supports, catwalks, handrails, footings, foundation, excavation, site grounding, painting, and incidentals necessary for a complete and accepted installation.

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700-10.11 Retroreflective Sign Strip: The Contract unit price per each will include the retroreflective sign strip, hardware, and labor necessary for a complete and accepted installation.

700-10.12 In Street Sign Assembly: The Contract unit price per each will include the vertical panel, retroreflective sign sheeting, rebounding boot support, and a base, for a complete and accepted installation.

700-10.13 Removal and Relocation Operations: The Contract unit price for removal of signs will include the removal of the support and footing. Restore the area to the condition of the adjacent area.

The Contract unit price for relocation of signs will consist of removing the existing sign assembly, including foundation removal and area restoration, and installing the sign at the new location shown in the Plans.

For the relocation of existing ground-mounted signs to be relocated or removed, after removing the sign panel from the assembly, remove supports and footings.

For the removal of overhead static sign structures, the Contract unit price will include the removal of the foundation: when partial foundation removal is called for, remove the support structure, and foundation to a minimum depth of four feet below existing grade; when complete foundation removal is called for, completely remove the support structure including the foundation.

700-10.14 Payment Items: Payment will be made under:

Item No. 700- 1-	Single Column Ground Sign Assembly, each.
Item No. 700- 2-	Multi-Column Ground Sign Assembly, each.
Item No. 700- 3-	Sign Panel, each.
Item No. 700- 4-	Overhead Static Sign Structure, each.
Item No. 700- 5-	Internally Illuminated Signs, each.
Item No. 700- 7-	Embedded Dynamic Message Sign - each.
Item No. 700- 8-	Front Access Dynamic Message Sign - each.
Item No. 700- 9-	Walk-in Dynamic Message Sign - each.
Item No. 700- 10-	Dynamic Message Sign Support Structure - each.
Item No. 700- 13-	Retroreflective Sign Strip, each.
Item No. 700- 14-	Enhanced Highway Sign Assembly, each.
Item No. 700- 15-	In Street Sign Assembly, each.

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SECTION 701
PROFILED THERMOPLASTIC PAVEMENT MARKINGS

701-1 Description.

Profiled thermoplastic pavement markings consist of thermoplastic material with raised thermoplastic bumps creating a raised profile marking. Apply profiled thermoplastic pavement markings in accordance with the Contract Documents.

701-2 Materials.

Use only materials listed on the Department's Approved Product List (APL) as an approved system and meeting the following requirements:

Profiled Thermoplastic..... 971-1 and 971-9
Retroreflective Elements*..... 971-1.7
Glass Spheres* ..... 971-1 and 971-2
*Use retroreflective elements or glass spheres recommended by the manufacturer.

The Engineer will take random samples of the materials in accordance with the Department's Sampling, Testing and Reporting Guide schedule.

701-3 Equipment.

Use equipment capable of providing continuous, uniform heating of the pavement marking material to temperatures exceeding 390ºF, mixing and agitating the material in the reservoir to provide a homogenous mixture without segregation. Use equipment that will maintain the pavement marking material in a plastic state, in all mixing and conveying parts, including the line dispensing device until applied. Use equipment which is capable of producing a consistent pattern of bumps with a longitudinal distance between bumps of approximately 30 inches center-to-center intervals. Use equipment which meets the following requirements:

1. Capable of traveling at a uniform, predetermined rate of speed, both uphill and downhill, to produce a uniform application of pavement marking material and capable of following straight lines and making normal curves in a true arc.

2. Capable of applying retroreflective elements or glass spheres to the surface of the completed pavement marking by automatic dispensers attached to the pavement marking machine such that the retroreflective elements or glass spheres are dispensed closely behind the installed line. Use retroreflective element or glass sphere dispensers equipped with an automatic cut-off control that is synchronized with the cut-off of the thermoplastic material and applies the retroreflective elements or glass spheres uniformly on the entire pavement marking surface with 50 to 60% embedment.

3. Equipped with a special kettle for uniformly heating and melting the pavement marking material. The kettle must be equipped with an automatic temperature control device and material thermometer for positive temperature control and to prevent overheating or scorching of the thermoplastic material.

4. Meets the requirements of the National Fire Protection Association (NFPA), State and Local authorities.

701-4 Application.

701-4.1 General: Remove existing thermoplastic pavement markings and raised bumps using a method approved by the Engineer such that pavement surface scars or traces of the

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removed thermoplastic pavement markings will not conflict with new pavement markings. Do not use paint to blackout, hide, or disguise existing pavement markings.

Before applying pavement markings, remove any material that would adversely affect the bond of the pavement markings by a method approved by the Engineer.

Before applying pavement markings to any portland cement concrete surface, apply a primer, sealer or surface preparation adhesive of the type recommended by the manufacturer. Offset longitudinal lines at least 2 inches from construction joints of portland cement concrete pavement.

Apply thermoplastic material thickness according to 701-4.2. Application on open graded friction surfaces may require more thermoplastic material to achieve the required thickness above the pavement surface.

Apply pavement markings to dry surfaces only, and when the ambient air and surface temperature is at least 50°F and rising for asphalt surfaces and 60°F and rising for concrete surfaces.

Apply pavement markings to the same tolerances in dimensions and in alignment specified in 710-5. When applying pavement marking over existing markings, ensure that no more than 2 inches on either end and not more than 1 inch on either side of the existing line is visible.

Conduct field tests in accordance with FM 5-541, Part A. Take test readings representative of the pavement marking performance. Remove and replace pavement markings not meeting the requirements of this Section at no additional cost to the Department.

701-4.2 Thickness: Apply flat base lines having a minimum thickness of 0.100 inches or 100 mils and not exceeding a thickness of 0.150 inches or 150 mils, exclusive of the bumps, when measured above the pavement surface.

Measure, record and certify on a Department approved form and submit to the Engineer, the thickness of white and yellow pavement markings in accordance with FM 5-541, Part A.

The Engineer will verify the thickness of the pavement markings in accordance with FM 5-541, Part A within 30 days of receipt of the Contractor's certification.

701-4.3 Dimensions of Raised Bumps: Apply the raised bumps with a profile such that the leading and trailing edges are sloped at a sufficient angle to create an audible and vibratory warning.

Bumps on edge line and centerline markings shall be at least 0.45 inches at the highest point of the bump, above the pavement surface, including the base line. The height shall be measured after application of drop-on retroreflective elements or glass spheres. Bumps shall have a minimum baseline coverage dimension of 2.5 inches in both transverse and longitudinal directions. The bumps may have a drainage channel, the width of each drainage channel will not exceed 1/4 inch at the bottom of the channel. The longitudinal distance between bumps shall be approximately 30 inches.

701-4.4 Retroreflectivity: Apply white and yellow profiled thermoplastic markings that will attain an initial retroreflectance of not less than 300 $mcd/m^2/lx$ and not less than 250 $mcd/m^2/lx$, respectively. Measure, record and certify on a Department approved form and submit to the Engineer, the retroreflectivity of white and yellow pavement markings in accordance with FM 5-541, Part A.

701-4.5 Color: Use pavement marking materials that meet the requirements of 971-1.

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701-4.6 Retroreflective Elements or Glass Spheres: Apply retroreflective elements or drop on glass spheres to all markings as identified on the APL and at the rates determined by the manufacturer's recommendations.

701-4.7 Loss: If more than 1% of the bumps or more than three consecutive bumps are missing or broken (less than half a bump remaining) within the first 45 days under traffic, replace all failed bumps at no expense to the Department. If more than 2% of the bumps fail within the first 45 days under traffic, the replacement period will extend an additional 45 days from the date all replacement bumps were installed. If, at the end of the additional 45 days, more than 2% of all bumps (initial and replacement) fail, replace all failed bumps at no expense to the Department. Measure, record and certify on a Department approved form and submit to the Engineer, the loss of bumps.

701-5 Contractor's Responsibility for Notification.

Notify the Engineer prior to the placement of the materials. At the time of notification, submit a certification to the Engineer with the APL number and the batch or LOT numbers of the thermoplastic materials and retroreflective elements or glass spheres to be used. Packaging labels that contain the information required by 971-1.1 will be accepted in lieu of a certification.

701-6 Protection of Newly Applied Profiled Thermoplastic Markings.

Do not allow traffic onto or permit vehicles to cross newly applied pavement markings until they are sufficiently dry. Remove and replace any portion of the pavement markings damaged by passing traffic or from any other cause, at no additional cost to the Department.

701-7 Observation Period.

Longitudinal pavement markings, with the exception of bumps, are subject to a 180 day observation period under normal traffic. The observation period will begin with the satisfactory completion and acceptance of the work. The observation period for bumps will be in accordance with the requirements of 701-4.7.

The longitudinal pavement markings shall show no signs of failure due to blistering, excessive cracking, chipping, discoloration, poor adhesion to the pavement, loss of retroreflectivity or vehicular damage. The retroreflectivity shall meet the initial requirements of 701-4.4. The Department reserves the right to check the retroreflectivity anytime prior to the end of the observation period.

Replace, at no expense to the Department, any longitudinal pavement markings that do not perform satisfactorily under traffic during the 180 day observation period.

701-8 Corrections for Deficiencies.

Correct all deficiencies by removal and reapplication of a one-mile section centered around the deficiency, at no cost to the Department.

701-9 Method of Measurement.

701-9.1 Profiled Thermoplastic Markings: The quantities of 6 inch solid and 10'-30' skip lines to be paid will be the plan quantity length, in gross miles, subject to 9-1.3.2. The gross mile measurement will be taken as the distance from the beginning of the profiled thermoplastic line to the end of the profiled thermoplastic line and will include the unmarked gaps for skip lines. The gross mile will not include designated unmarked lengths at intersections, turn lanes, etc.

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701-9.2 Removal of Existing Thermoplastic Markings: The quantity to be paid for removal of existing thermoplastic pavement markings will be the area, in square feet, acceptably removed. Payment for removal of thermoplastic pavement markings will only be made for locations where the existing pavement surface is to remain.

701-10 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including, all cleaning and preparing of surfaces, furnishing of all materials, application, curing and protection of all items, protection of traffic, furnishing of all tools, machines and equipment, and all incidentals necessary to complete the work. Final payment will be withheld until all deficiencies are corrected.

Payment will be made under:

Item No. 701	Profiled Thermoplastic Pavement Markings.
	Solid - per gross mile
	Skip - per gross mile
	Remove - per square foot

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SECTION 704
TUBULAR MARKERS

704-1 Description.

Furnish and install tubular markers at the locations called for in the Standard Plans or in the Plans.

704-2 Materials.

Meet the following requirements:

Tubular Markers.....Section 991

***** Use tubular markers listed on the Department's Approved Product List (APL).

704-3 Installation Requirements.

Install tubular markers in accordance with the manufacturer's installation instructions posted on the APL. Use the same color as the pavement marking being emphasized.

704-4 Method of Measurement.

The quantity to be paid will be the plan quantity of the number of tubular markers furnished, installed, and accepted.

704-5 Basis of Payment.

Prices and payments will be full compensation for work specified in this Section, including the cost of labor, materials, and incidental items required to complete the work.

Payment will be made under:

Item No. 704 - 1 Tubular Marker - each.

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SECTION 705
OBJECT MARKERS AND DELINEATORS

705-1 Description.

Furnish and install object markers to mark obstructions within or adjacent to the roadway of the types and at the locations called for in the Standard Plans or in the Plans.

Furnish and install delineators along the side of the roadway to indicate the alignment of the roadway as indicated in the Standard Plans or in the Plans.

705-2 Materials.

705-2.1 General: Meet the following requirements:

Flexible Post Delineators*.....Section 993
Barrier Delineators* .....Section 993
Retroreflective Sign Sheeting*.....Section 700
*Use products listed on the Department's Approved Product List (APL).

705-2.2 Flanged U-Channel Posts: Meet the mechanical requirements of ASTM A499, Grade 60. Galvanize after fabrication in accordance with ASTM A123, to produce a smooth uniform finish free from defects affecting strength, durability, and appearance. Punch or drill 3/8-inch diameter holes on 1-inch centers through the center of the post, starting approximately 1 inch from the top and extending the full length of the post. Punching or drilling operations shall be completed prior to galvanization. The weight per foot of a manufacturer's U-channel size shall not vary more than plus or minus 3.5% of its specified weight per foot. Machine-straighten the U-channel to a tolerance of 0.4% of the length.

705-2.3 Round Aluminum Posts: Meet the requirements of Standard Plans, Index 700-010.

705-2.4 Retroreflective Sheeting: Use Types IV, V or XI sheeting. The retroreflective area shall be in accordance with the MUTCD.

705-2.5 Aluminum Panel: For Object Markers and Nonflexible Delineators, adhere retroreflective sheeting to 6061 T6 aluminum meeting ASTM B209. Use 0.040-inch sheet aluminum for Type 2 markers and nonflexible delineators. Use 0.080-inch sheet aluminum for Type 1, Type 3, and Type 4 markers. Prepare aluminum in accordance with recommendations of the sheeting manufacturer.

705-3 Installation Requirements.

Install delineators and object markers in accordance with the MUTCD, Standard Plans and Plans.

705-3.1 Object Markers: For uniformity, all Type 1 markers shall be OM1-3 style markers, all Type 2 markers shall be OM2-2V style markers, and all Type 4 (end of road) markers shall be OM4-3 style markers. Install object markers at a mounting height of 4 feet measured in accordance with Standard Plans, Index 700-101.

Attach Type 1 and Type 4 object markers to round aluminum posts in accordance with Standard Plans, Index 700-010. Install Type 2 and Type 3 object markers directly to 3 lb/ft flanged U-Channel posts using two 1/4-inch bolts spaced to fit holes on the post.

Use attachment hardware (nuts, bolts, clamps, brackets, braces, etc.) of aluminum or galvanized steel.

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705-3.2 Flexible Post Delineators: Install in accordance with the manufacturer's instructions.

705-3.3 Nonflexible Post Delineators: Install nonflexible post delineators on 1.1 lb/ft flanged U-Channel. The retroreflective sheeting shall have a minimum width of 4 inches and have a minimum area of 32 square inches.

705-3.4 Barrier Delineators: Install barrier delineators by adhesive or mechanical means as per the manufacturer’s recommendations and in accordance with the details shown in the Plans and the Standard Plans. Install barrier delineators at a spacing of 25 feet for the first 100 feet of barrier and at 100 feet spacing thereafter. For installations with guardrail, install barrier delineators in accordance with Standard Plans, Index 536-001. Orient barrier delineators as detailed in the manufacturer’s instructions.

705-4 Method of Measurement.

The quantity to be paid will be the number of delineators or object markers furnished, installed and accepted, with the exception of barrier delineators on new barriers, which are included in the cost of the barrier.

705-5 Basis of Payment.

Prices and payments will be full compensation for work specified in this Section, including the cost of labor, materials, and incidental items required to complete the work.

Payment will be made under:

Item No. 705- 10	Object Marker - each.
Item No. 705- 11	Delineator - each.

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SECTION 706
RAISED PAVEMENT
MARKERS AND MARKER ADHESIVE

706-1 Description.

Raised pavement markers (RPMs) and adhesive provide a positive guidance system to supplement other reflective pavement markings.

706-2 Materials.

Use only Class B markers, except as follows:

For center line rumble strip installations where RPMs are in conflict with the grinding, install Class D RPMs with the first application of standard paint. Remove Class D RPMs prior to grinding, then install Class B RPMs in an unground area after grinding.

Install Class F RPMs only when shown in the plans.

Meet the requirements of Section 970.

706-2.1 Product Acceptance on the Project: Use only RPMs and adhesive that are listed on the Department's Approved Product List (APL). For Class F RPMs, provide a warranty assigned to the Department in accordance with Section 970.

706-3 Bituminous Adhesive Equipment.

Use equipment having either thermostatically controlled double boiler type units utilizing heat transfer oil or thermostatically controlled electric heating pots to install hot applied bituminous adhesive. Use a melter/applicator unit suited for both melting and pumping the bituminous adhesive through heated applicator hoses.

Heat the bituminous adhesive to between 375°F and 425ºF and apply directly to the bonding surface from the melter/applicator by either pumping or pouring. Maintain the application temperature between 375°F and 425ºF. The bituminous adhesive may be reheated. However, do not exceed the manufacturer's recommendations for pot life at application temperatures.

706-4 Application.

Install RPMs in accordance with the Plans and Standard Plans, Indexes 706-001 and 711-003, prior to opening the road to traffic.

Apply RPMs to the bonding surface using bituminous or epoxy adhesives in accordance with the manufacturer's instructions. Use epoxy adhesives when applying RPMs on concrete pavement.

For Class F RPMs, installation may include the removal of roadway surface material to recess a portion of the RPM housing.

Prior to application of adhesive, clean the portion of the bonding surface of any material which would adversely affect the adhesive.

Apply the adhesive to the bonding surface (not the RPM) so that 100% of the bonding area of the RPM will be covered, in accordance with adhesive manufacturer's recommendations. Apply sufficient adhesive to ensure that when the marker is pressed downward into the adhesive, adhesive will be forced out around the entire perimeter of the RPM.

Immediately remove excess adhesive from the bonding surface and exposed surfaces of the RPMs. Soft rags moistened with mineral spirits meeting Federal Specifications TT-T-291 or kerosene may be used to remove adhesive from exposed faces of the RPMs. Do not use any other

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solvent. If any adhesive, pavement marking materials or other foreign matter adheres to the traffic face of the RPM, replace the RPM at no cost to the Department.

Restore any areas impacted by the installation of Class F RPMs to original condition.

Ensure that all final RPMs are in place prior to opening the road to traffic.

If more than 2% of the RPMs fail in adhesion or alignment within the first 45 days under traffic, replace all failed RPMs at no expense to the Department. If more than 5% of the RPMs fail in adhesion and or alignment during the initial 45 day period, the Engineer will extend the replacement period an additional 45 days from the date that all replacement RPMs have been installed. If, at the end of the additional 45 day period, more than 2% of all RPMs (initial installation and 45 day replacements combined) fail in adhesion or alignment, replace all failed RPMs at no expense to the Department.

706-5 Contractor's Responsibility for Notification.

Notify the Engineer prior to the placement of RPMs. At the time of notification, submit the APL number and the batch or LOT numbers of RPMs and adhesive to be used.

706-6 Method of Measurement.

The quantity of RPMs to be paid for under this Section will be the quantity per each, furnished and installed, completed and accepted.

706-7 Basis of Payment.

706-7.1 Class B RPMs: Price and payment for Class B RPMs will be full compensation for all work and materials in this Section.

706-7.2 Class D RPMs: Payment will be made in accordance with Section 102.

706-7.3 Class F RPMs: Price and payment for Class F RPMs will be full compensation for all work and materials in this Section.

706-7.4 Payment Items: Payment will be made under:

Item No. 706- 1- Raised Pavement Marker - per each.

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SECTION 709
TWO REACTIVE COMPONENTS PAVEMENT MARKINGS

709-1 Description.

Apply two reactive components pavement markings in accordance with the Contract Documents.

709-2 Materials.

Use only materials listed on the Department's Approved Product List (APL) as an approved system and meeting the following requirements:

Two Reactive Components ..... 971-1 and 971-8
Retroreflective Elements* 971-1.7
Glass Spheres* ..... 971-1 and 971-2
*Use only retroreflective elements or glass spheres recommended by the manufacturer.

The Engineer will take random samples of the materials in accordance with the Department's Sampling, Testing and Reporting Guide schedule.

709-3 Equipment.

Use equipment that will produce continuous uniform dimensions of pavement markings of varying widths and meets the following requirements:

1. Capable of traveling at a uniform, predetermined rate of speed, both uphill and downhill, to produce a uniform application of the two reactive components material and capable of following straight lines and making normal curves in true arcs.

2. Capable of applying retroreflective elements or glass spheres to the surface of the completed line by an automatic retroreflective element dispenser attached to the pavement marking machine such that the retroreflective elements or glass spheres are dispensed closely behind the installed line. Use a retroreflective element or glass sphere dispenser equipped with an automatic cut-off control that is synchronized with the cut-off of the material and applies the retroreflective elements or glass spheres in a manner such that the retroreflective elements or glass spheres appear uniform on the entire pavement markings surface.

3. Capable of providing the manufacturer's recommended mixing ratio between the components in a thorough and consistent manner.

709-4 Application.

709-4.1 General: Remove existing pavement markings, such that scars or traces of removed markings will not conflict with new pavement markings by a method approved by the Engineer.

Before applying pavement markings, remove any material by a method approved by the Engineer that would adversely affect the bond of the pavement markings.

Offset longitudinal lines at least 2 inches from construction joints of portland cement concrete pavement.

Apply pavement markings to dry surfaces only, and when the ambient air and surface temperature is at least 40ºF and rising.

Do not apply two reactive components pavement markings when winds are sufficient to cause spray dust.

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Apply two reactive components pavement markings to the same tolerances in dimensions and in alignment specified in 710-5. When applying two reactive components pavement marking over existing markings, ensure that not more than 2 inches on either end and not more than 1 inch on either side of the existing line is visible.

Apply the two reactive components pavement markings to the pavement in accordance with the manufacturer's instructions or as directed by the Engineer.

Conduct field tests in accordance with FM 5-541, Part A. Take test readings representative of the pavement marking performance. Remove and replace two reactive components pavement markings not meeting the requirements of this Section at no additional cost to the Department.

Apply all final pavement markings prior to opening the road to traffic.

709-4.2 Thickness: Apply two reactive components pavement markings to attain a minimum wet film thickness in accordance with the manufacturer's recommendations as identified on the APL.

Measure, record and certify on a Department approved form and submit to the Engineer, the thickness of white and yellow pavement markings in accordance with FM 5-541, Part A. **709-4.3 Retroreflectivity:** Apply white and yellow two reactive components pavement markings that will attain an initial retroreflectivity of not less than 450 mcd/m^2/lx and not less than 350 mcd/m^2/lx, respectively for all longitudinal lines.

Measure, record and certify on the Department approved form and submit to the Engineer, the retroreflectivity of white and yellow two reactive components pavement markings in accordance with FM 5-541, Part A.

709-4.4 Color: Use materials that meet the requirements of 971-1.

709-4.5 Retroreflective Elements or Glass Spheres: Apply retroreflective elements or glass spheres type and rates to all two reactive components pavement markings as identified on the APL based on manufacturer's recommendations.

709-5 Contractor's Responsibility for Notification.

Notify the Engineer prior to the placement of the materials. At the time of notification, submit a certification to the Engineer with the APL number and the batch or LOT numbers of the materials and retroreflective elements or glass spheres to be used. Packaging labels that contain the information required by 971-1.1 will be accepted in lieu of a certification.

709-6 Protection of Newly Applied Pavement Markings.

Do not allow traffic onto or permit vehicles to cross newly applied pavement markings until they are sufficiently dry. Remove and replace any portion of the pavement markings damaged by passing traffic or from any other cause, at no additional cost to the Department.

709-7 Observation Period.

Longitudinal pavement markings are subject to a 180 day observation period under normal traffic. The observation period shall begin with the satisfactory completion and acceptance of the work.

The longitudinal pavement markings shall show no signs of failure due to blistering, excessive cracking, chipping, discoloration, poor adhesion to the pavement, loss of retroreflectivity or vehicular damage. The retroreflectivity shall meet the initial requirements of 709-4.3. The Department reserves the right to check the retroreflectivity any time prior to the end of the observation period.

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Replace, at no additional expense to the Department, any longitudinal pavement markings that do not perform satisfactorily under traffic during the 180 day observation period.

709-8 Corrections for Deficiencies.

Correct all deficiencies by removal and reapplication of a one mile section centered around the deficiency, as determined by the Engineer, at no additional cost to the Department.

709-9 Method of Measurement.

709-9.1 Two Reactive Components Markings: The quantity of solid, 10'-30' skip, and 3'-9' dotted, 6'-10' dotted, 2'-2' dotted, and 2'-4' dotted lines to be paid will be the plan quantity length, in gross miles, subject to 9-1.3.2.

The gross mile measurement will be taken as the distance from the beginning of the two reactive component line to the end of the two reactive component line and will include the unmarked gaps for skip and dotted lines. The gross mile measurement will not include designated unmarked lengths at intersections, turn lanes, etc.

709-9.2 Removal of Existing Thermoplastic Markings: The quantity to be paid for removal of existing thermoplastic pavement markings will be the area, in square feet, acceptably removed. Payment for removal of thermoplastic pavement markings will only be made for locations where the existing pavement surface is to remain.

709-10 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including, all cleaning and preparing of surfaces, furnishing of all materials, application, curing and protection of all items, protection of traffic, furnishing of all tools, machines and equipment, and all incidentals necessary to complete the work. Final payment will be withheld until all deficiencies are corrected.

Payment will be made under:

Item No. 709	Two Reactive Components	
	Solid -	per gross mile.
	Skip -	per gross mile.
	Remove -	per square foot.

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SECTION 710
PAINTED PAVEMENT MARKINGS

710-1 Description.

Apply painted pavement markings, in accordance with the Contract Documents.

710-2 Materials.

Use only materials listed on the Department's Approved Product List (APL) meeting the following requirements:

Standard Paint	971-1 and 971-3
Durable Paint	971-1 and 971-4
Glass Spheres	971-1 and 971-2

The Engineer will take random samples of all material in accordance with the Department's Sampling, Testing and Reporting Guide schedule.

710-3 Equipment.

Use equipment that will produce continuous uniform dimensions of pavement markings of varying widths and meet the following requirements:

1. Capable of traveling at a uniform, predetermined rate of speed, both uphill and downhill, in order to produce a uniform application of paint and capable of following straight lines and making normal curves in a true arc.

2. Capable of applying glass spheres to the surface of the completed line by an automatic sphere dispenser attached to the pavement marking machine such that the glass spheres are dispensed closely behind the installed line. Use a glass spheres dispenser equipped with an automatic cut-off control that is synchronized with the cut-off of the paint and applies the glass spheres in a manner such that the spheres appear uniform on the entire pavement markings surface.

3. Capable of spraying the paint to the required thickness and width without thinning of the paint. Equip the paint tank with nozzles equipped with cut-off valves, which will apply broken or skip lines automatically.

710-4 Application.

710-4.1 General: Remove existing pavement markings, such that scars or traces of removed markings will not conflict with new pavement markings, by a method approved by the Engineer.

Before applying pavement markings, remove any material that would adversely affect the bond of the pavement markings by a method approved by the Engineer.

Apply standard paint to dry surfaces only, and when the ambient air and surface temperature is at least 40ºF and rising.

Apply durable paint to dry surfaces only. Do not apply durable paint when the ambient air and surface temperature is below 50°F, relative humidity is above 80% or when the dew point is within 5°F of the ambient air temperature.

Do not apply painted pavement markings when winds are sufficient to cause spray dust.

Apply painted pavement markings, having well defined edges, over existing pavement markings such that not more than 2 inches on either end and not more than 1 inch on

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either side is visible. When stencils are used to apply symbols and messages, the areas covered by the stencil reinforcing will not be required to be painted.

Mix the paint thoroughly prior to pouring into the painting machine. Apply paint to the pavement by spray or other means approved by the Engineer.

Conduct field testing in accordance with FM 5-541 Part A. Remove and replace painted pavement markings not meeting the requirements of this Section at no additional cost to the Department.

Apply all pavement markings prior to opening the road to traffic.

710-4.1.1 Painted Pavement Markings (Final Surface): On concrete surfaces or newly constructed asphalt, the painted pavement markings (final surface) will include one application of standard paint applied to the final surface, except as noted herein.

For center line and edge line rumble strip installations where the pavement marking is placed within the grinding, apply a second application of standard paint within 24 hours of each day's grinding operation.

Do not apply final surface paint where preformed thermoplastic is required in 711-4.2.3.

Do not apply final surface paint where permanent tape will be applied.

710-4.2 Thickness: Apply standard paint to attain a minimum wet film thickness of 0.015 inches or 15 mils . Apply durable paint to attain a minimum wet film thickness of 0.025 inches or 25 mils. Measure, record, and certify on a Department approved form and submit to the Engineer, the thickness of white and yellow durable paint pavement markings in accordance with FM 5-541 Part A.

710-4.3 Retroreflectivity: Apply white and yellow standard paint that will attain an initial retroreflectance of not less than 300 mcd/m^2/lx and not less than 250 mcd/m^2/lx, respectively. Apply white and yellow durable paint that will attain an initial retroreflectance of not less than 450 mcd/m^2/lx and not less than 300 mcd/m^2/lx, respectively. Black pavement markings must have a retroreflectance of less than 20 mcd/m^2/lx.

Measure, record and certify on a Department approved form and submit to the Engineer, the retroreflectivity of white and yellow pavement markings in accordance with FM 5--541 Part A.

The Department reserves the right to test the markings within three days of receipt of the Contractor's certification. Failure to afford the Department opportunity to test the markings will result in non-payment. The test readings should be representative of the Contractor's pavement marking performance. If the retroreflectivity values measure below values shown above, reapply the pavement marking at no additional cost to the Department.

For standard paint, ensure that the minimum retroreflectance of white and yellow pavement markings are not less than 150 mcd/m^2/lx. If the retroreflectivity values for standard paint fall below the 150 mcd/m^2/lx value within 180 days of initial application, the pavement marking will be reapplied at the Contractor's expense. If the retroreflectivity values for durable paint fall below the initial values of 450 mcd/m^2/lx value for white and 300 mcd/m^2/lx for yellow within 180 days of initial application, the pavement marking will be reapplied at the Contractor's expense.

710-4.4 Color: Use paint material that meets the requirements of 971-1.

710-4.5 Glass Spheres: Apply glass spheres on all pavement markings immediately and uniformly following the paint application. The rate of application shall be based on the manufacturer's recommendation.

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For longitudinal durable paint markings, apply a double drop of Type 1 and Type 3 glass spheres. For transverse durable paint markings, apply a single drop of Type 3 glass spheres.

The rate of application shall be based on the manufacturer's recommendation.

710-5 Tolerances in Dimensions and in Alignment.

Establish tack points at appropriate intervals for use in aligning pavement markings, and set a stringline from such points to achieve accuracy.

710-5.1 Dimensions:

710-5.1.1 Longitudinal Lines: Apply painted skip line segments with no more than plus or minus 12 inches variance, so that over-tolerance and under-tolerance lengths between skip line and the gap will approximately balance. Apply longitudinal lines at least 2 inches from construction joints of portland cement concrete pavement.

710-5.1.2 Transverse Markings, Gore Markings, Arrows, and Messages: Apply paint in multiple passes when the marking cannot be completed in one pass, with an overall line width allowable tolerance of plus or minus 1 inch.

710-5.1.3 Contrast Lines: Use black paint to provide contrast on concrete or light asphalt pavement, when specified by the Engineer. Apply black paint in 10 foot segments following each longitudinal skip line.

710-5.2 Alignment: Apply painted pavement markings that will not deviate more than 1 inch from the stringline on tangents and curves one degree or less. Apply painted pavement markings that will not deviate more than 2 inches from the stringline on curves greater than one degree. Apply painted edge markings uniformly, not less than 2 inches or more than 4 inches from the edge of pavement, without noticeable breaks or deviations in alignment or width.

Remove and replace at no additional cost to the Department, pavement markings that deviate more than the above stated requirements.

710-5.3 Correction Rates: Make corrections of variations in width at a maximum rate of 10 feet for each 0.5 inch of correction. Make corrections of variations in alignment at a maximum rate of 25 feet for each 1 inch of correction, to return to the stringline.

710-6 Contractor's Responsibility for Notification.

Notify the Engineer prior to the placement of the materials. At the time of notification, submit a certification to the Engineer with the APL number and the batch or Lot numbers of the paint and glass spheres to be used.

710-7 Protection of Newly Applied Pavement Markings.

Do not allow traffic onto or permit vehicles to cross newly applied pavement markings until they are sufficiently dry. Remove and replace any portion of the pavement markings damaged by passing traffic or from any other cause, at no additional cost to the Department.

710-8 Corrections for Deficiencies to Applied Painted Pavement Markings.

Reapply a 1.0 mile section, centered around any deficiency, at no additional cost to the Department.

710-9 Submittals.

710-9.1 Submittal Instructions: Prepare a certification of quantities, using the Department's current approved form, for each project in the Contract. Submit the certification of

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quantities and daily worksheets to the Engineer. For Lump Sum pay item 710-90, document the quantity as an estimated percentage (in decimal form) of the total lump sum amount on the daily worksheet. The Department will not pay for any disputed items until the Engineer approves the certification of quantities.

710-9.2 Contractor's Certification of Quantities: Request payment by submitting a certification of quantities no later than Twelve O'clock noon Monday after the estimate cut-off date or as directed by the Engineer, based on the amount of work done or completed. Ensure the certification of quantities consists of the following:

1. Contract Number, FPID Number, Certification Number, Certification Date and the period that the certification represents.

2. The basis for arriving at the amount of the progress certification, less payments previously made and less any amount previously retained or withheld. The basis will include a detailed breakdown provided on the certification of items of payment.

710-10 Method of Measurement.

The quantities, authorized and acceptably applied, under this Section will be paid as follows:

1. The length, in gross miles, of solid, 10'-30' skip, 3'-9' dotted, 6'-10' dotted, 2'-2' dotted, and 2'-4' dotted lines.

2. The length, in linear feet, of transverse lines, diagonal lines, chevrons, and parking spaces.

3. The number of pavement messages, symbols, and arrows. Each arrow is paid as a complete marking, regardless of the number of "points" or directions.

4. Lump Sum, as specified in 710-4.1.1 (final surface) and 710-9.1.

5. The area, in square feet, for removal of existing markings acceptably removed. Payment for removal of conflicting markings will be in accordance with 102-11.20. Payment for removal of non-conflicting markings will be paid separately.

The gross mile measurement will be taken as the distance from the beginning of the painted line to the end of the painted line and will include the unmarked gaps for skip and dotted lines. The gross mile measurement will not include designated unmarked lengths at intersections, turn lanes, etc. Final measurement will be determined by plan dimensions or stations, subject to 9-1.3.1.

710-11 Basis of Payment.

710-11.1 General: Price and payment will be full compensation for all work specified in this Section, including, all cleaning and preparing of surfaces, furnishing of all materials, application, curing and protection of all items, protection of traffic, furnishing of all tools, machines and equipment, and all incidentals necessary to complete the work. Final payment will be withheld until all deficiencies are corrected.

710-11.2 Painted Pavement Markings (Final Surface): Price and payment for painted pavement markings (final surface) will be full compensation for all applications of painted pavement markings in accordance with 710-4.1.1 and 710-9.1.

710-11.3 Payment Items: Payment will be made under:

Item No. 710	Painted Pavement Markings.	
		Solid - per gross mile.
		Solid - per linear foot.
		Skip - per gross mile.

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Dotted - per gross mile.
Message or Symbol -each.
Arrows - each.
Yield Line - per linear foot.
Island Nose – per square foot

Item No. 710- 90 Painted Pavement Markings (Final Surface) - lump sum.

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SECTION 711
THERMOPLASTIC PAVEMENT MARKINGS

711-1 Description.

Apply new thermoplastic pavement markings, or refurbish existing thermoplastic pavement markings, in accordance with the Contract Documents.

711-2 Materials.

Use only materials listed on the Department's Approved Product List (APL) meeting the following requirements.

Hot-Applied Standard and Refurbishment Thermoplastic	
.....	971-1 and 971-5
Preformed Thermoplastic.....	971-1 and 971-6
Glass Spheres	971-1 and 971-2

The Engineer will take random samples of all material in accordance with the Department's Sampling, Testing and Reporting Guide schedule.

711-3 Equipment.

Use equipment capable of providing continuous, uniform heating of the pavement marking material to temperatures exceeding 390ºF, mixing and agitation of the material in the reservoir to provide a homogeneous mixture without segregation. Use equipment that will maintain the pavement marking material in a plastic state, in all mixing and conveying parts, including the line dispensing device until applied. Use equipment which can produce varying line widths and which meets the following requirements:

1. Capable of traveling at a uniform, predetermined rate of speed, both uphill and downhill, to produce a uniform application of pavement marking material and capable of following straight lines and making normal curves in a true arc.

2. Capable of applying glass spheres to the surface of the completed pavement marking by a double drop application for standard thermoplastic pavement markings and a single drop application for recapping and refurbishment thermoplastic pavement markings. The bead dispenser for the first bead drop shall be attached to the pavement marking machine in such a manner that the beads are dispensed closely behind the installed line. The second bead dispenser bead shall be attached to the pavement marking machine in such a manner that the beads are dispensed immediately after the first bead drop application. Use glass spheres dispensers equipped with an automatic cut-off control that is synchronized with the cut-off of the thermoplastic material and applies the glass spheres uniformly on the entire pavement markings surface with 50 to 60% embedment.

3. Equipped with a special kettle for uniformly heating and melting the pavement marking material. The kettle must be equipped with an automatic temperature control device and material thermometer for positive temperature control and to prevent overheating or scorching of the thermoplastic material.

4. Meet the requirements of the National Fire Protection Association, state, and local authorities.

711-4 Application.

711-4.1 General: Remove existing thermoplastic pavement markings using a method approved by the Engineer such that pavement surface scars or traces of the removed

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thermoplastic pavement markings will not conflict with new pavement markings. Do not use paint to blackout, hide, or disguise existing pavement markings.

Before applying pavement markings, remove any material that would adversely affect the bond of the pavement markings by a method approved by the Engineer.

Before applying pavement markings to any portland cement concrete surface, apply a primer, sealer, or surface preparation adhesive of the type recommended by the manufacturer. Offset longitudinal lines at least 2 inches from any longitudinal joints of portland cement concrete pavement.

Apply thermoplastic material thickness according to 711-4.2. Application on open graded friction surfaces may require more thermoplastic material to achieve the required thickness above the pavement surface.

Apply pavement markings to dry surfaces only, and when the ambient air and surface temperature is at least 50ºF and rising for asphalt surfaces and 60°F and rising for concrete surfaces.

Apply pavement markings to the same tolerances in dimensions and in alignment specified in 710-5. When applying pavement markings over existing markings, ensure that no more than 2 inches on either end and not more than 1 inch on either side of the existing line is visible.

Apply thermoplastic material to the pavement by extrusion or other means approved by the Engineer.

When thermoplastic pavement markings are to be removed and replaced, apply new thermoplastic pavement markings prior to opening to traffic.

Conduct field tests in accordance with FM 5-541 Part A. Take test readings representative of the pavement marking performance. Remove and replace pavement markings not meeting the requirements of this Section at no additional cost to the Department.

With the exception of short-term raised rumble strips, wait at least 14 days after constructing the final asphalt surface course to place thermoplastic pavement markings. Installation of thermoplastic on concrete requires a clean, dry surface. Follow the manufacturer's recommendations for surface preparation for thermoplastic on concrete. Provide temporary pavement markings during the interim period prior to opening the road to traffic.

711-4.1.1 Preformed Thermoplastic: Apply markings to dry surfaces only and when ambient air temperature is at least 32°F. Prior to installation, follow the manufacturer's recommendations for pre-heating. For railroad dynamic envelopes, keep all equipment and personnel out of the foul area.

711-4.2 Thickness:

711-4.2.1 Hot-Applied Standard Thermoplastic Markings: Apply or recap standard thermoplastic pavement markings for longitudinal lines to attain a minimum thickness of 0.10 inch or 100 mils and a maximum thickness 0.15 inch or 150 mils when measured above the pavement surface.

Markings other than longitudinal lines, wherever located, will have a thickness of 0.09 inch or 90 mils to 0.12 inch or 120 mils when measured above the pavement surface.

Measure, record and certify on Department approved form and submit to the Engineer, the thickness of white and yellow pavement markings in accordance with FM 5-541.

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The Engineer will verify the thickness of the pavement markings in accordance with FM 5-541 within 30 days of receipt of the Contractor's certification.

711-4.2.2 Hot-Applied Refurbishment Thermoplastic Markings: Apply a minimum of 0.06 inch or 60 mils of thermoplastic material. Ensure that the combination of the existing marking and the overlay after application of glass spheres does not exceed the maximum thickness of 0.150 inch or 150 mils for all lines.

Measure, record and certify on Department approved form and submit to the Engineer, the thickness of white and yellow pavement markings in accordance with FM 5-541 Part A.

The Engineer will verify the thickness of the pavement markings in accordance with FM 5-541 Part A within 30 days of receipt of the Contractor's certification.

711-4.2.3 Preformed Thermoplastic Markings: Apply 0.125 inch or 125 mils of preformed thermoplastic material.

Use preformed thermoplastic for bicycle markings, shared use path markings, 24-inch markings on special emphasis crosswalks, route shields, ramp exit numbers, railroad dynamic envelopes, white dotted lines (2'-4') with trailing black contrast, 12-inch transverse crosswalk lines with black contrast, 24-inch stop line with black contrast, and black contrast arrows, messages, and symbols.

Measure, record and certify on Department approved form and submit to the Engineer, the thickness of the pavement markings in accordance with FM 5-541 Part A.

711-4.3 Retroreflectivity:

711-4.3.1 General: Measure, record and certify on Department approved form and submit to the Engineer, the retroreflectivity of white and yellow pavement markings in accordance with FM 5--541 Part A.

711-4.3.2 Longitudinal Lines: Apply hot-applied standard and refurbishment thermoplastic pavement markings that will attain an initial retroreflectivity of not less than 450 mcd/m^2/lx and not less than 350 mcd/m^2/lx for white and yellow, respectively.

711-4.3.3 Markings Other Than Longitudinal Lines: Apply hot-applied standard and refurbishment thermoplastic markings that will attain an initial retroreflectivity of not less than 300 mcd/m^2/lx and 250 mcd/m^2/lx for white and yellow, respectively.

711-4.3.4 Preformed Markings: Apply white preformed thermoplastic markings that will attain an initial retroreflectivity of not less than 200 mcd/m^2/lx. Black pavement markings must have a retroreflectance of less than 20 mcd/m^2/lx.

711-4.4 Glass Spheres:

711-4.4.1 Longitudinal Lines: For hot-applied standard thermoplastic markings, apply the first drop of Type 4 or larger glass spheres immediately followed by the second drop of Type 1 glass spheres. For hot-applied refurbishment thermoplastic markings, apply a single drop of Type 3 glass spheres. Apply retroreflective glass spheres to all markings at the rates provided in the manufacturer's installation instructions.

711-4.4.2 Markings Other Than Longitudinal Lines: For hot-applied standard and refurbishment thermoplastic markings, apply a single drop of Type 1 glass spheres and sharp silica sand at the rates provided in the manufacturer's installation instructions. Use sharp silica sand materials meeting the requirements of 971-5.4. For hot-applied high friction thermoplastic markings, apply retroreflective and friction elements at the rates provided in the manufacturer's installation instructions.

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711-4.4.3 Preformed Markings: These markings are factory supplied with glass spheres and friction elements. Apply additional glass spheres and friction elements in accordance with the manufacturer's instructions.

711-5 Contractor's Responsibility for Notification.

Notify the Engineer prior to the placement of the materials. At the time of notification, submit a certification to the Engineer with the APL number and the batch or LOT numbers of the thermoplastic and glass spheres to be used. Packaging labels that contain the information required by 971-1.1 will be accepted in place of a certification.

711-6 Protection of Newly Applied Thermoplastic Pavement Markings.

Do not allow traffic onto or permit vehicles to cross newly applied pavement markings until they are sufficiently dry. Remove and replace any portion of the pavement markings damaged by passing traffic or from any other cause, at no additional cost to the Department.

711-7 Observation Period.

Longitudinal pavement markings are subject to a 180 day observation period under normal traffic. The observation period shall begin with the satisfactory completion and acceptance of the work.

The longitudinal pavement markings shall show no signs of failure due to blistering, excessive cracking, chipping, discoloration, poor adhesion to the pavement, loss of retroreflectivity or vehicular damage. The retroreflectivity shall meet the initial requirements of 711-4.3. The Department reserves the right to check the retroreflectivity any time prior to the end of the observation period.

Replace, at no additional expense to the Department, any longitudinal pavement markings that do not perform satisfactorily under traffic during the 180 day observation period.

711-8 Corrections for Deficiencies.

Recapping applies to conditions where additional pavement marking material is applied to new or refurbished pavement markings to correct a thickness deficiency. Correct deficiencies by recapping or removal and reapplication of a 1 mile section centered around the deficiency, as determined by the Engineer, at no additional cost to the Department.

711-9 Method of Measurement.

711-9.1 Thermoplastic Pavement Markings: The plan quantity, acceptably applied and subject to 9-1.3.2, under this Section will be paid as follows:

1. The length, in gross miles, of solid, 10'-30' skip, 3'-9' dotted, 6'-10' dotted, 2'-2' dotted, and 2'-4' dotted lines.

2. The length, in linear feet, of transverse lines, diagonal lines, chevrons, parking spaces, special emphasis crosswalk markings, and railroad dynamic envelope markings.

3. The number of pavement messages, symbols, and arrows. Each arrow is paid as a complete marking, regardless of the number of "points" or directions.

The gross mile measurement will be taken as the distance from the beginning of the thermoplastic line to the end of the thermoplastic line and will include the unmarked gaps for skip and dotted lines. The gross mile measurement will not include designated unmarked lengths at intersections, turn lanes, etc.

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711-9.2 Removal of Existing Thermoplastic Markings: The quantity for removal of existing thermoplastic pavement markings to be paid will be the area, in square feet, acceptably removed. Payment for removal of thermoplastic pavement markings will only be made for locations where the existing pavement surface is to remain.

711-10 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section, including, all cleaning and preparing of surfaces, furnishing of all materials, application, curing and protection of all items, protection of traffic, furnishing of all tools, machines and equipment, and all incidentals necessary to complete the work. Final payment will be withheld until all deficiencies are corrected.

Payment will be made under:

Item No. 711	Thermoplastic Pavement Markings
	Solid - per gross mile.
	Solid - per linear foot.
	Skip - per gross mile.
	Dotted - per gross mile.
	Message or Symbol - each.
	Arrows - each.
	Yield Line - per linear foot.
	Railroad Dynamic Envelope - per linear foot.
	Remove - per square foot.

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SECTION 713
PERMANENT TAPE PAVEMENT MARKINGS

713-1 Description.

Apply permanent tape pavement markings, in accordance with the Contract Documents.

713-2 Materials.

Use only materials listed on the Department's Approved Product List (APL) meeting the following requirements:

Permanent Tape ..... 971-1 and 971-7

The Engineer will take random samples of all material in accordance with the Department's Sampling, Testing and Reporting Guide schedule.

713-3 Equipment.

Use equipment that is mobile and maneuverable to the extent that straight lines can be followed, and normal curves can be made in a true arc.

Ensure the mechanical applicator is equipped with film cut-off device and a measuring device that automatically and accumulatively measures the length of each line placed with an accuracy tolerance of plus or minus 2 percent. Tape may be placed by hand on short sections, 500 feet or less if the tolerances in dimensions and in alignment specified in 710-5 are met.

713-4 Application.

713-4.1 General: Remove existing pavement markings, such that scars or traces of removed markings will not conflict with new pavement markings by a method approved by the Engineer.

Before applying permanent tape, remove any material by a method approved by the Engineer that would adversely affect the bond of the tape.

Apply a primer, sealer or surface preparation adhesive of the type recommended by the manufacturer. Ensure the permanent tape adheres to the pavement surface.

Offset longitudinal lines at least 2 inches from construction joints on portland cement concrete pavement.

Apply permanent tape to dry surfaces only, and when the ambient air and surface temperature is at least 55ºF and rising.

Apply permanent tape to the same tolerances in dimensions and in alignment specified in 710-5.

Apply permanent tape to the pavement by means approved by the Engineer.

Conduct field testing in accordance with FM 5-541, Part A. Take test readings representative of the pavement marking performance. Remove and replace permanent tape not meeting the requirements of this Section at no additional cost to the Department.

Apply all pavement markings prior to opening the road to traffic.

713-4.2 Thickness: Apply permanent tape pavement markings that have a thickness as designated on the APL for the particular product used.

Measure, record and certify on a Department approved form and submit to the Engineer, the thickness of white and yellow pavement markings in accordance with FM 5-541, Part A.

713-4.3 Retroreflectivity: Apply white and yellow pavement markings that will attain an initial retroreflectivity of not less than 450 mcd/m^2/lx for white markings and not less than

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350 mcd/m^2/lx for yellow markings. Black pavement markings must have a retroreflectance of less than 20 mcd/m^2/lx.

Measure, record and certify on Department approved form and submit to the Engineer, the retroreflectivity of white and yellow pavement markings in accordance with FM 5-541, Part A.

713-4.4 Color: Use material meeting the requirements of 971-1.

713-5 Contractor's Responsibility for Notification.

Notify the Engineer prior to the placement of the material. At the time of notification, submit the APL number and the batch or LOT numbers of tape to be used.

713-6 Protection of Newly Applied Pavement Markings.

Do not allow traffic onto or permit vehicles to cross newly applied pavement markings until they are sufficiently bonded. Remove and replace any portion of the pavement markings damaged by passing traffic or from any other cause, at no additional cost to the Department.

713-7 Observation Period.

Longitudinal pavement markings are subject to a 180 day observation period under normal traffic. The observation period shall begin with the satisfactory completion and acceptance of the work.

The longitudinal pavement markings shall show no signs of failure due to blistering, excessive cracking, chipping, discoloration, poor adhesion to the pavement, loss of retroreflectivity or vehicular damage. The retroreflectivity shall meet the initial requirements of 713-4.3. The Department reserves the right to check the retroreflectivity any time prior to the end of the observation period.

Replace, at no additional expense to the Department, any longitudinal pavement markings that do not perform satisfactorily under traffic during the 180 day observation period.

713-8 Corrections for Deficiencies.

Correct all deficiencies by removal and reapplication of a one mile section centered around the deficiency, as determined by the Engineer, at no additional cost to the Department.

713-9 Method of Measurement.

713-9.1 Permanent Tape Markings: The quantities of 6 inch solid, 10'-30' skip, and 3'-9' dotted lines to be paid will be the plan quantity length, in gross miles, subject to 9-1.3.2.

The gross mile measurement will be taken as the distance from the beginning of the permanent tape line to the end of the permanent tape line and will include the unmarked gaps for skip and dotted lines. The gross mile measurement will not include designated unmarked lengths at intersections, turn lanes, etc.

713-9.2 Removal of Existing Markings: The quantity paid for removal of existing permanent tape pavement markings will be the area, in square feet, for removal of existing markings acceptably removed. Payment for removal of existing permanent tape pavement markings will only be made for locations where the existing pavement surface is to remain.

713-10 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including, all cleaning and preparing of surfaces, furnishing of all materials, application, curing

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and protection of all items, protection of traffic, furnishing of all tools, machines and equipment, and all incidentals necessary to complete the work. Final payment will be withheld until all deficiencies are corrected.

Payment will be made under:

Item No. 713- 1- Permanent Tape.

Solid – per gross mile.
Skip – per gross mile.
Dotted – per gross mile.
Remove – per square foot.

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SECTION 714
GREEN-COLORED PAVEMENT MARKINGS

714-1 Description.

Apply new green-colored pavement markings in accordance with the Contract Documents.

714-2 Materials.

Use materials meeting the following requirements:

Green-Colored Pavement Marking Materials ..... Section 974

*Use products on the Department's Approved Products List (APL).

714-3 Equipment.

Use equipment in accordance with the manufacturer's installation instructions.

714-4 Application.

714-4.1 General: Remove existing pavement markings using a method approved by the Engineer such that pavement surface scars or traces of the removed pavement markings will not conflict with new pavement markings. Do not use paint to blackout, hide, or disguise existing pavement markings.

For installation on new asphalt roadways, apply pavement markings a minimum of 14 days after placement of the final asphalt surface course.

Before applying pavement markings, remove any material that would adversely affect the bond of the pavement markings by a method approved by the Engineer. Follow the manufacturer's recommendations for surface preparation.

For each green-colored pavement marking location, produce and provide a video record of the pavement before and after installations. Video records with timestamp will be provided to the Department within one week after installation. Provide video files via digital media (DVD, flash drive, or other) or by online digital distribution with a minimum standard resolution of 720 x 480 and at a speed not greater than 6 feet per second. The video image shall be clear, focused, and relatively free from roll, static, or other image distortion qualities that would prevent the reviewer from evaluating the condition of the roadway surface.

714-4.2 Preformed Thermoplastic: Apply a primer, sealer, or surface preparation adhesive as recommended by the manufacturer's recommendations prior to installation. Perform mechanical blasting or abrading and subsequent surface cleaning as recommended.

Apply markings to dry surfaces only and when ambient air temperature is at least 32°F. Prior to installation, follow the manufacturer's recommendations for pre-heating. Apply 0.125 inch or 125 mils of preformed thermoplastic material. Apply skid resistant material in accordance with the manufacturer's instructions.

714-4.3 Two Reactive Component System: Install two reactive component pavement markings in accordance with manufacturer's recommendations.

Install two reactive component pavement markings in areas subject to vehicular traffic to a thickness meeting manufacturer recommended thickness requirements.

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714-5 Contractor's Responsibility for Notification.

Notify the Engineer prior to the placement of the materials. At the time of notification, submit a certification to the Engineer with the Product name and the batch or Lot numbers of the preformed thermoplastic or two component reactive pavement markings to be used.

714-6 Protection of Newly Applied Pavement Markings.

Do not allow traffic onto or permit vehicles to cross newly applied pavement markings until they are sufficiently dry. Remove and replace any portion of the pavement markings damaged by passing traffic or from any other cause, at no additional cost to the Department.

714-7 Method of Measurement.

The quantity to be paid for will be the plan quantity area, in square feet, of green-colored pavement markings acceptably applied, subject to 9-1.3.2.

714-8 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section, including, all cleaning and preparing of surfaces, furnishing of all materials, application, curing and protection of all items, protection of traffic, furnishing of all tools, machines and equipment, and all incidentals necessary to complete the work. Final payment will be withheld until all deficiencies are corrected.

Payment will be made under:

Item No. 714- 10- Green-Colored Pavement Markings – per square foot.

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SECTION 715
HIGHWAY LIGHTING SYSTEM

715-1 Description.

Install a highway lighting system in accordance with the details shown in the Plans. Use pole assemblies as shown in the Standard Plans when standard aluminum pole assemblies or standard high mast light assemblies are required by the Contract Documents. Include in the system the light poles, bases, luminaires, drivers, cable, conduit, protective devices, and control devices; all as specified or required for the complete facility.

Obtain conventional light pole and high mast light pole assemblies from a fabrication facility that is approved in one of the following fabrication categories:

1. American Institute of Steel Construction, Highway Component Manufacturer
2. American Welding Society, Certified Welding Fabricator
3. Canadian Welding Bureau, Fusion Welding of Aluminum (W47.2)

Provide metal lighting poles, excluding high mast lighting, with internal vibration damping devices in accordance with Standard Plans, Index 715-002 in all installations on bridges, walls, and median concrete barriers.

715-2 Painting.

715-2.1 General: When required by the Contract Documents, provide painted conventional light pole assemblies. Provide products that will meet specification requirements throughout the warranty period. Meet the color requirement as specified in the Contract Documents. Provide the Engineer with two metal sample coupons, a minimum of 2 inches by 4 inches, painted concurrently and with the same paint as was used on the first LOT of any conventional aluminum light poles assemblies delivered to the jobsite. Submit sample coupons and manufacturer product data sheets to the Engineer along with the delivery of the first shipment of any painted conventional aluminum light pole assemblies delivered to the jobsite. At the time of their delivery, the sample coupons described in this paragraph must match the color of the conventional light pole assemblies to within 1ΔE measured as specified in 975-4. If the delivered sample coupons exhibit a difference in color from the conventional light pole assemblies greater than 1ΔE then the sample coupons will be considered unacceptable and no payment shall be made for the materials which the sample coupons represent. Those materials shall not be accepted by the Department until acceptable representative sample coupons in accordance with the requirements of this Section have been submitted to the Engineer.

715-2.2 Responsible Party Warranty: When the Contract Documents call for painted conventional light pole assemblies the Contractor shall designate a responsible party to accept responsibility. The responsible party designated by the Contractor must execute and submit to the Department a form, provided by the Department, prior to the first delivery to the jobsite of any painted conventional light pole assemblies stipulating that the responsible party accepts responsibility for ensuring the coating system adhesion and color retention requirements as specified in 975-4 are met for a period of five years after final acceptance in accordance with 5-11. The responsible party shall also bear the continued responsibility for performing all remedial work associated with repairs of any adhesion or color retention failure as defined in Section 975, as to which notice was provided to the responsible party within the five-year warranty period. Failure to timely designate the responsible party will result in the Contractor being the responsible party unless otherwise agreed to in writing by the Department. The

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responsible party shall be either the Contractor or the supplier of the painted conventional light pole assemblies. When the responsible party is the fabricator, the responsible party shall be one of the fabricators listed on the Prequalified Painted Galvanized Steel and Aluminum Products Fabricators List. This list may be viewed on the Department's website at the following URL: https://www.fdot.gov/construction/Engineers/PaintedPoleSuppliers.shtm

Upon final acceptance of the Contract in accordance with 5-11, the Contractor's responsibility to ensure that the coating system adhesion and color retention requirements specified in 975-4 will terminate. The obligations of the responsible party set forth in this Section shall start at final acceptance of the Contract in accordance with 5-11 and continue thereafter until expiration of the five-year warranty period.

715-3 Remedial Work.

During the painting warranty period, the responsible party shall perform all painting remedial work necessary to meet the requirements of this Specification at no cost to the Department. Such remedial work shall be performed within 180 days of notification of a failure by the Department or by the determination of the Statewide Disputes Review Board. Failure to perform such remedial work within the time frame specified will result in the work being performed by other forces at the responsible party's cost.

If the responsible party is the fabricator, the fabricator will be removed from the Prequalified Painted Galvanized Steel Poles and Aluminum Products Fabricators List for a minimum of six months or until payment in full for the correction of the deficiencies or defects has been made, whichever is longer.

If the responsible party is the Contractor, the Department will suspend, revoke, or deny the responsible party's certificate of qualification under the terms of Section 337.16(d)(2), Florida Statutes, for a minimum of six months or until payment in full for the correction of the deficiencies or defects has been made, whichever is longer.

715-4 Statewide Disputes Review Board.

The Statewide Disputes Review Board in effect for this Contract will resolve any and all disputes that may arise involving administration and enforcement of this Specification related to the painting remedial work performed during the warranty period. The Responsible Party and the Department acknowledge that use of the Statewide Disputes Review Board is required, and the determinations of the Statewide Disputes Review Board for disputes arising out of this Specification will be binding on both the Responsible Party and the Department, with no right of appeal by either party. Meet the requirements of 8-3.

715-5 Shop Drawings and Working Drawings.

Submit shop drawings and working drawings with descriptive specifications and engineering data for the service main, control panel enclosure, control panel main disconnect, lighting contactor, electrical panel, transformer, in-line fuse holders, surge protective devices, non-standard light poles (including brackets), luminaires, LED drivers, photo-electric cell, conduit and cable or any other item requested by the Engineer as specified in Section 5.

715-6 Materials and Equipment to be Installed.

715-6.1 General: All welds must be visually inspected for final approval by an actively certified welding inspector, qualified through the American Welding Society. Meet the materials and equipment requirements of Section 992.

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715-6.2 Luminaires: Use the make and model of the luminaire(s) shown in the Plans. Luminaires other than those shown in the Plans may be substituted if the Contractor proves photometric and electrical equivalence per the approval of the lighting EOR.

Use only luminaires listed on the Department's Approved Product List (APL).

715-6.3 Criterion Designation of Materials and Equipment: Where a criterion specification is designated for any material or equipment to be installed, by the name or catalog number of a specific manufacturer, understand that such designation is intended only for the purpose of establishing the style, quality, performance characteristics, etc., and is not intended to limit the acceptability of competitive products. The Engineer will consider products of other manufacturers which are approved as similar and equal as equally acceptable.

715-7 Furnishing of Electrical Service.

Provide service point in accordance with Section 639.

715-8 Excavation and Backfilling.

715-8.1 General: For excavation and backfilling, meet the requirements of Section 125, except that when rock is encountered, carry the excavation 3 inches below the required level and refill with sand or with selected earth material, 100% of which passes the 1 inch sieve.

715-8.2 Trenches for Cable: Construct trenches for cable or conduit no less than 6 inches in width and deep enough to provide a minimum cover in accordance with the Standard Plans.

715-8.3 Placing Backfill for Cable: For installation of the cable, place an initial layer of 6 inches thick, loose measurement, sand or selected earth material, 100% of which passes a 1 inch sieve. Place and compact the remaining material in accordance with 125-8.

715-9 Foundations for Light Poles.

715-9.1 Concrete Foundations: Provide foundations for light poles of the sizes and shapes shown in the Plans. Construct precast or cast-in-place concrete foundations in accordance with the Standard Plans. Obtain precast foundations from a plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.

715-9.2 Setting Anchor Bolts: Set anchor bolts according to manufacturer's templates and adjust to a plumb line, check for elevation and location, and hold rigidly in position to prevent displacement while pouring concrete.

715-9.3 Installation: Do not erect roadway light poles or high mast light poles until the concrete strength in the cast-in-place foundation is at least 2,500 psi. Determine concrete strength from tests on a minimum of two test cylinders sampled and tested in accordance with ASTM C31 and ASTM C39 and verifying test results have been submitted to the Engineer.

Fill the voids around precast concrete foundations under roadway light poles with flowable fill meeting the requirements of Section 121 or clean sands placed using hydraulic methods to a level 6 inches below grade.

715-10 Pulling Conductors.

Leave at least 3 feet of conductor where the cable enters and leaves conduit. Protect conductors pulled into conduit or ducts against abrasion, kinking, and twisting. Locate pull boxes so that the conductors are not subjected to excessive pulling stresses.

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715-11 Splicing.

Make all conductor splices in the bases of the light poles, or in pull boxes designed for the purpose. Do not make underground splices unless specifically authorized by the Engineer, and then only as directed by him.

Unless otherwise shown in the Standard Plans or authorized by the Engineer, splices shall be made with split bolt connectors. The connector shall be sealed in silicone gel that easily peels away leaving a clean connection. The gel will be contained in a closure that when snapped around the split bolt will provide a waterproof connection without the use of tools or taping. This closure will be UV resistant, impact resistant and abrasion resistant.

715-12 Conduit.

Install conduit at the locations shown in the Plans and in accordance with Section 630.

715-13 Erecting Light Poles.

715-13.1 General: Install the light poles at the locations and in accordance with the details shown in the Plans. Unless otherwise specifically approved by the Engineer, fasten bracket (truss) arms to the pole prior to erection. Erect light poles with the orientation of the access door on the opposite side of approaching traffic. Do not field weld on any part of the pole assembly. Plumb the poles after erection and use metal shims or leveling nuts if necessary to obtain precise alignment. Use a thin cement grout where necessary to eliminate unevenness or irregularities in the top of the base.

715-13.2 Adjusting Anchor Bolts and Installing Nuts on Anchor Bolts: Where poles are to be placed on existing foundations or bases with anchor bolts in place, furnish poles with a base which fits the anchor bolt spacing. Include the cost of any necessary extension of existing anchor bolts in the price bid for the lighting system. For high mast light pole bases, install nuts on anchor bolts in accordance with 649-5.

715-13.3 Installation of Luminaire: Make primary LED driver connections in accordance with manufacturer's instructions. Install sufficient cable to allow all connections to be made outside the light pole base. Connect the ground conductor to the ground stud provided.

715-13.4 Electrical Connections: Make primary ballast connections in accordance with manufacturer's instructions. Install sufficient cable to allow all connections to be made outside the light pole base. Connect the ground conductor to the ground stud provided.

715-13.5 Pole Identification Plates: Furnish and install a 2 inch by 8 inch aluminum identification plate on each light pole. Attach plates to the pole as approved by the Engineer. Attachment methods requiring screws, bolts, or rivets must be approved by the pole manufacturer. Install plates five feet above grade on the exterior traffic lane side of the pole. Use 3/4-inch black text on white or yellow background. Orient the text vertically on the plate with the following information: load center designation, circuit number, and the pole number. Number the poles as shown in the Plans.

715-13.6 Screen Installation for High Mast Light Pole Bases: Install a screen in accordance with 649-6.

715-14 Grounding.

Ground in accordance with the NEC, and local codes which exceed these Specifications.

Ground each metal light pole, not on a bridge structure, with an approved rod, 20 feet in length and at least 5/8 inch in diameter.

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For poles on bridge structures, bring the grounding conductors out to a pull box at each end of the structure and connect them to driven ground rods, 20 feet in length and at least 5/8 inch in diameter.

The 20 feet length of rod may be either two rods 10 feet in length connected by a threaded coupling and driven as a single rod or two rods 10 feet in length separated by at least 6 feet.

Make all bonds between ground wires and grounding electrode assemblies or arrays with an exothermic bond with the following exception: do not exothermically bond grounding electrode to grounding electrode connections.

The work specified in this Section will not be paid for directly, but will be considered as incidental work.

Ground all high mast poles in accordance with the details for grounding in the Standard Plans, Index 715-010.

715-15 Labeling.

Stencil labels on the cases of transformer and panel board with white oil paint, as designated by the Engineer. Also, mark the correct circuit designations in accordance with the wiring diagram on the terminal marking strips of each terminal block and on the card holder in the panel board.

715-16 Tests of Installation.

Upon completion of the work, test the installation to ensure that the installation is entirely free of ground faults, short circuits, and open circuits and that it is in satisfactory working condition. Furnish all labor, materials, and apparatus necessary for making the required tests. Remove and replace any defective material or workmanship discovered as a result of these tests at no expense to the Department, and make subsequent re-tests to the satisfaction of the Engineer.

Make all arrangements with the power supplier for power. Pay all costs, excluding energy charges, required for the test period.

Not less than 48 hours prior to the beginning of the test period, give the power supplier the schedule for such test.

Test the installation under normal operating conditions during the seven-day test period specified in 715-14, rather than as a continuous burn test period.

If the work is not open to traffic at the end of the seven-day test period, de-energize the lighting system until the work is opened.

715-17 Acceptance of Highway Lighting.

715-17.1 Partial Acceptance: The Engineer may make partial acceptance of the highway lighting based on satisfactory performance of all highway lighting for seven consecutive days. The seven-day evaluation period may commence upon written authorization by the Engineer that highway lighting is considered ready for acceptance evaluation. Contract Time will be charged during the entire highway lighting evaluation period. Correct any defects in materials or workmanship which might appear during the evaluation period at no expense to the Department.

Provide a certification from the welding inspector identifying the project information, date of inspection, welding inspector name, and inspector certification number.

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715-17.2 Final Acceptance: Upon acceptance of as-built drawings, transfer manufacturers' warranties to the Department upon final acceptance in accordance with 5-11. Submit all warranties and warranty transfers to the Engineer.

715-18 Method of Measurement.

The quantities to be paid for will be as follows, completed and accepted:

1. Conduit: Payment will be made in accordance with Section 630.

2. Luminaire and Truss Arm: The Contract unit price will include the truss arm, luminaire with lamp, and all necessary mounting hardware as indicated in the Plans and Standard Plans.

3. Service Point: Payment will be made in accordance with Section 639.

4. Load Center: The Contract unit price will include the enclosure, panel boards, breakers, lightning arrestor, contactors, photo electric switch, grounding, and the concrete pad as shown in the Plans and Standard Plans.

5. Luminaire: The Contract unit price will include the luminaire with lamp and necessary mounting hardware as indicated in the Plans and Standard Plans.

6. Pull Box: Payment will be made in accordance with Section 635.

7. High Mast Lighting Pole Complete: The Contract unit price will include the pole, luminaires with lamps, lowering system, breakers and anchor bolts with lock nuts and washers, and foundation as indicated in the Plans and Standard Plans.

When partial foundation removal is called for, remove the pole and foundation to a minimum depth of four feet below existing grade.

When complete foundation removal is called for, completely remove the pole and foundation.

8. Conductor: The quantity to be paid for will be the plan quantity, in feet, completed and accepted. Measurement will be based on the horizontal distance between pull boxes, or between pull boxes and luminaire poles, plus 8 feet for each conductor entering and 8 feet for each conductor leaving the pull box and 8 feet for each conductor entering the luminaire pole.

9. Lighting Pole Complete: The Contract unit price will include the pole, internal vibration damping device, truss arm, luminaire with lamp, anchor bolts with lock nuts and washers, frangible base, and foundation.

10. Pole Cable Distribution System: The Contract unit price will include the surge protector, fuse holders with fuses, waterproof connectors, and the waterproof wiring connection to the luminaires.

715-19 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section, including all materials, equipment, and tests.

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DIVISION III

Materials

AGGREGATES

SECTION 901
COARSE AGGREGATE

901-1 General.

901-1.1 Composition: Coarse aggregate shall consist of naturally occurring materials such as gravel, or resulting from the crushing of parent rock, to include natural rock, slags, expanded clays and shales (lightweight aggregates) and other approved inert materials with similar characteristics, having hard, strong, durable particles, conforming to the specific requirements of this Section.

Materials substantially retained on the No. 4 sieve, shall be classified as coarse aggregate.

Approval of mineral aggregate sources shall be in accordance with 6-2.3.

901-1.2 Deleterious Substances: All coarse aggregates shall be reasonably free of clay lumps, soft and friable particles, salt, alkali, organic matter, adherent coatings, and other substances not defined which may possess undesirable characteristics. The weight of deleterious substances shall not exceed the following percentages:

Coal and lignite (AASHTO T 113)	1.00
Soft and friable particles (AASHTO T 112)*	2.00
Clay lumps (AASHTO T 112)*	2.00
Plant root matter (visual inspection in AASHTO T 27)****	0.005
Wood and wood matter (visual inspection in AASHTO T 27)****	0.005
Cinders and clinkers	0.50
Free shell**	1.00
Total Material passing the No. 200 sieve (FM 1-T011)	
At Source with Los Angeles Abrasion less than or equal to 30	2.50
At Source with Los Angeles Abrasion greater than 30	1.75
At Redistribution Terminal for Aggregates Certified for Concrete Products Only	2.50
At Point of Use	3.75
Fine-Grained Organic Matter (AASHTO 194)	0.03
Chert (less than 2.40 specific gravity SSD) (AASHTO T 113)***	3.00

* The maximum percent by weight of soft and friable particles and clay lumps together shall not exceed 3.00.

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** Aggregates to be used in asphalt concrete may contain up to 5% free shell. Free shell is defined as that portion of the coarse aggregate retained on the No. 4 sieve consisting of loose, whole, or broken shell, or the external skeletal remains of other marine life, having a ratio of the maximum length of the particle to the shell wall thickness exceeding five to one. Coral, molds, or casts of other shells, and crushed clam and oyster shell indigenous to the formation will not be considered as free shell.

*** This limitation applies only to coarse aggregates in which chert appears as an impurity. It is not applicable to aggregates which are predominantly chert.

**** Plant root matter, and wood and wood matter shall be considered deleterious when any piece exceeds two inches in length or 1/2 inch in width.

The weights of deleterious substances for reclaimed Portland cement concrete aggregate shall not exceed the following percentages:

Bituminous Concrete 1.00
Bricks 1.00
Wood and other organic substances (by weight)***** 0.1
Reinforcing Steel and Welded Wire Reinforcement 0.1
Plaster and gypsum board 0.1
Joint Fillers.....0.1

***** Supersedes requirement for other coarse aggregate

901-1.3 Physical Properties: Coarse aggregates shall meet the following physical property requirements, except as noted herein:

Los Angeles Abrasion (FM 1-T096).....maximum loss 45%
Soundness (Sodium Sulfate) AASHTO T 104 .....
.....maximum loss 12%*
Flat or elongated pieces** .....maximum 10%

* For source approval - aggregates exceeding soundness loss limitations will be rejected unless performance history shows that the material will not be detrimental for portland cement concrete or other intended usages.

** A flat or elongated particle is defined as one having a ratio between the maximum and the minimum dimensions of a circumscribing prism exceeding five to one.

901-1.4 Gradation: Coarse aggregates shall conform to the gradation requirements of Table 901-1, when the stone size is specified. However, Table 901-1 is waived for those aggregates intended for usage in bituminous mixtures, provided the material is graded on sieves specified in production requirements contained in 6-2.3, and meets uniformity and bituminous design requirements.

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Table 901-1 Standard Sizes of Coarse Aggregate								
Amounts Finer than Each Laboratory Sieve (Square Openings), weight percent								
Size No.	Nominal Size Square Openings	4 inches	3-1/2 inches	3 inches	2-1/2 inches	2 inches	1-1/2 inches	1 inch
1	3-1/2 to 1-1/2 inches	100	90 to 100	-	25 to 60	-	0 to 15	-
2	2-1/2 inches to 1-1/2 inches	-	-	100	90 to 100	35 to 70	0 to 15	-
24	2-1/2 inches to 3/4 inch	-	-	100	90 to 100	-	25 to 60	-
3	2 inches to 1 inch	-	-	-	100	90 to 100	35 to 70	0 to 15
357	2 inches to No. 4	-	-	-	100	95 to 100	-	35 to 70
4	1-1/2 inches to 3/4 inch	-	-	-	-	100	90 to 100	20 to 55
467	1-1/2 inches to No. 4	-	-	-	-	100	95 to 100	-
5	1 inch to 1/2 inch	-	-	-	-	-	100	90 to 100
56	1 inch to 3/8 inch	-	-	-	-	-	100	90 to 100
57	1 inch to No. 4	-	-	-	-	-	100	95 to 100
6	3/4 inch to 3/8 inch	-	-	-	-	-	-	100
67	3/4 inch to No. 4	-	-	-	-	-	-	100
68	3/4 inch to No. 8	-	-	-	-	-	-	-
7	1/2 inch to No. 4	-	-	-	-	-	-	-
78	1/2 inch to No. 8	-	-	-	-	-	-	-
8	3/8 inch to No. 8	-	-	-	-	-	-	-
89	3/8 inch to No. 16	-	-	-	-	-	-	-
9	No. 4 to No. 16	-	-	-	-	-	-	-
10	No. 4 to 0	-	-	-	-	-	-	-

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Table 901-1 (Continued) Standard Sizes of Coarse Aggregate								
Amounts Finer than Each Laboratory Sieve (Square Openings), weight percent								
Size No.	Nominal Size Square Openings	3/4 inch	1/2 inch	3/8 inch	No. 4	No. 8	No. 16	No. 50
1	3-1/2 inches to 1-1/2 inches	0 to 5						
2	2-1/2 inches to 1-1/2 inches	0 to 5						
24	2-1/2 inches to 3/4 inch	0 to 10	0 to 5					
3	2 inches to 1 inch	-	0 to 5					
357	2 inches to No. 4	-	10 to 30	-	0 to 5			
4	1-1/2 inches to 3/4 inch	0 to 15	-	0 to 5				
467	1-1/2 inches to No. 4	35 to 70	-	10 to 30	0 to 5			
5	1 inch to 1/2 inch	20 to 55	0 to 10	0 to 5				
56	1 inch to 3/8 inch	40 to 85	10 to 40	0 to 15	0 to 5			
57	1 inch to No. 4	-	25 to 60	-	0 to 10	0 to 5		
6	3/4 inch to 3/8 inch	90 to 100	20 to 55	0 to 15	0 to 5			
67	3/4 inch to No. 4	90 to 100	-	20 to 55	0 to 10	0 to 5		
68	3/4 inch to No. 8	90 to 100	-	30 to 65	5 to 25	0 to 10	0 to 5	
7	1/2 inch to No. 4	100	90 to 100	40 to 70	0 to 15	0 to 5		
78	1/2 inch to No. 8	100	90 to 100	40 to 75	5 to 25	0 to 10	0 to 5	
8	3/8 inch to No. 8	-	100	85 to 100	10 to 30	0 to 10	0 to 5	
89	3/8 inch to No. 16	-	100	90 to 100	20 to 55	0 to 30	0 to 10	0 to 5
9	No. 4 to No. 16	-	-	100	85 to 100	10 to 40	0 to 10	0 to 5
10	No. 4 to 0	-	-	100	85 to 100	-	-	-

The gradations in Table 901-1 represent the extreme limits for the various sizes indicated which will be used in determining the suitability for use of coarse aggregate from all sources of supply. For any grade from any one source, the gradation shall be held reasonably uniform and not subject to the extreme percentages of gradation specified above.

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901-2 Natural Stones.

Coarse aggregate may be processed from gravels, granites, limestones, dolomite, sandstones, or other naturally occurring hard, sound, durable materials meeting the requirements of this Section.

901-2.1 Gravels: Gravel shall be composed of naturally occurring quartz, free from deleterious coatings of any kind. The minimum dry-rodded weight AASHTO T 19 shall be 95 pounds per cubic foot.

Crushed gravel shall consist of a minimum of 85%, by weight, of the material retained on the No. 4 sieve, having at least three fractured faces.

901-2.2 Granites: Coarse aggregate produced from the crushing of granites shall be sound and durable. For granites to be used in bituminous mixtures and surface treatments, the Los Angeles Abrasion requirement of 901-1.3 is modified to permit a maximum loss up to 50 (FM 1-T096). Maximum amount of mica schist permitted is 5% (FM 5-584).

901-2.3 Limestones, Dolomite and Sandstone: Coarse aggregates may be produced from limestone, dolomite, sandstones, and other naturally occurring hard, durable materials meeting the requirements of this Section. When used as a friction course, crushed limestone shall have a minimum acid insoluble content of 12% (FM 5-510). Other materials must meet the approval requirements for friction course determined by Rule 14-103.005(1), Florida Administrative Code (FAC).

Pre-Cenozoic limestones and dolomite shall not be used as coarse crushed stone aggregates for asphalt concrete friction courses, or any other asphalt concrete mixture or surface treatment serving as the final wearing course. This specifically includes materials from the Ketone Dolomite (Cambrian) Newala Limestone (Mississippian) geologic formations in Northern Alabama and Georgia.

901-2.4 Cemented Coquina Rock: For cemented coquina rock to be used in bituminous mixtures, the Los Angeles Abrasion requirement of 901-1.3 is modified to permit a maximum loss up to 50 (FM 1-T 096) provided that the amount of material finer than No. 200 generated during the Los Angeles Abrasion test is less than 18%.

901-3 Manufactured Stones.

901-3.1 Slags: Coarse aggregate may be produced from molten nonmetallic by-products consisting essentially of silicates and aluminosilicates of calcium and other bases, such as air-cooled blast-furnace slag or phosphate slag, provided it is reasonably uniform in density and quality, and reasonably free from deleterious substances as specified in 901-1.2. In addition, it must meet the following specific requirements:

Sulphur content ..... not more than 1.5%
Dry rodded weight AASHTO T 19 ..... minimum 70 lb/ft^3
Glassy Particles ..... not more than 10%

Slag shall not be used as an aggregate for Portland cement concrete.

For air-cooled blast furnace slag, the Los Angeles Abrasion requirement of 901-1.3 is modified to permit a maximum loss up to 50 (FM 1-T096) provided that the amount of material finer than No. 200 sieve generated during the Los Angeles Abrasion test is less than 18%.

901-4 Lightweight Aggregates.

901-4.1 Lightweight Coarse Aggregate for Bituminous Construction: Lightweight coarse aggregate may be produced from naturally occurring materials such as pumice, scoria and

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tuff or from expanded clay, shale or slate fired in a rotary kiln. It shall be reasonably uniform in quality and density, and free of deleterious substances as specified in 901-1.2, except that the term cinders and clinkers shall apply to those particles clearly foreign to the extended aggregate in question.

In addition, it must meet the following specific requirements:

Material passing the No. 200 Sieve .....maximum 3.00%, (FM 1-T011)
Dry loose weight (AASHTO T 19)*..... 33-55 lb/ft^3
Los Angeles Abrasion (FM 1-T096). maximum 35%
Ferric Oxide (ASTM C641)..... maximum 1.5 mg

* Source shall maintain dry-loose unit weight within plus or minus 6% of Quality Control average. Point of use dry-loose unit weight shall be within plus or minus 10% of Source Quality Control average.

901-4.2 Lightweight Coarse Aggregate for Structural Concrete: The requirements of 901-4.1 are modified as follows:

Aggregates shall not be produced from pumice and scoria.

Los Angeles Abrasion (FM 1-T096, Section 12) shall be 45%, maximum.

Gradation shall meet the requirements of AASHTO M 195 for 3/4 inch, 1/2 inch and 3/8 inch.

901-5 Recycled Concrete Aggregate (RCA).

RCA shall be crushed and processed to provide a clean, hard, durable aggregate having a uniform gradation free from adherent coatings.

RCA can be used as coarse aggregate in pipe backfill under wet conditions, underdrain aggregate, or concrete meeting the requirements of Section 347. RCA can only be used in bituminous mixtures if the RCA originated from a concrete mix which was produced and placed in accordance with Section 346. RCA shall be asbestos free.

The Contractor's (Producer's) crushing operation shall produce an aggregate meeting the applicable gradation requirements. The physical property requirements of 901-1.3 for soundness shall not apply and the maximum loss as determined by the Los Angeles Abrasion (FM 1-T096) is changed to 50.

The sources of reclaimed portland cement concrete will be treated as a mine and subject to the requirements of Section 6 and Section 105.

901-6 Exceptions, Additions and Restrictions.

Pertinent specification modifications, based on material usage, will be found in other Sections of the specifications.

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SECTION 902
FINE AGGREGATE

902-1 General.

902-1.1 Composition: Fine aggregate shall consist of natural silica sand, screenings, local materials, or subject to approval, other inert materials with similar characteristics, or combination thereof, having hard, strong, durable particles, conforming to the specific requirements of this Section.

Approval of construction aggregate sources shall be in accordance with 6-2.3.

902-1.2 Deleterious Substances: All fine aggregate shall be reasonably free of lumps of clay, soft or flaky particles, salt, alkali, organic matter, loam or other extraneous substances. The weight of deleterious substances shall not exceed the following percentages:

Shale.....1.0
Coal and lignite.....1.0
Cinders and clinkers.....0.5
Clay Lumps.....1.0

902-2 Silica Sand.

902-2.1 Composition: Silica sand shall be composed only of naturally occurring hard, strong, durable, uncoated grains of quartz, reasonably graded from coarse to fine, meeting the following requirements, in percent total weight.

Table 902-1

Sieve Opening Size	Percent Retained	Percent Passing
No. 4	0 to 5%	95 to 100%
No. 8	0 to 15%	85 to 100%
No. 16	3 to 35%	65 to 97%
No. 30	30 to 75%	25 to 70%
No. 50	65 to 95%	5 to 35%
No. 100	93 to 100%	0 to 7%
No. 200	minimum 96%	maximum 4%

Silica sand from any one source, having a variation in Fineness Modulus greater than 0.20 either way from the Fineness Modulus of target gradations established by the producer, may be rejected.

902-2.2 Organic Impurities: Silica sand shall be subject to the colorimetric test for organic impurities. If the color produced is darker than the standard solution, the aggregate shall be rejected unless it can be shown by appropriate tests that the impurities causing the color are not of a type that would be detrimental to portland cement concrete. Such tests shall be in accordance with AASHTO T 21 and AASHTO T 71. When tested for the effect of organic impurities on strength of mortar, the strength ratio at seven and 28 days, calculated in accordance with Section 11 of AASHTO T 71, shall not be less than 95%.

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902-3 Sands for Miscellaneous Uses.

902-3.1 Anchor Bolts and Pipe Joints: Sand for setting anchor bolts, pipe joints or other similar uses shall meet the quality requirements of 902-2, except that gradation requirements are waived.

902-3.2 Brick Masonry: Sand for brick masonry shall meet the quality requirements of 902-2, except for gradation requirements. All the materials shall pass the No. 8 sieve, and be well graded from coarse to fine.

902-3.3 Sand-Cement Riprap: Sand for sand-cement riprap shall meet the quality requirements of 902-2, except for gradation requirements. The material shall meet the following gradation limits:

Table 902-2	
Sieve Size	Percent Passing
No. 4	minimum 97%
No. 100	maximum 20%
No. 200	maximum 5%

902-4 Filter Material for Underdrains.

Silica sand for use as filter material for Types I through IV underdrains shall meet the requirements of 902-2, except that the requirements of 902-1.2 and 902-2.2 shall not apply. The aggregate shall be reasonably free of organic matter and other deleterious materials. The gradation requirements of 902-2.1 shall apply except no more than 2% shall pass the No. 200 sieve.

Filter material for Type V underdrain shall meet the above requirements except that there shall be no more than 1% of silt, clay and organic matter, that the aggregate shall have a Uniformity Coefficient of 1.5 or greater, and that 10% diameter shall be No. 70 to 35 sieve. The Uniformity Coefficient shall be determined by the ratio D60 divided by D10, where D60 and D10 refer to the particle diameter corresponding to 60% and 10% of the material which is finer by dry weight.

902-5 Screenings.

902-5.1 Composition: Screenings shall be composed of hard, durable particles, either naturally occurring, such as gravel screenings, or resulting from the crushing or processing of the parent rock, to include natural rock, slags, expanded clays or shales (lightweight aggregates), or other approved inert materials with similar characteristics.

Aggregates classified as screening shall conform to the following gradation requirements:

Table 902-3	
Sieve Size	Percent Passing
3/8 in.	100%
No.4	75 to 100%

902-5.2 Specific Requirements:

902-5.2.1 Screenings from Department Approved Sources of Coarse Aggregate: Processed screenings from fully approved sources of coarse aggregate are subject to

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gradation. Should coarse aggregate source approval status change, or unsatisfactory in-service history develop, additional control requirements may be implemented.

Screenings for use in hot bituminous mixture may consist of screenings from the processing of reclaimed portland cement concrete pavement to produce coarse aggregate.

902-5.2.2 Screenings from Other Sources: Screenings, from sources other than Department Approved Sources of Coarse Aggregate, must meet the following additional general requirements:

Modified Los Angeles Abrasion: 95% statistical probability of meeting maximum loss of 23%.

Specific Gravity*
Absorption*
Soundness*
Sulfur*
Phosphate*
Extraneous Substances*

*Specific specification requirements based on material usage found in appropriate Bituminous or Portland Cement Sections.

Based on specific material characteristics, processing techniques and in-service history on Department projects, specific source requirements may be assigned.

902-5.2.3 Screenings for Use in Portland Cement Concrete: Screenings produced from either the Miami Oolite, Miami Ft. Thompson, or Loxahatchee Ft. Thompson Formations may be substituted for silica sand for use in concretes, except for concrete pavements, approach slabs, bridge decks and precast superstructure segments. (However, screenings will be permitted in the concrete when the bridge deck or approach slab is to be covered with an asphalt concrete surface course.)

These screenings must meet the gradation requirements of AASHTO M 6, Section 6.1, as well as the maximum percent passing the No. 200 sieve, Fineness Modulus, and Organic requirements of 902-2 Silica Sand. In addition, the saturated, surface dry specific gravity shall be at least 2.48.

902-6 Local Materials.

Local materials shall be composed of hard, strong, durable particles, either naturally occurring, such as natural sands, or resulting from the crushing or processing of parent rock, to include natural sand and rock, slags, expanded clays or shales (lightweight aggregate), or other approved inert materials with similar characteristics.

Aggregates classified as local material shall conform to the following gradation requirements:

Table 902-4	
Sieve Size	Percent Passing
3/8 in.	100%
No. 10	85 to 100%
No. 200	maximum 15%

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In addition to meeting the requirements of 902-1.2, the material shall not contain excessive quantities of other deleterious substances, such as roots, cans, debris, etc. If clay size material is present, it shall not exceed 7%, as determined by AASHTO T 88, and it shall be of a type which will not produce clay balls when used. The aggregate must be suitable for designated use, as determined by laboratory tests. If the deposit consists of stratified layers of varying characteristics and gradation, the producer shall employ such means as necessary to secure a uniform material.

Local materials will not be required to be produced under the requirements of 6-2.3, provided they can meet the above requirements.

902-7 Lightweight Fine Aggregate for Internal Curing.

Fine lightweight aggregate suitable for internal curing shall meet the requirements of ASTM C1761.

902-8 Exceptions, Additions and Restrictions.

Other specification modifications, based on material usage may be found in the appropriate sections of the Specifications.

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SECTION 911
BASE AND STABILIZED BASE MATERIALS

911-1 Description.

This Section governs materials to be used in the construction of base and subgrade stabilization including limerock, shell, shell-rock, cemented coquina shell, and recycled concrete aggregate (RCA).

911-2 Materials.

911-2.1 General:

911-2.1.1 Approval of Material: Approval of mineral aggregate sources shall be in accordance with 6-2.3.

911-2.1.2 Deleterious Substances: Materials shall not contain deleterious substances that would result in: prevention of the bituminous prime coat from adhering to the base course; a detriment to the finishing, strength, or performance of the base; or a surface which is susceptible to distortion under construction traffic. Such substances include, but are not limited to: cherty or other extremely hard pieces, lumps, balls or pockets of sand or clay size material, organic matter, loose sand, loose, free shells, corals or skeletal remain of other marine invertebrates retained on the No. 4 sieve, or water sensitive clay minerals.

911-2.2 Limerock Composition: Limerock material shall consist of unconsolidated or partly consolidated limestone of marine origin.

911-2.3 Shell Material: Composition: Shell materials shall consist of naturally occurring deposits formed essentially of broken mollusk shell, corals and the skeletal remains of other marine invertebrates. Live or steamed shell, or man-made deposits as a by-product of the shellfish industry will not be permitted.

911-2.3.1 Bank Run Shell: Shell materials meeting the requirements of this Section which are presently found as “dry land” deposits.

911-2.3.2 Dredged Shell: Shell materials meeting the requirements of this Section which are dredged from ocean, bay or lake deposits.

911-2.4 Shell-Rock Material Composition: Shell-rock materials shall consist of naturally occurring heterogeneous deposits of limestone with interbedded layers or lenses of loose and cemented shell, to include cemented sands (calcitic sandstone). This material shall be mined and processed in a manner that will result in a reasonably homogenous finished product.

911-2.5 Cemented Coquina Shell Material Composition: Cemented coquina shell materials to be used as cemented coquina base or stabilized base, shall be defined as naturally occurring deposits formed essentially of broken mollusk shell, corals and the skeletal remains of other marine invertebrates, which are presently found as “dry land” deposits and which have been cemented together by carbonates or other natural cementing agents.

911-2.6 Recycled Concrete Aggregate (RCA) Composition: RCA shall consist of concrete material derived from the crushing of hard portland cement concrete. In addition to the deleterious materials noted in 911-2.1.2, RCA shall be asbestos free. The following limits shall not be exceeded:

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Bituminous Concrete ..... 1% by weight
Bricks ..... 1% by weight
Glass and Ceramics ..... 1% by weight
Wood and other organic substances ..... 0.1% by weight
Reinforcing steel and welded wire fabric .... 0.1% by weight
Plaster and gypsum board ..... 0.1% by weight

911-3 Material Requirements.

911-3.1 Limerock Bearing Ratio (LBR): Materials shall meet the requirements in Table 911-1 in accordance with FM 5-515:

Table 911-1
Limerock Bearing Ratio (LBR)

Material	Requirement
Limerock	Average Results per LOT - 100, minimum Individual Results - 90, minimum
Shell	
Shell-Rock	
Cemented Coquina Shell	
RCA	Individual Results - 150, minimum

911-3.2 Liquid Limit and Plasticity: Materials shall meet the requirements in Table 911-2 in accordance with AASHTO T 89 and AASHTO T 90:

Table 911-2
Liquid Limit and Plastic Properties

Material		Liquid Limit	Plastic Properties
Limerock	Base	Not to exceed 35	Non-Plastic (NP)
	Stabilized Base		Plasticity not to exceed 10
Shell		-	NP
Shell-Rock			
Cemented Coquina Shell		-	NP
RCA		-	NP

911-3.3 Carbonates: Materials shall meet the carbonate requirements in Table 911-3 in accordance with FM 5-514:

Table 911-3
Percentage of Carbonates (Calcium and Magnesium)

Material	Requirement
Limerock	minimum - 70%
Shell	minimum - 50%
Shell-Rock	minimum - 50%
Cemented Coquina Shell	minimum - 50%
RCA	Not Applicable

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911-3.4 Gradation and Size Requirements: Materials shall meet the gradation and size requirements in Table 911-4 in accordance with FM 1-T27 and FM 1-T11:

Table 911-4[1]
Gradation Requirements

Material		Requirement	
Limerock	Base	At least 97% shall pass a 3-1/2 inch sieve[2]	
	Stabilized Base	At least 97% shall pass a 1-1/2 inch sieve[2]	
Shell	Dredged shell	Passing 3-1/2 inch sieve - 97% Passing No. 4 sieve - 50%, maximum Passing No. 200 sieve - maximum 7.5% (washed)	
	Bank-run shell	Passing 3-1/2 inch sieve - 97% Passing No. 4 sieve - 80%, maximum Passing No. 200 sieve - 20%, maximum (washed)	
Shell-Rock		Passing 3-1/2 inch sieve - 97%, minimum Passing No. 4 sieve - 70%, maximum Passing No. 200 sieve - 20%, maximum (washed)	
Cemented Coquina Shell			
RCA		Sieve Size	Percent by Weight Passing
		2 inch	100
		3/4 inch	65 to 95
		3/8 inch	40 to 85
		No. 4	25 to 65
		No. 10	20 to 50
		No. 50	5 to 30
		No. 200	0 to 10

(1) The maximum dimension shall not exceed six inches.
(2) The material shall be well graded down to dust. The fine material shall consist entirely of dust of fracture.

911-4 Exceptions, Additions, and Restrictions.

Approved materials shall not be mixed with other approved or non-approved materials.

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SECTION 914
STABILIZATION MATERIALS

914-1 General.

This Section governs materials to be used in subgrade stabilization. Meet the following requirements:

Table 914-1	
Plasticity Index (AASHTO T 90)	Maximum 10
Liquid Limit (AASHTO T 89)	Maximum 40
Passing a 3-1/2 inch screen (AASHTO T 27)	Minimum 97%
LBR	No Requirement

914-2 Materials for Stabilizing (Limerock Bearing Ratio-LBR).

914-2.1 Commercial Materials: Materials may be either limerock, shell rock, cemented coquina or shell base sources approved in accordance with 6-2.3.

914-2.2 Local Materials: Local materials used for stabilizing may be soils or recyclable materials such as crushed concrete, roof tiles and asphalt coated base, reclaimed asphalt pavement (RAP) or Fossil Fuel Combustion Products (FFCPs) provided the following limits for organic content are met.

Table 914-2	
Average Organic Content* (FM 1-T267)	Maximum 2.5%
Individual Organic Content Sample (FM 1-T267)	Maximum 4%
*Note: A minimum of three samples per source.	

FFCPs may be used provided they meet the requirements of 403.7047, F.S., are not used outside the paved area and are not less than 3 feet above the design high groundwater table. All materials for stabilizing must meet all applicable air or water quality standards or criteria in Florida Department of Environmental Protection (FDEP) rules.

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SECTION 916
BITUMINOUS MATERIALS

916-1 General.

All products supplied under this Specification shall be one of the products included on the Approved Product List (APL). Producers seeking evaluation of a product for inclusion on the APL shall submit an application in accordance with Section 6.

Any marked variation from the original test values for a material below the established limits or evidence of inadequate quality control or field performance of a material will be considered sufficient evidence that the properties of the material have changed, and the material will be removed from the APL.

916-2 Superpave PG Asphalt Binder.

916-2.1 Requirements: Superpave Performance Graded (PG) asphalt binders, identified as PG 52-28, PG 58-22, PG 67-22, polymer modified asphalt (PMA) binders, PG 76-22 (PMA) and High Polymer, and asphalt rubber binders (ARB), PG 76-22 (ARB), shall meet the requirements of 916-2 and AASHTO M 332. When the Contract Documents specify either a PG 76-22 (PMA), PG 76-22 (ARB), or PG 76-22 binder, either binder can be used interchangeably at no additional cost to the Department. All PG asphalt binders shall meet the following additional requirements:

1. The intermediate test temperature at 10 rad/sec. for the Dynamic Shear Rheometer (DSR) test (AASHTO T 315) shall be 26.5ºC for PG grades PG 67 and higher.
2. An additional high temperature grade of PG 67 is added for which the high test temperature at 10 rad/sec for the DSR test (AASHTO T 315) shall be 67ºC.
3. All PG asphalt binders having a high temperature designation of PG 67 or lower shall be prepared without modification.
4. All PMA binders having a high temperature designation higher than PG 67 shall only be produced with a styrene-butadiene-styrene (SBS) or styrene-butadiene (SB) elastomeric polymer modifier and the resultant binder shall meet all requirements of this Section.
5. Polyphosphoric acid may be used as a modifier not exceeding 0.75% by weight of asphalt binder for PG 76-22 (PMA) and PG 76-22 (ARB) binders. Polyphosphoric acid may not be used in High Polymer binder.
6. PG 76-22 (ARB) shall meet the additional requirements of 916-2.1.1.
7. All PG asphalt binders having a high temperature designation of PG 67 or lower shall not have a high temperature true grade more than 5.9°C higher than the specified PG grade, (for example, if a PG 58-22 is specified, do not supply a PG 64-22 or higher).
8. The use of waste oil is prohibited in the modification of any PG binder grade. Waste oil shall be defined as recycled oil products that have not been processed through a vacuum tower and have an initial boiling point of 385°C (725°F) or lower when tested in accordance with ASTM D6352.
9. Re-refined engine oil bottoms (REOB)/vacuum tower asphalt extenders (VTAE) may be used as a modifier not exceeding 8.0% by weight of asphalt binder. REOB/VTAE are materials as defined in Asphalt Institute document IS-235.

For all PG binder used in all hot mix asphalt, silicone may be added to the PG binder at the rate of 25 cubic centimeters of silicone mixed to each 5,000 gallons of PG binder. If a disbursing fluid is used in conjunction with the silicone, the resultant mixture containing the full

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25 cubic centimeters of silicone shall be added in accordance with the manufacturer's recommendation. The blending of the silicone with the PG binder shall be done by the supplier prior to the shipment. When the asphalt binder will be used with a foaming warm mix technology, refer to the technology supplier's guidance on the addition of silicone.

Where an anti-strip additive is required, the anti-strip additive shall meet the requirements of 916-4. The anti-strip additive shall be introduced into the PG binder by the supplier during loading.

916-2.1.1 Additional Requirements for PG 76-22 (ARB): The following additional requirements apply only to PG 76-22 (ARB):

1. The asphalt binder shall contain a minimum of 7.0% ground tire rubber (GTR) by weight of asphalt binder.
2. The GTR shall meet the requirements of Section 919.
3. Polymer modification is optional for PG 76-22 (ARB).

916-2.1.2 High Polymer Binder Blending: Existing high polymer binder may be blended in an asphalt producer's storage tank to make a PG 76-22 binder provided the following requirements are met:

1. Notify the State Materials Office (SMO) and the local District Materials Office prior to blending.
2. Follow the blending instructions of the high polymer binder supplier.
3. Submit a sample of the blended binder to a SMO approved laboratory for testing. Provide test results to the SMO.
4. Use the newly blended binder only after approval from the SMO.

916-2.2 Compliance with Materials Manual: Producers of Superpave PG binders shall meet the requirements of Section 3.5, Volume II of the Department's Material Manual, which may be viewed at the following URL: https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/Section35V2.shtm.

916-2.3 Reporting: Specification compliance testing results shall be reported for the tests in Table 916-1 below, unless noted otherwise. Quality control (QC) testing results shall be reported for original binder DSR (G/sin δ and phase angle, as applicable).

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Table 916-1 SUPERPAVE PG ASPHALT BINDER		
Test and Method	Conditions	Specification Minimum/Maximum Value
Superpave PG Asphalt Binder Grade		Report
APL Number		Report
Modifier (name and type)	Polymer, Ground Tire Rubber with Approved Product List (APL) number, Sulfur, PPA, REOB, and any Rejuvenating Agents	Report
Original Binder		
Solubility, AASHTO T 44	in Trichloroethylene	Minimum 99.0% (Not applicable for PG 76-22 (ARB))
Flash Point, AASHTO T 48	Cleveland Open Cup	Minimum 450ºF
Rotational Viscosity, AASHTO T 316	275ºF	Maximum 3 Pa·s[(a)]
Dynamic Shear Rheometer [(b)], AASHTO T 315	$G^*/\sin\delta$	Minimum 1.00 kPa
	Phase Angle, δ[(c)] PG 76-22 (PMA) and PG 76-22 (ARB)[(d)]	Maximum 75 degrees
Separation Test, ASTM D7173 and Softening Point, AASHTO T 53	163±5°C 48 hours	Maximum 15°F (PG 76-22 (ARB) only)
Rolling Thin Film Oven Test Residue (AASHTO T 240)		
Rolling Thin Film Oven, AASHTO T 240	Mass Change %	Maximum 1.00
Multiple Stress Creep Recovery, $J_{nr,\ 3.2}$ AASHTO T 350	Grade Temperature (Unmodified binders only)	"S" = 4.50 kPa^{-1} max
Multiple Stress Creep Recovery, $J_{nr,\ 3.2}$[(d, e, f)] AASHTO T 350	67°C (Modified binders only) 76°C (High Polymer binder only)	"V" = 1.00 kPa^{-1} max Maximum $J_{nr,diff}$ = 75% 0.10 kPa^{-1} max
Multiple Stress Creep Recovery, %Recovery[(d, e)] AASHTO T 350	67°C (Modified binders only) 76°C (High Polymer binder only)	$\%R_{3.2} \geq 29.371\ (J_{nr,\ 3.2})^{-0.2633}$ $\%R_{3.2} \geq 90.0$

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Table 916-1 SUPERPAVE PG ASPHALT BINDER		
Pressure Aging Vessel Residue (AASHTO R 28)		
Dynamic Shear Rheometer, AASHTO T 315	$G^*\sin\delta$, 10 rad/sec.	Maximum 6,000 kPa [g,h]
Creep Stiffness, AASHTO T 313	S (Stiffness), @ 60 sec. m-value, @ 60 sec.	Maximum 300 MPa Minimum 0.300
ΔTc, ASTM D7643	20 hours PAV aging S (Stiffness), @ 60 sec. m-value, @ 60 sec.	ΔTc ≥ -5.0°C

(a) Binders with values higher than 3 Pa·s should be used with caution and only after consulting with the supplier as to any special handling procedures, including pumping capabilities.
(b) Dynamic Shear Rheometer (AASHTO T 315) shall be performed on original binders for the purposes of QC testing only. The original binder G*/sin δ shall be performed at grade temperature. Grade temperature for High Polymer binder is 76°C.
(c) The original binder phase angle (AASHTO T 315) shall be performed at grade temperature.
(d) AASHTO T 315 and AASHTO T 350 will be performed at a 2-mm gap for PG 76-22 (ARB).
(e) All binders with a high temperature designation >67 will be tested at 67°C. PG 76-22 (PMA) and PG 76-22 (ARB) shall pass a "V" grade per AASHTO M 332.
(f) A maximum Jnr diff = 75% does not apply for any Jnr value ≤ 0.50 kPa-1.
(g) For 5000 kPa ≤ G*sin δ ≤6,000 kPa, the phase angle, δ, shall be a minimum of 42°.
(h) For PG 67 or higher grades, perform the PAV residue testing at 26.5°C.

916-3 Asphalt Emulsions.

916-3.1 Compliance with Materials Manual: Producers of asphalt emulsions shall meet the requirements of Section 3.4, Volume II of the Department's Material Manual, which may be viewed at the following URL:
https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/Section34V2.shtm.

916-3.2 Requirements: Use a prime coat meeting the requirements of AASHTO M 140 for anionic emulsions, AASHTO M 208 or AASHTO M 316 for cationic emulsions, or as specified in the Producer's QC Plan. For anionic emulsions, the cement mixing test will be waived. For tack products, the minimum testing requirements shall include percent residue, naphtha content (as needed), one-day storage stability, sieve test, Saybolt Furol viscosity, original DSR, re-emulsification (FM 5-624), and solubility (on an annual basis). Residue testing shall be performed on residue obtained from distillation, AASHTO T 59 or low-temperature evaporation (AASHTO R 78).

At the direction of the Engineer, sample tack from the distributor used on the project at a minimum frequency of once per project per product. The sample shall be tested by the Department for the following specified material properties: percent residue, contaminants, and the residue property G*/sin δ. Should any of the test results fail the specification requirements, the tack material will be considered defective and shall not to be used on Department projects unless waived by the Engineer. Should a tack sample fail specifications, the Engineer may require three 6-inch diameter roadway cores be obtained from the day of production from which the tack sample was obtained. The roadway cores shall be tested for bond strength in accordance with FM 5-599. Individual bond strength results less than 80 psi will require removal and replacement. Failing bond strength results may result in bond strength testing for additional areas represented by the failing tack material.

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916-4 Liquid Anti-strip Agents.

916-4.1 Requirements: Liquid anti-strip agents shall be tested by the Department in accordance with FM 1-T 283. A minimum tensile strength ratio of 0.80 must be obtained when testing the liquid anti-strip with various aggregate sources and two nominal maximum aggregate size mixtures for approval to be placed on the APL.

916-4.2 Mix Design Verification: Particular aggregate sources may require moisture susceptibility testing per FM 1-T283 for each mix design. Results from this testing may meet the Department's requirement of minimum tensile strength ratio of 0.80 or may indicate the need for a larger dosage rate of anti-strip agent (up to 0.75% maximum) or may require a different anti-strip agent to meet the specification requirements.

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SECTION 917
MINERAL FILLER

917-1 Composition.

Mineral filler shall consist, in general, of limerock dust, portland cement, slag dust, hydrated lime, or any other inert mineral matter from sources approved by, the Engineer. The mineral filler shall be thoroughly dry and free from lumps consisting of aggregations of fine particles. Ground phosphate will not be allowed as a mineral filler.

Stone or slag screenings may also be used as filler material for asphalt concrete mixtures, under the provisions specified in 917-3, below.

917-2 Gradation.

The mineral filler shall meet the following gradation requirements:

Total passing No. 30 sieve	100%
Total passing No. 80 sieve	95% (minimum)
Total passing No. 200 sieve	65% (minimum)

917-3 Provision for Use of Coarser Filler Material.

Process screenings from stone or slag, having a coarser gradation than as specified above, may also be used as filler material provided the particular product, and the source thereof, are approved by the Engineer and that the material meets the following requirements.

1. All of the material shall pass the No. 10 sieve, and not more than 35% shall pass the No. 200 sieve.

2. The material passing the No. 200 sieve shall be free from organic impurities, and not more than 4.0% of such shall consist of clay minerals. The plasticity index of the material passing the No. 200 sieve shall not exceed 4.

3. For the stone or slag material from which the screenings are produced the loss, when subjected to the Los Angeles Abrasion Test, shall not exceed 45%.

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SECTION 919
GROUND TIRE RUBBER

919-1 Description.

This Section specifies the requirements for ground tire rubber (GTR).

919-2 General Requirements.

919-2.1 General: The GTR shall be produced from tires and shall be substantially free from contaminants including fabric, metal, mineral, and other non-rubber substances. Up to 4% (by weight of rubber) of talc or other inert dusting agent, may be added to prevent sticking and caking of the particles.

919-2.2 Ground Tire Rubber (GTR) for Use in Asphalt Rubber Binder: GTR shall be sufficiently dry so as to be free flowing and to prevent foaming when mixed with asphalt cement.

The use of pelletized asphalt rubber is permitted provided the components of the pelletized rubber particles meet the requirements of this Section. Additionally, the pelletized particles must disassociate once blended with asphalt cement.

919-2.3 Ground Tire Rubber (GTR) for Use in Flowable Fill: GTR may replace up to 20% of the fine aggregate.

919-2.4 Approved Product List (APL): GTR and pelletized rubber used shall be one of the products listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6.

919-3 Physical Requirements.

The physical properties of the ground tire rubber shall be determined in accordance with FM 5-559, and shall meet the following requirements:

Specific Gravity	1.02 to 1.20
Moisture Content	Maximum 0.75%
Metal Contaminants	Maximum 0.01%
Gradation	Minimum 98% Passing the No. 30 Sieve

919-4 Chemical Requirements.

The chemical composition of the ground tire rubber shall be determined in accordance with ASTM D297-13 and shall meet the following requirements:

Acetone Extract	Maximum 25%
Rubber Hydrocarbon Content	40 to 60%
Ash Content	Maximum 8%
Carbon Black Content	20 to 40%
Natural Rubber	16 to 45%

919-5 Packaging and Identification Requirements.

The ground tire rubber shall be supplied in moisture resistant packaging such as either disposable bags or other appropriate bulk containers. Each container or bag of ground tire rubber shall be labeled with the manufacturer's designation for the rubber and the specific type, maximum nominal size, weight and manufacturer's batch or LOT designation.

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919-6 Certification Requirements.

The Contractor shall submit to the Engineer a certification conforming to the requirements of Section 6 from the manufacturer, confirming that the ground tire rubber meets the requirements of this Section.

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SECTION 921
PORTLAND CEMENT AND BLENDED CEMENT

921-1 General.

Cement shall conform to the requirements of AASHTO M 85 or AASHTO M 240, as applicable, except as provided in this Section.

921-1.1 Type of Cement: Cement may be Types I, II, III, V (as defined by AASHTO M 85), or IL, IP, IS, IT (as defined by AASHTO M 240). Cement type shall be selected based on component and environmental conditions in accordance with Section 346. Different brands of cement, cement of the same brand from different facilities, or different types of cement shall be stored separately, identified, and shall not be mixed.

921-1.2 Heat of Hydration: The cement heat of hydration for Type II, Type IT, Type IL, Type IP, and Type IS shall be tested in accordance with ASTM C1702 and reported at three days.

921-2 Definitions.

The following definitions are applicable to the production and Quality Control (QC) of cement:

1. Approved Laboratory: A laboratory that is currently inspected by the Cement and Concrete Reference Laboratory (CCRL), is actively participating in the CCRL proficiency program, and which has all deficiencies noted at the time of inspection corrected. The laboratory must also authorize CCRL to submit their inspection reports to the State Materials Office (SMO).

2. Producer: A cement supplier, including but not limited to a plant, a terminal, or a transfer facility, that has been qualified by the SMO. The Cementitious Materials Production Facility Listing will be maintained by the SMO.

3. Test Report: A certification from the Producer showing that the cement meets the requirements of Section 921.

The test report must include, at a minimum, the following information:

a. The type of cement.
b. The production period.
c. Chemical and physical analysis of the cement.
d. The silo identification where the cement is stored.
e. The base cement phase composition, except for blended cements.
f. Amount of limestone and/or inorganic processing additions used, expressed as a percentage of the cement mass.
g. The oxide composition of the limestone and/or inorganic processing additions.
h. The specific gravity of cement reported as an average of the last twelve monthly tests, updated every six months.
i. The heat of hydration at three days.
j. The approved laboratory that performed all tests.

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Acceptable test reports are available in the appendices of AASHTO M 85 for portland cement and AASHTO M 240 for blended cement, except as modified by the requirements of this Section.

4. Purchaser: The term "purchaser" in the AASHTO requirements shall be taken as the Department.

921-3 Quality Control Program.

921-3.1 General: Develop a Producer QC Program as specified in Section 105.

Producers shall submit a proposed QC Plan to the SMO for acceptance. Complete the Cementitious Materials Producer QC Plan Checklist (Appendix B02) and submit it along with the QC Plan, in a separate file. The checklist can be found on the SMO website: https://www.fdot.gov/materials/quality/programs/qualitycontrol/checklists/index.shtm. In addition to the QC Plan, the Producer must submit monthly test reports from an approved laboratory which certifies that the cement in current production or supply conforms to the requirements of this Section.

Producers with an accepted QC Plan will appear on the Cementitious Materials Production Facility Listing.

QC test data that does not comply with this Section will not be a reason for rejection of the material if the Producer's QC Plan indicated that material will be diverted and not used for Department work.

921-3.2 Sampling and Testing: An approved laboratory shall perform one QC test per day. Test reports representing no more than one month's production shall be submitted to the SMO on a monthly basis, for foreign cement, refer to 921-5.

Representatives from the Department may take verification samples at the Producer's plant, terminal, distribution facility, or the concrete production facility. Samples shall be obtained by one of the methods described in FM 5-503. Sample size shall be a minimum of one gallon. At the concrete production facility, cement samples shall be jointly obtained by the Department inspector and the concrete producer's representative.

Upon request of the Department, the Producer shall provide split samples of the cement collected for QC testing. Split samples shall be delivered to the SMO and shall be identified as representing a designated LOT of cement.

Notification of failing verification sample test results will be distributed to the Producer and concrete producer, if applicable. Split samples of the initial sample may be provided to the Producer and concrete producer upon request, as available.

921-3.3 Limestone and Inorganic Processing Additions: Producers intending to use limestone and/or inorganic processing additions as component materials in the production of cement shall describe the type, source, and the target amount, expressed as a percentage of cement mass. In addition, the Producer shall display the information required in 921-2 on the test report. Samples of any pulverized limestone and/or inorganic processing additions shall be provided to the SMO for evaluation upon request.

921-4 Shipping and Storage.

Cement shall be delivered in bags or in bulk. Portland cement from a Producer on the Cementitious Materials Production Facility Listing shall be shipped on the basis of test reports meeting the requirements of this Section. Ensure that each shipment is accompanied by a delivery ticket that is traceable to the test report and includes, at a minimum, the following information:

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1. FDOT Facility Identifier
2. Type of cement
3. Date shipped
4. Silo Identification

The storage building, bin or silo shall be weatherproofed.

921-5 Foreign Cement Acceptance.

Cement being imported from a foreign source shall conform to all requirements of this Section and will be subject the following process:

1. The proposed QC Plan and the QC Plan Checklist (Appendix B02) referenced in 921-3.1 shall be sent to the SMO and will include information regarding the QC, sampling, storage, and handling of the cement at the arrival terminal as well as the shipping control to and from the arrival terminal. In addition, the QC Plan from the foreign source shall be translated to English and will be included with the proposed QC Plan for the arrival terminal.

2. An initial one-gallon sample of the imported cement shall be sent to the SMO for chemical and physical verification testing.

3. When the first ship is being loaded from foreign source, a one-gallon verification sample will be obtained and shipped to the SMO for chemical and physical property testing.

The material will be accepted for use on Department projects provided that the QC Plan has been accepted, and the results of the initial and verification samples have been confirmed to meet the requirements of this Section.

Upon receiving the shipment of cement at the arrival terminal, the Department will be notified, and a Department representative may obtain another verification sample.
Test reports representing each shipment shall be sent to the SMO.

921-6 Rejection of Material:

Reject the entire container of cement if it does not meet the requirements of this Section, including cement that has been damaged, is partially set, lumpy or caked.

Reject bagged cement if it varies more than 5% from the designated weight, or if the average weight of 50 randomly selected sacks is less than the designated weight.

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SECTION 923
WATER FOR CONCRETE

923-1 General Requirements.

Water for use with cement shall be clear and free from oil, and injurious amounts of acid, alkali, chlorides, organic matter, and other deleterious substances. It shall not be salty or brackish. Water that contains quantities of substances which makes it discolored or smell unusual or objectionable, shall not be used unless approved by the Department. Water sources permitted include potable water supplies that are approved by a public health department, open bodies of water, well water, reclaimed water, and recycled water. Reclaimed water shall be as defined in Chapter 62-610, F.A.C. Open bodies of water are defined as naturally occurring rivers, lakes, and ponds. Recycled water includes wash water from mixer washout operations and stored in a lined settling pond. Water sources that meet the requirements of Table 923-1, Table 923-2 or from a public health department may be used alone or blended in a storage tank for use in batching structural or non-structural concrete. All other sources of water not listed above shall be considered recycled and reclaimed water.

923-2 Evaluation of Water for Concrete.

923-2.1 General: Water from potable water supplies approved by a public health department may be used without additional testing. The concrete producer shall submit test data of water samples from other sources. To determine chemical properties, the concrete producer shall use a laboratory accredited by the Construction Materials Engineering Council Accreditation Program including accreditation on referred chemical tests on Table 923-1 and 923-2.

923-2.2 Initial Sampling and Testing Frequency: Open bodies of water and well water shall be initially sampled once prior to use. Recycled and reclaimed water shall be tested once per week for four weeks initially, and thereafter once per month for four months prior to its use, provided that the results of the test samples comply with all the applicable limits. Failing test results will result in restarting initial sampling and testing.

923-2.3 Production Sampling and Testing Frequency: Open bodies of water and recycled water shall be tested monthly. Well water and reclaimed water shall be tested once every three months. If the last eight consecutive well water and reclaimed water samples meet the requirements, then the sample frequency may be reduced to one sample every six months, as approved by the Department. If a well water or reclaimed water sample fails once the frequency has been reduced, then the sampling frequency shall revert to once every three months.

923-3 Chemical Requirements.

923-3.1 Testing: All chemical analysis shall be performed in accordance with the test methods listed in Tables 923-1 and 923-2 or equivalent Standard Methods for the Examination of Water and Wastewater (SM). Inorganic Anions (Chlorides and Sulfates) shall be determined simultaneously using SM 4110B Ion Chromatography or separately using SM 4500 Cl^- B and SM 4500 SO_4^{2-} E. ASTM D516 may be used as an alternative method for sulfates. The test method used shall be included in the concrete producer report.

923-3.2 Recycled and Reclaimed Water: Recycled and reclaimed water shall be tested before use and shall not exceed the limits in Table 923-1:

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Table 923-1		
Chemical Test	Test Method	Maximum (%)
Total Solids	SM 2540 B	5.00
Total Chlorides as Cl^-	SM 4500 Cl^- B or SM 4110 B	0.05
Total Sulfates as SO_4^{2-}	ASTM D516	0.30

923-3.3 Open Bodies of Water and Well Water: Open bodies of water and well water shall be tested before use and shall not exceed the limits of Table 923-2:

Table 923-2		
Chemical Test	Test Method	Maximum (%)
Alkalinity Calculated in terms of Calcium Carbonate	SM 2320 B	0.05
Total Organic Solids	SM 2540 E	0.05
Total Inorganic Solids	SM 2540 E	0.08
Total Chlorides as Cl^-	SM 4500 Cl^- B or SM 4110 B	0.05

923-4 Physical Requirements for Mortar.

923-4.1 General: To determine physical properties, use a laboratory accredited by the Construction Materials Engineering Council Accreditation Program or inspected by the Cement and Concrete Reference Laboratory.

923-4.2 Testing: Mortar shall be tested in accordance with ASTM C109 with the following exception: the mortar shall not be tested for flow. The mortar, composed of the sampled water, shall have a compressive strength of not less than 90% when compared to a mortar prepared using distilled water and tested at seven days.

Water of a questionable quality, as determined by the Department, shall be subject to the acceptance criteria for time of set as required by ASTM C1602, Table 1.

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SECTION 924
ADMIXTURES FOR CONCRETE

924-1 General.

This Section covers admixtures for specific concrete applications. Admixtures shall comply with applicable ASTM specifications and the requirements of this Section. Admixtures that have been previously qualified for Department use are listed on the Department's Approved Product List (APL).

924-2 Acceptance of Admixtures.

924-2.1 Approved Product List (APL): All admixtures must be listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their products shall submit an application is accordance with Section 6 and include product data sheets, certified independent test data showing the product meets the requirements of this Section, safety data sheet (SDS), and a certification of the average solids content and specific gravity.

Admixtures shall meet the following requirements:

Air-Entraining - ASTM C260
Type A Water-Reducing - ASTM C494
Type C Accelerating - ASTM C494
Type D Water-Reducing and Retarding - ASTM C494
Type E Water-Reducing and Accelerating - ASTM C494
Type F High Range Water Reducing - ASTM C494
Type G High Range Water-Reducing and Retarding - ASTM C494
Type I - Plasticizing - ASTM C1017
Type II - Plasticizing and Retarding - ASTM C1017
Type S Specific Performance - ASTM C494 and the performance requirements of this Section.
Corrosion Inhibitors – ASTM G109 and the requirements of this Section.

The inclusion of any specific product on the APL, as specified in 6-1, indicates that the product has been given contingent approval, as evidenced by previous tests and apparent effectiveness under field conditions.

Unless otherwise specified, no further testing will be required for any product on the APL unless there is indication in actual field use of inadequate or unreliable results.

924-2.2 Additional Requirements for Corrosion Inhibitors: Calcium nitrite is a chemically reactive admixture used in concrete to inhibit the corrosion of embedded reinforcing steel and other metallic components. The calcium nitrite supplier shall submit to the Engineer test certificates from an independent laboratory indicating compliance with this Specification. The test certificate shall include corrosion inhibiting properties per ASTM G109 and results of physical tests included in this section. Calcium nitrite shall be supplied by the same manufacturing source throughout the project. If a single primary source of calcium nitrite cannot be maintained throughout the project, new test certificates shall be submitted. The Engineer will determine specification compliance of a new supplier's product, and evaluate the effectiveness of the new calcium nitrite product before approving the source.

The active ingredient shall be calcium nitrite $Ca(NO_2)_2$.

The calcium nitrite shall be furnished in solution containing not less than 29% calcium nitrite solids. The concentration of the calcium nitrite solution shall be verified by

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spectrophotometric analysis or other comparable methods. The nitrite concentration shall be measured in accordance with Standard Methods for the Examination of Water and Waste Water, 18th Edition.

A volume of one gallon of calcium nitrite solution shall weigh within the range of 10.40 to 11.92 lb.

The calcium nitrite solution shall be added to the concrete mixture at a rate of 4.50 to 4.60 gal/yd^3 of concrete.

The addition of calcium nitrite to the concrete mix shall not adversely affect the properties of fresh and hardened concrete.

Calcium nitrite concrete shall meet the following physical requirements when mixed and tested in accordance with ASTM C494:

Table 924-1	
Water Content, % of control	95 to 100
Time of setting, allowable deviation from control, h:min:	
Initial: at least not more than	1:00 earlier nor 1:30 later
Final: at least not more than	1:00 earlier nor 1:30 later
Compressive Strength, min. % of control:	shall be 100 for all ages
Flexural strength, min, % of control:	shall be 100 for all ages
Length change, max Shrinkage (alternative requirements): % of control	135
Increase over control	0.010
Relative durability factor, min	80

The following table lists the corrosion inhibiting test result limits for calcium nitrite concrete tested in accordance with ASTM G109:

Table 924-2	
Maximum Allowable Test Results of Calcium Nitrite Concrete	
Measured average macrocell current any time during the test	10 µA
Average macrocell current at test completion	2 µA
Average visible corrosion measured as percent corroded area of control	85%

924-2.3 Type S (Specific Performance): Trial batches shall use concrete meeting the requirements of ASTM C494. Additional trial batches may be required. Dosage rate shall be the same for all testing.

924-2.3.1 Workability Retention: Workability retention admixtures are used to extend workability and slump life without retarding the setting time. The dosage rate used shall be capable of maintaining 80% of the initial measured slump after 60 minutes. Perform an initial slump test, hold the trial batch in the mixer for 60 minutes, remix for 30 seconds and perform a second slump test. Workability retention shall be calculated as the percent difference in the initial slump and the slump at 60 minutes.

924-2.3.2 Shrinkage Reducing: Shrinkage reducing admixtures are used to minimize the shrinkage of plastic and hardened concrete. The dosage rate used shall reduce shrinkage a minimum of 50% after dry curing for 28 days. Shrinkage shall be determined in accordance with ASTM C157, except omit curing period in ASTM C157(10.3). Air storage for

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the 28-day curing period shall be in accordance with ASTM C157(11.1.2). Shrinkage reduction shall be calculated as the percent difference in the control mix length change and the test mix length change.

924-2.3.3 Viscosity Modifying: Viscosity modifying admixtures are used primarily in flowing and self-consolidating concrete to maximize the rheology of plastic concrete and reduce segregation. The dosage rate used shall reduce static segregation to a minimum of 10%. A flowing concrete control mix shall be established by adding a compatible high range water-reducing or plasticizing admixture to increase the slump to 10 inches, plus or minus 0.5 inches. To establish the test mix, the control mix shall be reproduced with the addition of the viscosity admixture. The static segregation for both mixes shall be determined in accordance with ASTM C1610. Static segregation shall be calculated as the percent difference of the control mix static segregation to the test mix static segregation.

924-2.3.4 Rheology Modifying: Rheology modifying admixtures are used to maximize the rheology of plastic concrete. The dosage rate used shall be based on the manufactures recommendation and may vary for a specific application.

924-3 Retesting.

The approved admixtures are required to be tested for their uniformity and equivalence whenever there is an indication of erratic results. The tests shall be performed in accordance with the following procedure. The admixture shall be checked for comparison between infrared spectrophotometry, pH value, specific gravity, and solids content. Any marked variation from the original curve, pH value, specific gravity, or solids content will be considered sufficient evidence that the chemistry of the original material has been changed and, therefore, the use of this material will be rejected and the material will be removed from the APL.

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SECTION 925
CURING MATERIALS FOR CONCRETE

925-1 Burlap.

Burlap for curing concrete shall consist either of two layers, each weighing 10 to 18 ounces/10 square feet, or of four layers, each weighing 6 to 7 ounces/10 square feet. Burlap which has been used as a container for sugar shall not be used. Burlap that is being used for the first time shall be thoroughly washed in order to remove starches used in sizing the material. Burlap shall be furnished in strips of at least 3 feet wide and shall be at least 3 feet longer than the width of surface to be covered.

925-2 Membrane-Forming Curing Compound.

925-2.1 General: Membrane-forming curing compound shall conform to requirements of ASTM C309 and the following requirements:

Table 925-1

Requirement	Test Method	Test Value
Water Loss@72 hours	ASTM C156	0.55 kg/m^2
Deleterious Reaction with Concrete	ASTM C309	None
Reflectance	ASTM E1347	60% minimum*
Drying Time	ASTM C309	4 hours maximum
Non-Volatile Content	ASTM D1644 (Method A)	(informational)
Density, lbs/gal	ASTM D1475	(informational)

*Type 2 (White) compounds only.

The membrane-forming curing compound shall be of a consistency suitable for spraying at temperatures prevalent at the time of application, and which forms a continuous, uniform film. It shall be free from precipitated matter caused by conditions of storage or temperature. Thoroughly agitate the curing compound in accordance with the manufacturer's recommendations prior to shipment from manufacturer's plant and prior to use at job site.

Curing compound delivered to the jobsite shall be in the manufacturer's original container and clearly labeled with the following information:

1. manufacturer's name
2. product name (trade name)
3. type
4. batch or LOT number
5. date of manufacture

925-2.2 Product Acceptance: Acceptance of membrane-forming curing compound shall be based on the product being listed on the Department's Approved Product List (APL).

925-2.2.1 Approved Product List: Manufacturers seeking evaluation of their product must submit an application in accordance with Section 6 and include product data sheets, material safety data sheets (SDS) and certified test reports from an independent laboratory showing the product meets the requirements of this Section. Testing in accordance with the

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AASHTO Product Evaluation & Audit Solutions Project Work Plan for the Laboratory Testing of Liquid Membrane-Forming Compounds for Curing Concrete shall be acceptable as independent laboratory data. Include an Infrared Spectrophotometry (IR) Scan and a certification stating the nominal minimum percentage of non-volatile material for the product formulation. Deviation of the non-volatile material below this certified value shall be considered a change in formulation and shall be grounds for removal from the APL.

925-2.2.2 Certification: Prior to use, the Contractor shall submit to the Engineer a certification from the manufacturer conforming to the requirements of Section 6 that the requirements of this Section are met.

925-2.3 Product Life: Store the curing compound in accordance with the manufacturer's recommendations. Curing compounds not used within one year of the date of manufacture shall not be incorporated into the work.

925-3 Sheet Materials.

925-3.1 General: Waterproof paper, polyethylene film and white burlap-polyethylene sheet, for curing concrete shall meet the requirements of ASTM C171, with the additional requirements for waterproof paper and for polyethylene film as shown below.

925-3.2 Additional Requirements for Waterproof Paper: The paper as prepared for use shall be in such dimensions that each unit as laid will extend at least 18 inches beyond the edges of the slab. If laid longitudinally, paper not manufactured in sizes which will provide this width shall be securely sewed or cemented together; the joints being sealed in such manner that they do not open up or separate during the curing period.

At the option of the Contractor, instead of the single longitudinal strip specified above, the blanket may be furnished in three strips; one strip being the neat width of the pavement, with two side strips.

925-3.3 Additional Requirements for Polyethylene Sheeting: The sheets, as prepared for use, shall be of such dimensions that each unit as laid will extend beyond the edges of the slab by at least twice the thickness dimension of the pavement edge, and the sheets shall overlap by at least 18 inches.

No sheet may be reused except after individual inspection and approval by the Engineer. Any sheets determined by the Engineer to be so damaged as to not afford the protection to the concrete in preventing moisture loss during the curing period will be rejected.

925-4 Certification.

For burlap or white burlap-polyethylene, the Contractor shall submit to the Engineer a certification conforming to the requirements of Section 6 from the manufacturer confirming that the requirements of this Section are met. Each certification shall cover only one type of burlap or white burlap-polyethylene sheeting.

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SECTION 926
EPOXY COMPOUNDS

926-1 Types of Compounds.

Epoxy resin-based compounds for application to portland cement concrete, bituminous cement concrete, metals and other type surfaces shall be applicable for the following types as designated. Products may only be used for applications recommended by the manufacturer.

Table 926-1

Type	Description
AB*	An epoxy resin, for bonding fresh or hardened concrete to hardened concrete and constructing doweled splices in precast prestressed concrete piles.
E*	A fluid epoxy for crack injection in the repair of old structures.
F F-1* F-2**	An epoxy for repairing spalled areas on concrete bridge structures with these subtypes: A non-sagging gel type for vertical surfaces. A pourable type for repairs where forms are to be used.
H**	An epoxy for structural bonding where asphalt overlays are to be in contact with the hardened compound.
K*	An epoxy for underwater sealing of the bottom of the jacket of an integral pile jacket system.
M***	A coal tar or modified glass flake epoxy coating for steel sheet piles and H piles (water immersion) and hot applied coal tar epoxy tape.
PSE*	A two-part epoxy system to match the cast faces of joints between precast segmental concrete superstructure and/or substructure segments.
Q*	An epoxy for use in post tensioning anchorage protection systems.

*Accepted by APL
**Accepted by certified test report
***Accepted by certification

926-2 Epoxy Design Requirements.

926-2.1 General: All types of compounds, except for Type M, shall be thermosetting containing no volatile solvent, and be pure reactive material. All types of compounds except for Type M shall have simple mix ratios of one to one, two to one, or shall be supplied in pre-proportioned containers in which all the contents are to be mixed.

All types of compounds shall be labeled with the manufacturer's name, brand name, component type (resin, hardener or filler), mix ratio, mixing directions, date manufactured, shelf life, and the manufacturer's LOT number. Potential hazards shall be stated on each package in accordance with the Federal Hazardous Products Labeling Act.

Certain terms used in this specification shall have these meanings:

low modulus - the stress-strain property for which ultimate tensile strength is attained at over 10% elongation.

high modulus - the stress-strain property for which ultimate tensile strength is attained at under 6% elongation.

non-sagging gel - grades of mixed compounds which will not perceptibly flow under their own weight on a vertical surface in the unhardened state.

pourable - grades of mixed compound sufficiently fluid that they (either neat or filled) can be cast into and will take the shape of a mold.

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Fillers for mixing mortars and grouts shall be recommended by the manufacturer of the epoxy compound and supplied as packages accompanying the epoxy or premixed.

926-2.2 Approved Product List (APL): All epoxy materials shall be one of the products listed on the Department's Approved Product List (APL) unless an alternative acceptance is identified in this Specification. Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6 and identify the epoxy type. Include with the submittal product data sheets, safety data sheets (SDS), and certified test reports from an independent laboratory showing the product meets the requirements of this Section. Manufacturers may submit performance test reports from the AASHTO Product Evaluation & Audit Solutions as acceptable independent laboratory data.

Upon request, submit product samples to the Department for confirmatory testing and Infrared (IR) analysis.

926-3 Specific Requirements for Type AB Epoxy Compounds.

926-3.1 Mixing and Application: Type AB epoxy compounds are used for bonding fresh or hardened concrete to harden concrete and constructing doweled splices in precast prestressed concrete piles.

926-3.2 Performance Tests: Meet the requirements of ASTM C881 Type IV and V, Class C, when tested at 73° ± 2° F.

926-4 Specific Requirements for Type E Compounds.

Epoxies for crack injection shall meet the requirements of ASTM C881 Type IV compound with these additional requirements:

Table 926-2	
Viscosity five minutes after mixing	300 to 600 cps at 77°F by ASTM D2556
Wet bond strength to concrete, minimum	250 psi at seven days by FM 5-518

926-5 Specific Requirements for Type F Compounds.

926-5.1: Repairing Spalled Areas: Epoxies for repairing spalled areas shall meet the requirements in this Section.

926-5.2: Subtype F-1: Subtype F-1 epoxy is used for repairing vertical and other surfaces and shall be a trowelable low modulus, non-sagging gel epoxy compound capable of bonding to wet surfaces with these properties:

Table 926-3	
Color	Shall match gray color No. 36622 of FED-STD-595
Consistency	Gel
Maximum sand loading	Recommended by the manufacturer
Elongation in tension minimum	10% by ASTM D638, seven-day cure
Wet bond to Steel and Concrete minimum	250 psi by Florida Test Method FM 5-518

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926-5.3: Subtype F-2: Subtype F-2 epoxy is used for filling larger spalls where a form is required to build back to the original surface. Materials shall be a pourable low modulus type compound capable of bonding to wet surfaces with these properties:

Table 926-4	
Color	Shall match gray color No. 36622 of FED-STD-595-
Maximum sand loading	Recommended by the manufacturer
Elongation in tension, minimum	10% by ASTM D638, seven-day cure
Exotherm	110°F by ASTM D2471, 1 pint sample
Wet bond strength	250 psi at seven days by FM 5-518

Type F-2 epoxy compounds will be accepted by certified test report. Submit to the Engineer testing from the manufacturer of the product for each LOT of material to be incorporated in the project. The test results will indicate that the material is in conformance with the Specifications, and will include actual values from the required tests. Obtain approval from the Engineer before incorporating material into the project.

926-6 Specific Requirements for Type H Compounds.

Type H epoxies for structural bonding where bituminous pavement overlays will come in contact with the hardened compound shall meet the requirements for Types AB compounds above. Submit from the manufacturer test data showing that cutback and emulsified asphalts, asphalt cement, and bituminous mixes shall bond to but not soften or otherwise damage the epoxy after a curing period of four days.

Type H epoxy compounds will be accepted by certified test report. Submit to the Engineer testing from the manufacturer of the product for each LOT of material to be incorporated in the project. The test results will indicate that the material is in conformance with the Specifications and will include actual values from the required tests. Obtain approval from the Engineer before incorporating material into the project.

926-7 Specific Requirements for Type K Compounds.

Type K epoxies are used for sealing the bottom of integral pile jackets in the repair of concrete piles. These epoxies will be extended with the aggregate supplied by the manufacturer. The epoxy shall be factory pre-proportioned including factory supplied aggregate and meet the following requirements:

Table 926-5	
Compressive strength at seven days, minimum by ASTM C579B	4,500 psi
Bond Strength by FM 5-518	
to wet concrete, minimum	250 psi
to wet pile jacket, minimum	150 psi
Viscosity of mixed epoxy component at 77°F, five minutes by ASTM D2556	1,000-2,000 cps

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The epoxy shall be capable of flowing through water in the void area of the jacket and hardening under water so as to provide a water tight seal of the depth indicated in the Plans or approved shop drawings and to maintain this seal during subsequent construction steps.

926-8 Specific Requirements for Type M Compounds.

Type M Coal Tar epoxy coatings for steel sheet and H piles used in bridges, fender systems and other structures subject to immersion in water shall comply with the requirements of SSPC Paint 16 with Type 1 pitch. Modified glass flake epoxies must be designed for immersion service and include a passivator. Application of the epoxy coating shall meet the requirements of Section 560 for a coal tar epoxy coating.

Hot applied coal tar epoxy tape used to protect tie back rods on sheet pile walls and bulkheads shall comply with the requirements of American Water Works Association standard C203. Application shall be according to the manufacturers published recommendations.

Submit to the Engineer a manufacturer certification, confirming that the coal tar or modified glass flake epoxy meets the requirements of this Section. The certification shall conform to the requirements of Section 6. Do not incorporate these materials into the project until the Engineer has accepted and approved the certification for the material. Submit such certification for each LOT of material delivered to the project. In each certification, identify the serial or LOT numbers of the containers certified.

926-9 Specific Requirements for Type PSE Epoxy Compounds.

Precast Segmental Epoxy (PSE) compounds are used for match-cast joints between precast concrete segments. Normal set PSE shall remain workable for a short open time (about one hour) and meet the requirements of ASTM C881, Type VI Grade 3. Slow set PSE shall remain workable over an extended open time (about eight hours), meet the requirements of ASTM C881, Type VII Grade 3, and have a compressive yield strength of 6,000 psi at 14 days.

PSE compounds shall be factory pre-proportioned and formulated to provide application temperature ranges which are suitable for the erection of match cast segments with substrate temperatures between 40°F and 105°F with a minimum of at least two, but preferably three, formulations dividing the range into approximately equal subranges which overlap by at least 5ºF.

926-10 Specific Requirements for Type Q Compounds.

Type Q epoxy compounds are used to protect the anchorages of post-tensioning tendons or bars and other uses indicated in the Plans. The material shall produce a low exothermic reaction and have flow and fill characteristics suitable for machine base plate applications. The material shall be factory pre-proportioned including factory supplied aggregate. Mix with the full aggregate loading unless the use of less aggregate is approved by the Engineer.

The epoxy grout plus aggregate mix shall meet or exceed the specified physical properties stated herein as determined by the following standard ASTM test methods.

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Table 926-6		
Property	Test Value	Test Method
Compressive Strength at 7-day Cure at 77°F	> 10,000 psi	ASTM C579B
Tensile Strength at 7 days, Cure at 77ºF	> 2,100 psi	ASTM C307
Flexural Strength at 7days Cure at 77ºF	> 3,600 psi	ASTM C580
Modulus of Elasticity 7 days Cure at 77ºF	< 2,100,000 psi	ASTM C580
Coefficient of Thermal Expansion at 74° to 210°F	< 20 x 10^{-6} in/in/ºF	ASTM C531
Peak Exotherm, Specimen 12 x 12 x 3 in.	< 150ºF	ASTM D2471
Slant Shear at 7 days (Bond Strength to Concrete)	> 3000 psi	FM 5-587
Thermal Compatibility	90% of control	FM 5-609
Linear Shrinkage at 7 days	0.025%	ASTM C531
Flowability and Bearing Area	90% Contact area	ASTM C1339
Gel Time, Specimen 12 x 12 x 3 in.	< 4:00 (hr.)	ASTM D2471

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SECTION 929
SUPPLEMENTARY CEMENTITIOUS MATERIALS

929-1 General.

Supplementary cementitious materials (SCMs) shall conform to the requirements of this Section. SCMs shall be used in concrete mix designs in accordance with Section 346.

Repulpable bags may be accepted by the Engineer, provided a successful demonstration by the producer has indicated complete degradation of the repulpable bags during the mixing operation and before the mix is discharged.

The Engineer may require additional testing beyond the requirements of this Section prior to the acceptance of any SCM sources.

929-1.1 Definitions.

The following definitions are applicable to the production and quality control (QC) of SCMs:

1. Approved Laboratory: A laboratory that is currently inspected by the Cement and Concrete Reference Laboratory (CCRL), is actively participating in the CCRL proficiency program, and has corrected all deficiencies noted at the time of inspection. The laboratory must authorize the CCRL to send a copy of the final inspection report and proficiency sample results to the State Materials Office (SMO).

2. SCM Producer: Indicates an SCM supplier, including but not limited to a plant, a terminal, or a transfer facility, that has been qualified by the SMO. The Cementitious Materials Production Facility Listing will be maintained by the SMO.

3. Test Report: A certification from the SCM Producer showing that the SCM meets the requirements of this Section. The test report must include, at a minimum, the following information:

   a. The type of SCM.
   b. The production period.
   c. Chemical and physical analysis of the SCM.
   d. The silo numbers where the SCM is stored.
   e. The specific gravity of the SCM reported as an average of the last twelve monthly tests, updated every six months.
   f. The approved laboratory that performed all tests.

4. Purchaser: The term “purchaser” in the ASTM requirements shall be taken as the Department.

929-2 Quality Control Program.

929-2.1 General: Develop a Producer QC Program as specified in Section 105.

SCM Producers shall submit a proposed QC Plan to the SMO for acceptance.

Complete the Cementitious Materials Producer QC Plan Checklist (Appendix B02) and submit it along with the QC Plan, in a separate file. The checklist can be found on the SMO website: https://www.fdot.gov/materials/quality/programs/qualitycontrol/checklists/index.shtm. In addition to the QC Plan, the SCM Producer must submit monthly test reports from an approved laboratory which certifies that the SCM in current production or supply conforms to the requirements of this Section.

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SCM Producers with an accepted QC Plan will appear on the Cementitious Materials Production Facility Listing.

QC test data that does not comply with the Specification will not be reason for rejection of the material if the SCM Producer's QC Plan indicates that material will be diverted and not used for Department projects.

929-2.2 Sampling and Testing: Representatives from the Department may take verification samples at the SCM Producer's plant, terminal, distribution facility or the concrete production facility. Samples shall be obtained by one of the methods described in FM 5-503. Sample sizes shall be a minimum of one gallon by volume.

Upon request of the Department, the SCM Producer shall provide split samples of the SCM collected for QC testing. Split samples shall be delivered to the SMO and shall be identified as representing a designated LOT of the SCM.

Notification of failing verification sample test results will be distributed to the SCM Producer and concrete producers (if applicable). Split samples of the initial sample may be provided to the SCM Producer and concrete producer upon request, as available.

929-3 Coal Ash.

929-3.1 General: Sampling and testing of coal ash shall follow the requirements of ASTM C311. Coal ash shall not include the residue resulting from the burning of municipal waste or any other refuse with coal, or the burning of industrial or municipal waste in incinerators. The Engineer may accept sources of coal ash containing bottom ash on a case-by-case basis. The SCM Producer shall report:

1. If the material is fly ash or harvested coal ash.
2. If harvested coal ash is combined with any other material.

929-3.1.1 Fly Ash (Class F or Class C): Coal ash derived from the combustion of ground or powdered coal meeting the requirements of ASTM C618 Class F or Class C coal ash, and this Section.

929-3.1.2 Harvested Coal Ash (Class F or Class C): Coal ash derived from the combustion of ground or powdered coal that has been stored in a landfill or surface impoundment and subsequently excavated and processed to meet the requirements of ASTM C618 Class F or Class C coal ash, and this Section.

929-3.2 Acceptance Testing of Coal Ash: Coal Ash derived from the combustion of ground or powdered coal shall meet the requirements of ASTM C618 Class F or Class C coal ash.

Acceptance of coal ash from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C618 Class F or Class C, and this Section. When the loss on ignition exceeds 6.0%, the Supplementary Optional Physical Requirements shall be mandatory.

Class C coal ash may be used if the concrete test results provide improved or comparable compressive strength, sulfate resistance, corrosion protective properties, and other durability requirements, when compared to concrete containing Class F fly ash.

929-3.2.1 Concrete/Mortar Testing: Six concrete mixes shall be prepared by an accredited laboratory, three control batches using Class F coal ash and three comparison batches with Class C coal ash, while all other constituents remain the same except for small adjustments to get the mix to yield. Concrete constituents used in the mixes must be obtained from FDOT approved sources. Use a Class IV (5,500 psi) Conventional binary concrete mix design meeting the requirements of Section 346, with the following attributes:

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1. Type II or Type IL cement.
2. Size No. 57 coarse aggregate.
3. Control batches: Replace 18 to 22% of the cement with Class F coal ash.
4. Comparison batches: Replace a portion of cement with a quantity of Class C coal ash sufficient to produce properties comparable to those of the control batches.
5. Water/cementitious materials ratio of 0.41.

The following testing shall be performed on each concrete mix, as appropriate.

Table 929-1
Concrete/Mortar Testing Requirements

Test Description	Standard Test Method	Test Age
Surface Resistivity	AASHTO T 358	28, 56, 91, and 180 days
Compressive Strength	ASTM C39	28, 56, 91, and 180 days
Chloride Diffusion	ASTM C1556 or NT Build 443	6 and 12 months
Length Change	ASTM C157	Per ASTM C157 (1)
Sulfate Resistance (2)	ASTM C1012	6, 12, and 18 months

(1) Follow both the Water and Air Storage procedures.
(2) Prepare a mortar mix using a fixed water/cementitious materials ratio of 0.485.

Upon completion of the 6-month concrete and mortar testing, the SCM Producer may present the data to the SMO for acceptance. The 12 and 18-month data shall be provided to the SMO upon completion.

929-4 Slag Cement.

Slag cement (ground granulated blast furnace slag, GGBFS) is the quenched, ground by-product of the iron ore refinement process conducted in blast furnaces. It is primarily an amorphous material of calcium aluminosilicate constituents.

929-4.1 General: Slag cement and reference cement used for determination of slag activity tests shall meet the requirements of ASTM C989. Sampling and testing procedures shall follow the requirements of ASTM C989.

929-4.2 Acceptance Testing of Slag Cement: Acceptance of slag cement from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C989 and this Section. The test report shall include:

1. For slag granules, provide X-ray Fluorescence (XRF) elemental analysis of the granules, presented in oxide form. Include CaO, SiO_2, Al_2O_3, MgO, Mn_2O_3, TiO_2, Fe_2O_3, and sulfur (as sulfide).
2. For slag cement, provide XRF elemental analysis, presented in oxide form. Include CaO, SiO_2, Al_2O_3, MgO, Mn_2O_3, TiO_2, Fe_2O_3, sulfur as sulfide (S), sulfate sulfur (SO_3), and total sulfur as sulfate (SO_3).
3. The results of all testing listed under Test Methods section of ASTM C989.

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4. Indicate the amount of any additions introduced during grinding of the slag granules and report compliance with Section 6 of ASTM C989.

a. Amount of limestone added and its $CaCO_3$ content.

b. Amount of other inorganic processing addition.

5. For calcium sulfate additions, indicate:

a. Amount of calcium sulfate added.

b. Form of calcium sulfate.

c. SO_3 content.

d. Method used to determine the amount of calcium sulfate that was added.

929-4.2.1 Assessment of Sulfate Resistance: Following guidance in ACI 233R-17 Guide to the Use of Slag Cement in Concrete and Mortar, slag cements with Al_2O_3 contents greater than 11% should be interground with calcium sulfate to avoid an undersulfated cementitious system. Provide ASTM C1012 data with a 50:50 cement-slag cement blend, using a Type II or Type IL cement on the Department's Cementitious Materials Production Facility Listing, with an alkali content of no more than 0.6%, when any of the following conditions occur:

1.The Al_2O_3 content of the slag cement is equal to or greater than 12%.

2. The slag cement is a blend of slag granules from more than one source that are interground during production of the slag cement and for which one or more of the following are true:

a. The Al_2O_3 contents of both slag sources are equal to or greater than 12%.

b. The average Al_2O_3 content of the blend is equal to or greater than 12%.

c. One of the slag sources has an Al_2O_3 content that is equal to or greater than 14%.

The Department will consider the ASTM C1012 data acceptable when the results indicate no more than 0.10% expansion at 12 months.

The Department may grant provisional acceptance if the expansion does not exceed 0.05% at 6 months.

For any slag cements with Al_2O_3 content equal to or greater than 12%, perform a retest of ASTM C1012 if the monthly test report indicates that any of the following conditions have occurred:

1. The Al_2O_3 content increases by greater than or equal to 1.0% of the content measured during qualification of the sulfate resistance.

2. The sulfate sulfur (SO_3) content decreases by 0.25% less than that measured during qualification of the sulfate resistance.

3. The Blaine fineness increases by 50 m^2/kg greater than that measured during qualification of the sulfate resistance.

The Department may grant provisional acceptance of the slag cement source if ASTM C1012 data is required for any of the above retesting conditions.

929-5 Calcined Clay.

929-5.1 General: Sampling and testing of calcined clay shall follow the requirements of ASTM C311. Calcined clay shall meet the requirements of ASTM C618 Class N.

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929-5.2 Acceptance Testing of Calcined Clay: Acceptance of calcined clay from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C618 Class N and this Section.

Calcined clay may be used in concrete if the test results provide improved or comparable compressive strength, sulfate resistance, corrosion protective properties, and other durability requirements of concrete, when compared to concrete containing Class F coal ash.

929-5.2.1 Concrete/Mortar Testing: Six concrete mixes shall be prepared by an accredited laboratory, three control batches using Class F coal ash and three comparison batches with the calcined clay, while all other constituents remain the same except for small adjustments to get the mix to yield. Concrete constituents used in the mixes must be obtained from FDOT approved sources. Use a Class IV (5,500 psi) Conventional binary concrete mix design meeting the requirements of Section 346, with the following attributes:

1. Type II or Type IL cement.
2. Size No. 57 coarse aggregate.
3. Control batches: Replace 18 to 22% of the cement with Class F coal ash.
4. Comparison batches: Replace a portion of cement with a quantity of calcined clay sufficient to produce properties comparable to those of the control batches.
5. Water/cementitious materials ratio of 0.41.

Testing shall be performed in accordance with Table 929-1.

929-6 Ground Glass.

929-6.1 General: Sampling and testing of ground glass shall follow the requirements of ASTM C311. Ground glass shall meet the requirements of ASTM C1866. Sampling and testing procedures shall follow the requirements of ASTM C1866.

929-6.2 Acceptance Testing of Ground Glass: Acceptance of ground glass from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C1866 and this Section.

Ground glass may be used in concrete if the test results provide improved or comparable compressive strength, sulfate resistance, corrosion protective properties, and other durability requirements of concrete, when compared to concrete containing Class F coal ash.

929-6.2.1 Concrete/Mortar Testing: Six concrete mixes shall be prepared by an accredited laboratory, three control batches using Class F coal ash and three comparison batches with the ground glass, while all other constituents remain the same except for small adjustments to get the mix to yield. Concrete constituents used in the mixes must be obtained from FDOT approved sources. Use a Class IV (5,500 psi) Conventional binary concrete mix design meeting the requirements of Section 346, with the following attributes:

1. Type II or Type IL cement.
2. Size No. 57 coarse aggregate.
3. Control batches: Replace 18 to 22% of the cement with Class F coal ash.
4. Comparison batches: Replace a portion of cement with a quantity of ground glass sufficient to produce properties comparable to those of the control batches.
5. Water/cementitious materials ratio of 0.41.

Testing shall be performed in accordance with Table 929-1.

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929-7 Natural Pozzolan.

929-7.1 General: Sampling and testing of natural pozzolans shall follow the requirements of ASTM C311. Natural pozzolans shall meet the requirements of ASTM C618 Class N.

929-7.2 Acceptance Testing of Natural Pozzolans: Acceptance of natural pozzolans from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C618 Class N and this Section.

Natural pozzolans may be used in concrete if the test results provide improved or comparable compressive strength, sulfate resistance, corrosion protective properties, and other durability requirements of concrete, when compared to concrete containing Class F coal ash.

929-7.2.1 Concrete/Mortar Testing: Six concrete mixes shall be prepared by an accredited laboratory, three control batches using Class F coal ash and three comparison batches with the natural pozzolan, while all other constituents remain the same except for small adjustments to get the mix to yield. Concrete constituents used must be obtained from FDOT approved sources. Use a Class IV Conventional (5,500 psi) binary concrete mix design meeting the requirements of Section 346, with the following attributes:

1. Type II or Type IL cement.
2. Size No. 57 coarse aggregate.
3. Control batches: Replace 18 to 22% of the cement with Class F coal ash.
4. Comparison batches: Replace a portion of cement with a quantity of natural pozzolan sufficient to produce properties comparable to those of the control batches.
5. Water/cementitious materials ratio of 0.41.

Testing shall be performed in accordance with Table 929-1.

929-8 Highly Reactive Pozzolans.

929-8.1 Silica Fume:

929-8.1.1 General: Silica Fume shall meet the requirements of ASTM C1240 using the referenced test methods and frequencies.

929-8.1.2 Acceptance Testing of Silica Fume: Acceptance of silica fume from sources operating under an accepted QC Plan shall be based on monthly test reports that the material meets the requirements of ASTM C1240 and this Section.

929-8.2 Metakaolin:

929-8.2.1 General: Metakaolin shall meet the requirements of ASTM C618 Class N and the following:

1. The sum of $SiO_2 + Al_2O_3 + Fe_2O_3$ shall be at least 85%.
2. The loss on ignition shall be less than 3.0%.
3. The available alkalis, as equivalent Na_2O, shall not exceed 1.0%.
4. The strength activity index, at 7 days, shall be at least 85%.

929-8.2.2 Acceptance Testing of Metakaolin: Acceptance of metakaolin from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C618 Class N, as modified herein, and this Section.

929-8.3 Ultra-Fine Fly Ash:

929-8.3.1 General: Sampling and testing of the ultra-fine fly ash shall follow the requirements of ASTM C311. Ultra-fine fly ash derived from the combustion of ground or

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powdered coal shall meet the requirements of ASTM C618 as a Class F fly ash with the following modifications:

1. The strength activity index, at 7 days, shall be at least 85% of the control and the strength activity index, at 28 days, shall be at least 95% of the control.
2. The amount of material retained when wet-sieved on a 45-µm sieve shall be less than 6.0%.
3. The moisture content shall be less than 1.0%.
4. The loss on ignition shall be less than 2.0%.

929-8.3.2 Acceptance Testing of Ultra-Fine Fly Ash: Acceptance of fly ash from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C618 Class F fly ash, as modified herein, and this Section. When the loss on ignition exceeds 2.0%, the Uniformity Requirements in the Supplementary Optional Physical Requirements shall be mandatory.

929-9 Shipping and Storage.

SCMs may be delivered in bags or in bulk. SCMs from an SCM Producer on the Cementitious Materials Production Facility Listing shall be shipped on the basis of test reports meeting the requirements of this Section. Ensure that each shipment is accompanied by a delivery ticket that is traceable to the test report and includes, at a minimum, the following information:

1. FDOT Facility Identifier
2. Type of material (e.g., Class F coal ash or Grade 120 slag)
3. Date shipped
4. Silo Identification

The storage building, bin or silo shall be weatherproofed.

929-10 Foreign SCM Acceptance.

SCMs being imported from a foreign source shall conform to all requirements of this Section and will be subject to the following process:

1. The proposed QC Plan shall be sent to the SMO and will include information regarding the QC, sampling, storage, and handling of the material at the arrival terminal as well as the shipping control to and from the arrival terminal. In addition, the QC Plan from the foreign source shall be translated to English and will be included with the proposed QC Plan for the arrival terminal.
2. An initial one gallon by volume sample of the imported SCM shall be sent to the SMO for chemical and physical testing.
3. When the first ship is being loaded from the foreign source, a one gallon by volume verification sample will be obtained and shipped to the SMO for chemical and physical property testing.

The material will be accepted for use on Department projects provided that the QC Plan has been accepted, and the results of the initial and verification samples have been confirmed to meet the requirements of this Section.

Upon receiving the shipment of SCM at the arrival terminal, the Department will be notified, and a Department representative may obtain another verification sample.

Test reports representing each shipment shall be sent to the SMO.

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SECTION 930
MATERIALS FOR CONCRETE REPAIR

930-1 Description.

This Section covers cementitious materials used to repair concrete including defects or purposely placed openings in concrete elements. Materials containing organic compounds, such as bitumen and epoxy resin as the principal binder are not included. The requirements for epoxy resin materials are covered in Section 926. Any depth larger than the manufacturer's recommendation for the specific material shall be repaired with portland cement concrete meeting the requirements of Section 346.

930-2 Product Acceptance on the Project.

930-2.1 Product Acceptance: Use only products listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of products must submit an application in accordance with Section 6 and include independently certified test reports that the material meets the requirements of this Section. The application package must describe detailed quality control requirements for installation including, but not limited to: maximum water to cementitious material ratio, formulation for two or more component systems, special materials and/or equipment, recommendations for all surface preparation, and curing requirements.

Provide the Engineer certification conforming to the requirements of Section 6 from the manufacturer confirming that the materials used meets the requirements of this Section and is the appropriate product for the intended use.

When specified in the Contract Documents, submit a report of test results from an independent laboratory on samples taken from material shipped. Ensure the test was performed within 45 days prior to the shipping date of the material.

930-2.2 Material Supply, Storage, and Marking: The material shall be pre-proportioned including aggregate. Deliver products in original, unopened containers with manufacturer's name, date of manufacture, and clearly marked with all information described below. Store the material in an elevated dry and weather protected enclosure in full compliance with the manufacturer's recommendations. Material must be used within manufacturer's recommended shelf life.

The material from which the containers are made shall have water vapor transmission not greater than 100 g/m^2 in 24 hours as determined in accordance with Procedure B of ASTM E96.

All containers shall be marked with the following information:

1. LOT identification number and material expiration date
2. Directions for use shall include but are not limited to the following:
    a. The type and kind of adhesive recommended (if any) to bond fresh repair material to the concrete or mortar being repaired.
    b. The recommended amount of resin, other liquid component, or both, to be mixed with the package contents.
    c. The recommended length of mixing time or sequence of mixing and resting times in minutes.
3. Date the material was packaged.
4. The yield in cubic feet or yield in ft^2/in. thickness when mixed with the recommended amount of liquid.

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5. The net weight in each container. The contents of any container shall not vary by more than 2% from the weight stated in the declarations. The average weight of filled containers in a LOT shall be not less than the individual weight stated in the declarations.

6. Instructions for the maximum and minimum water (or solutions) to cementitious material ratio.

7. State the approximate working time.

930-2.3 Sampling, Mixing, and Additional Testing: A LOT is the packaged repair material normally placed on a pallet. A unit sample is a single container or package of material randomly selected from the LOT. Mix and install the materials in accordance with the manufacturer's recommendations. Manufacturers will be required to provide field representation upon request by the Engineer. The Department reserves the right to conduct further field testing on any approved material.

930-2.4 Rejection: All broken containers will be rejected. Material that fails to meet any of the requirements of this Specification will be rejected. Report all materials failing to meet this specification and state the reasons for rejection in writing to the Engineer and the producer or supplier. Material in local storage in the hands of a vendor for more than six months after testing will be retested before use, except for the scaling resistance test and length change immersed in sulfate solution test for magnesium ammonium phosphate concrete. Retested material will be rejected if it fails to conform to any of the requirements of this Specification.

930-3 Laboratory Specimen Preparation.

930-3.1 Mixing and Fabrication: Mechanically mix the dry packaged materials with liquid components in accordance with the manufacturer's recommendations.

930-3.2 Length Change: Make and cure the test specimens in accordance with ASTM C157, except omit the curing period in Section 10.3; however both 11.1.1 and 11.1.2 shall apply for 28 day curing period.

930-3.3 Manifestly Faulty Specimens: Visually examine each group of specimens representing a given test or a given age of test, including tests of freshly mixed concrete, before or during the test, or both, whichever is appropriate. Discard any specimen found to be manifestly faulty by such examination without testing. Visually examine all specimens representing a given test at a given age after testing, and should any specimen be found to be manifestly faulty the test results thereof shall be disregarded. Should more than one specimen representing a given test at a given age be found manifestly faulty either before or after testing, the entire test shall be disregarded and repeated. The test result reported shall be the average of the individual test results of the specimens tested or, in the event that one specimen or one result has been discarded, it shall be the average of the test results of the remaining specimens.

930-4 Materials for Repair of Predominately Horizontal Surfaces.

930-4.1 General: This material is intended to be used to repair concrete where the area to be treated will be on a horizontal surface. Examples of the type of locations for these materials are bridge decks, portland cement concrete pavements and other locations required by the Contract Documents. Follow the manufacturer's recommendations for preparing the surfaces, mixing, placing, and curing the repair material unless otherwise directed in the Contract Documents.

930-4.2 Classification: The materials to be considered under this classification shall meet the following requirements:

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930-4.2.1 Rapid Hardening: Moderate compressive strength for repairing concrete with an in-place compressive strength less than or equal to 4,000 psi.

930-4.2.2 Very Rapid Hardening: High compressive strength for repairing concrete with an in-place compressive strength greater than 4,000 psi. This material may be used in lieu of rapid hardening materials.

930-4.3 Physical Properties: The repair material shall meet or exceed the physical properties stated in Table 930-1 as determined by the specified test methods.

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Table 930-1 Physical Properties of Repair Materials for Horizontal Surfaces			
Requirement	Test Method	Rapid Hardening	Very Rapid Hardening
Minimum Compressive Strength, psi			
3 hours	ASTM C39* or ASTM C109*	N/A	2,000
24 hours		2,000	4,000
7 days		4,000	6,000
28 days		Greater than or equal to strength at 7 days.	
Maximum Length Change, %			
Allowable expansion at 28 days when water cured compared to length at one day	ASTM C157**	0.12	0.12
Allowable shrinkage at 28 days when air cured compared to length at one day		-0.12	-0.12
Allowable difference between increase in water and decrease in air		0.20	0.20
Minimum Slump (Concrete), inches	ASTM C143***	3	3
Minimum Flow (Mortar), %	ASTM C1437***	100	80
Time of Setting (Initial), minutes	ASTM C191* or ASTM C403*	Minimum 30	10 to 29
Coefficient of Thermal Expansion, in/in/°F	ASTM C531* or AASHTO T 336	3.0×10^{-6} to 9.0×10^{-6}	3.0×10^{-6} to 9.0×10^{-6}
Minimum Bond Strength by Slant Shear, psi			
24 hours	FM 5-587	400	450
7 days		Greater than or equal to strength at 24 hours.	
Maximum Allowable Total Chlorides lb/yd^3	FM 5-516	0.40	

* as applicable
** Make and cure the test specimens in accordance with ASTM C157, except omit the curing period in Section 10.3; however both 11.1.1 and 11.1.2 shall apply for 28 day curing period.
*** Testing for flow/slump will be completed in 15 plus or minus 1/2 minute after the start of mixing liquid with the rapid hardening materials or 5 plus or minus 1/2 minute after mixing the liquid with the very rapid hardening materials.

930-4.4 Specimen Preparation:

930-4.4.1 Flow/Slump: Testing for flow/slump will be completed in 15 minutes, plus or minus 1/2 minute, after the start of mixing liquid with the rapid hardening materials or 5 minutes, plus or minus 1/2 minute, after mixing the liquid with the very rapid hardening materials.

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930-5 Materials for Repair of Predominately Vertical Surfaces.

930-5.1 General: This material is intended to be used to repair concrete where the area exposed in the field to be treated will be on a vertical surface. If an element has both horizontal and vertical surfaces, then the repair used will be for vertical surfaces. If it is not apparent which material is to be used, the vertical application will prevail. Examples of the type of locations for these materials are columns, caps, beams, piles, incidental concrete products, drainage structures and other locations required by the Contract Documents. Follow the manufacturer's recommendations for preparing the surfaces and for mixing, placing and curing the repair material.

930-5.2 Classification: The materials to be considered under this classification shall meet the following requirements:

930-5.2.1 High Performance: Moderate compressive strength for repairing concrete with a designed compressive strength greater than or equal to 5,000 psi.

930-5.2.2 Ultra-high Performance: High compressive strength for repairing concrete with a designed compressive strength greater than 5,000 psi. These materials may be used in lieu of high performance vertical materials.

930-5.3 Physical Properties: The repair material shall meet or exceed the physical properties stated in Table 930-2 as determined by the specified test methods.

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Table 930-2 Physical Properties of Repair Materials for Vertical Surfaces*			
Requirement	Test Method	High Performance	Ultra-high Performance
Minimum Compressive Strength, psi			
24 hours	ASTM C39** or ASTM C109**	1,000	2,000
7 days		N/A	5,000
28 days		5,000	Greater than or equal to strength at 7 days
Maximum Length Change, %			
Allowable expansion at 28 days when water cured compared to length at one day	ASTM C157**	0.12	0.12
Allowable shrinkage at 28 days when air cured compared to length at one day		-0.08	-0.08
Maximum Slump (Concrete), inches	ASTM C143	3****	3****
Maximum Flow (Mortar), %	ASTM C1437	100****	100****
Time of Setting (Initial), minutes	ASTM C191** or ASTM C403**	10 to 180****	10 to 180****
Coefficient of Thermal Expansion, in/in/°F	ASTM C531*** or AASHTO T 336***	3.0×10^{-6} to 9.0×10^{-6}	
Minimum Bond Strength by Slant Shear, psi,			
24 hours	FM 5-587	450	750
7 days		750.	750
Minimum Flexural Strength (at 7 days), psi	ASTM C580	500	700
Maximum Absorption (Mortar at 7 days), %	ASTM C413	4	4
Minimum Surface Resistivity (Concrete at 28 days), kohm-cm	AASHTO T 358	N/A	22
Maximum Allowable Total Chlorides lb/yd^3	FM 5-516	0.40	

* Use cement-based materials modified with polymers and silica fume for extremely aggressive environments
** Make and cure the test specimens in accordance with ASTM C157, except omit the curing period in Section 10.3; however both 11.1.1 and 11.1.2 shall apply for 28 day curing period.
*** As applicable
**** For pump and pour applications, the maximum flow, slump and time of setting can be adjusted according to the manufacturer's recommendation.

930-6 Material for Repair of Concrete in High Stress Concentration Areas.

930-6.1 General: This material is intended to be used to repair block-outs and voids in post-tensioned elements, load bearing area of a beam, and other locations required by the Contract Documents. This material may be used for the repair of horizontal or vertical surfaces. Follow the manufacturer's recommendations for preparing the surfaces and for mixing, placing and curing the concrete. This material shall be a magnesium ammonium phosphate based concrete (MAPC) or a magnesium potassium phosphate based concrete (MPPC).

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930-6.2 Physical Properties: The MAPC and MPPC materials shall meet or exceed physical properties stated in Table 930-3 as determined by the specified standard test methods.

Table 930-3
Physical Properties of Repair Material in High Stress Areas

Requirement	Test Method	Test Value
Minimum Compressive Strength (at 28 days), psi	ASTM C109*	8,500
Minimum Flexural Strength (at 28 days), psi	ASTM C348*	600
Minimum Slant Shear Bond (at 14 days), psi	FM 5-587*	2,500
Time of Setting (Initial), minutes	ASTM C191**	15 to 60
Maximum Scaling Resistance	ASTM C672	No scaling
Maximum Length Change, %		
Allowable expansion at 28 days when water cured compared to length at one day	ASTM C157***	0.03
Allowable shrinkage at 28 days when air cured compared to length at one day		-0.03
Maximum Allowable Total Chlorides lb/yd^3	FM 5-516	0.40

* The test methods for compressive strength (ASTM C109), flexural strength (ASTM C348), and Slant Shear Bond (FM 5-587) shall be modified so that the specimens are air cured instead of moist cured. All of these samples shall be air cured until the time of testing.

** Initial time of set for MAPC or MPPC will be tested in accordance with ASTM C191 with the following modification. The initial time of set shall be tested at 95° plus or minus 5°F.

*** Make and cure the test specimens in accordance with ASTM C157, except omit the curing period in Section 10.3; however both 11.1.1 and 11.1.2 shall apply for 28 day curing period.

930-6.3 Curing of Compressive Strength, Flexural Strength and Slant Shear Bond Specimens: The test methods for compressive strength (ASTM C109), flexural strength (ASTM C348), and Slant Shear Bond (FM 5-587) shall be modified so that the specimens are air cured instead of moist cured. All of these samples shall be air cured until the time of testing.

930-7 Special Fillers.

930-7.1 General: This material is intended to be used as filler material and for rapid repairs to pile jacket structures and other locations specified in the Plans. Meet the requirements of the contract documents for preparing the surfaces, placing, sampling, testing, and curing the concrete. Mix the material in accordance with the manufacturer's recommendations.

930-7.2 Classification: The materials to be considered under this classification shall meet the following requirements:

930-7.2.1 Cathodic Protection (CP) Filler: Provide cementitious based materials with a minimum cement content of 900 pounds of cement per cubic yard of mix. Material formulation must not contain coal ash, slag, silica fume or other mineral admixtures which may produce increased electrical resistance. The material shall not contain any substances corrosive to metals.

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930-7.2.2 Non-Cathodic Protection (Non-CP) Filler: Provide cementitious based materials with a minimum cement content of 650 pounds of cement per cubic yard of mix. The material shall not contain any substances corrosive to metals.

930-7.2.3 Extended Materials: Where concrete filler materials are specified, approved mortar materials may be extended using size number 89 gradation aggregates from a certified FDOT approved source.

930-7.3 Physical Properties: The repair material shall meet or exceed the physical properties stated in Table 930-4 as determined by the specified standard test methods. If extended, materials shall meet the minimum requirements of Table 930-4.

930-7.4 Constructability: Submit to the Engineer for approval shop drawing as may be required to complete repairs in compliance with the design shown in the Plans and the manufacturer's recommended repair system.

Table 930-4
Physical Properties of Special Fillers

Requirement	Test Method	Cathodic Protection	Non-Cathodic Protection
Minimum Compressive Strength, psi			
24 hours	ASTM C39* or ASTM C109*	1,500	2,000
28 days		5,000	5,000
Maximum Length Change, %			
Allowable expansion at 28 days when water cured compared to length at one day	ASTM C157**	0.12	0.12
Allowable shrinkage at 28 days when air cured compared to length at one day		-0.12	-0.12
Allowable difference between increase in water and decrease in air		0.20	0.20
Slump (Concrete), inches	ASTM C143	7-9	7-9
Minimum Flow (Mortar), %	ASTM C1437	100	100
Time of Setting (Initial), minutes	ASTM C191* or ASTM C403*	200 to 400	200 to 400
Minimum Bond Strength by Slant Shear (at 7 days), psi	FM 5-587	450	450
Minimum Flexural Strength (at 7 days), psi	ASTM C580	700	700
Minimum Tensile Strength (at 7 days), psi	ASTM C307	200	200
Surface Resistivity (at 28 days), kohm-cm	AASHTO T 358	15 or less	22 or greater
Maximum Allowable Total Chlorides lb/yd^3	FM 5-516	0.40	

* as applicable

** Make and cure the test specimens in accordance with ASTM C157, except omit the curing period in Section 10.3; however both 11.1.1 and 11.1.2 shall apply for 28 day curing period.

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SECTION 931
METAL ACCESSORY MATERIALS FOR CONCRETE PAVEMENT AND CONCRETE STRUCTURES

931-1 Reinforcement Steel (for Pavement and Structures).

931-1.1 Steel Bars:

931-1.1.1 Carbon Steel Bars: Carbon steel bars for concrete reinforcement shall conform to the requirements of ASTM A615 Grades 60 or 80.

931-1.1.2 Stainless Steel Bars: Stainless steel bars for concrete reinforcement shall conform to the requirements of ASTM A955, Grades 60 or 75; or ASTM A276, UNS S31653 or S31803.

931-1.1.3 Low-Carbon Chromium Steel Bars: Low-carbon chromium steel bars for concrete reinforcement shall conform to the requirements of ASTM A1035 Grade 100.

931-1.1.4 Special Requirements: The following special requirements shall apply:

1. Unless otherwise specified or shown in the Plans all reinforcing bars No. 3 and larger shall be deformed bars.
2. Twisted bars shall not be used.
3. Wherever in the Specifications the word “purchaser” appears it shall be taken to mean the Department.

931-1.1.5 Acceptance of Steel Bars: Acceptance of reinforcing steel shall be based on the manufacturer being on the AASHTO Product Evaluation & Audit Solutions list of compliant producers, samples taken by the Department, and manufacturer’s certified mill analysis. The test results shall meet the specification limits of the ASTM or AASHTO designation for the size, grade, and any additional requirements. The manufacturer’s certified mill analysis for each heat, size, and grade per shipment of reinforcing steel shall be provided to the Engineer prior to use.

The Engineer will select samples representing each LOT of reinforcing steel. A sample is defined as the reinforcing steel and the certified mill analysis corresponding to the sample. A LOT is defined as the weight of all bars, regardless of size, grade or pay item in consecutive shipments of 100 tons or less. Samples shall be cut from bundled steel that is shipped to the jobsite.

Projects with less than two tons of bars do not require Department sampling.

931-1.2 Wire Reinforcement:

931-1.2.1 Carbon Steel Wire Reinforcement: Plain and deformed carbon steel wire reinforcement shall meet the requirements of ASTM A1064. Deformed carbon steel wire shall be Grade 75.

931-1.2.2 Stainless Steel Wire Reinforcement: Plain and deformed stainless steel wire reinforcement shall meet the requirements of ASTM A276, UNS S30400.

931-1.2.3 Acceptance of Wire Reinforcement: Acceptance of wire reinforcement shall be based on the manufacturer’s certified mill analysis certifying that the test results meet the specification limits of the ASTM designation for the sizes and any additional

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requirements. Prior to use, submit to the Engineer the manufacturer's certified mill analysis for each heat and size per shipment.

931-1.3 Carbon Steel Welded Wire Reinforcement:

931-1.3.1 Carbon Steel Welded Wire Reinforcement: Welded wire reinforcing steel shall meet the requirements of ASTM A1064.

931-1.3.2 Acceptance of Carbon Steel Welded Wire Reinforcement: Acceptance of welded wire reinforcement shall be based on the manufacturer's certified mill analysis certifying that the test results meet the specification limits of the ASTM designation for the sizes and any additional requirements. Prior to use, submit to the Engineer the manufacturer's certified mill analysis for each heat and size per shipment.

931-1.4 Couplers for Steel Bars:

931-1.4.1 Approved Product List (APL): The couplers used shall be a product included on the Department's APL.

Manufacturers seeking approval of their product shall demonstrate the performance of their product in accordance with the requirements in 931-1.4.2 through 931-1.4.4 as applicable and 931-1.4.5.

931-1.4.2 Couplers for Carbon Steel Bars: Couplers for use with carbon steel bars shall be fabricated from an alloy that is electrochemically compatible with bars that meet the requirements of 931-1.1.1.

931-1.4.3 Couplers for Stainless Steel Bars: Couplers for use with stainless steel bars shall be fabricated from an alloy that is electrochemically compatible with bars that meet the requirements of 931-1.1.2.

931-1.4.4 Couplers for Low-Carbon Chromium Steel Bars: Couplers for use with low-carbon chromium steel bars shall be fabricated from an alloy that is electrochemically compatible with bars that meet the requirements of 931-1.1.3.

931-1.4.5 Special Requirements: Couplers shall develop at least 125% of the specified yield strength of the bar being spliced.

931-2 Metal Materials for Joints in Concrete Pavement.

931-2.1 Sheet Metal Bottom Strips: For concrete pavement using the special select soil base option, the sheet metal strip for protecting the bottom and side edges of transverse expansion joints shall be composed of galvanized sheet metal of 0.0157 inches minimum thickness and shall conform to the requirements of ASTM A653.

The sheets shall be furnished in accordance with the dimensions shown in the Plans. They may be in one continuous piece, or spliced. When splicing is used the metal shall be lapped not less than 3 inches and securely fastened, by welding or otherwise, in such manner as to leave the spelter undamaged and produce a smooth sliding surface in contact with the pavement slab. The splices shall be spaced not less than 10 feet apart and not less than 5 feet from either end. The complete sheet shall not vary from a straight line by more than 1 inch from end to end.

The Contractor shall submit to the Engineer a certified mill analysis from the manufacturer of the sheet metal bottom strips including test results for thickness, dimension, grade, length, size, and spacing. Each certified mill analysis shall cover only one type of metal material for joints.

931-2.2 Bars and Chairs for Longitudinal Joints: Transverse reinforcing steel across the joint shall be deformed steel bars conforming to the requirements of 931-1.1 except that the bars may be any grade shown in ASTM A615.

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These bars, and the chairs to hold them in place, shall be of the type and spacing as indicated in the Plans.

931-2.3 Dowel Bars: Dowel bars must meet the requirements of Table 931-1. They shall be of the length, size and spacing as shown in the Plans.

The Contractor shall submit to the Engineer a certified test report from the manufacturer of the dowel bars confirming that the requirements of this Section are met. The certified test report shall conform to the requirements of Section 6 and include metallurgical mill analysis, grade, length and size. Each certification shall cover only one LOT for dowel bars.

931-2.4 Chairs and Metal Expansion Caps: The chairs and metal expansion caps shall be of an approved type as shown in the Plans.

Dowel bars for expansion joints shall have a metal cap on one end so placed to provide ample space for movement of the slab. Continuous sleeves covering one half of the length of the bar will not be permitted. Other fasteners may be approved. Dowel bars shall be coated with an approved material to break the bond.

931-3 Metal Dowel Bar Assemblies for Joints in Concrete Pavement.

931-3.1 Approved Product List (APL): The dowel bars and basket assembly must meet the requirements of Table 931-1 and shall be a product included on the Department's APL.

Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6 and shall submit product photo and drawings, technical data sheets, and certifications that demonstrate the performance of their products in accordance with the requirements in 931-3.1 thru 931-3.5.

Table 931-1 Material Requirement for Dowel Bar and Basket Assemblies

Component	Base Metal	Coating
Dowel Bar	ASTM A615	ASTM A775 or SSPC Paint 20 or Epoxy ≥ 1.25% self-healing microcapsules (by weight)
Wire Basket Assembly	ASTM A1064	ASTM A775 or SSPC Paint 20 or Primer with ≥ 40% Solids (by weight) or Asphaltum Protective Coating or Modified Wax Coating or Corrosion Preventative Compound

Produce dowel bars coated in the shop. Wire basket assemblies may be coated in the shop or the field. For welded wire basket assemblies fabricated after coating, apply touch-up coating in the shop or field over all welded connections. All field applied coatings must have a volatile organic compound (VOC) content ≤ 420g/L.

931-3.2 Rigidity: The dowel bars shall be supported by an approved welded assembly possessing sufficient rigidity to hold the dowel bars in position to such accuracy that error or deviation from its required position in any bar in the entire installation after the pavement has been finished shall be no greater than 1/2 inch.

The assembly shall have continuous parallel spacer bars and two continuous parallel bearing members of no less than 1/4 inch diameter wire. One spacer bar shall be located

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at or near each end of the dowel. Alternate ends of dowels shall be welded to a spacer bar in such a manner as to maintain the dowels parallel to each other and permit sliding movement in the joint.

The free ends of each dowel shall be retained securely in place by means of wire loops or metal tubes welded to the other spacer bar. An expansion cap shall be installed on one end of each bar if the dowels are being used in an expansion joint.

Suitable struts or ties shall be provided to hold the assembly in correct position during installation.

The assembly shall have an upright support welded to the spacer bar and continuous bearing member at the end of each dowel and a continuous bearing member.

If the upright support consists of a single vertical wire, the support shall be no less than 5/16 inch diameter wire. Otherwise, the support shall be no less than 1/4 inches in diameter.

931-3.3 Sand Plates: Sand plates, if required, shall be made from no less than 3/8 inch sheet steel. Each plate shall have no less than 0.1 square feet of bearing area. The plates shall be furnished in sufficient number to provide uniform support for the complete assembly. They may be furnished separate from the assembly units or attached thereto by welding, suitable clips, or other approved means.

931-3.4 Welds: The welds of the assembly shall be made securely. A broken weld will be cause for rejection of the length of section of the assembly where it occurs.

931-3.5 Assembly Placement: When the dowel bar assembly is in place, it shall act as a rigid unit with each component part securely held in position relative to the other member of the assembly.

The entire assembly shall be held securely in place during placing, consolidating, and finishing the concrete by means of metal pins. Pins used on granular subbase or cold mixed bituminous stabilized subbase shall penetrate at least 12 inches below the dowel bar assembly. The pins shall be of no less than 1/4 inch diameter wire and shall be provided with a hook or arm welded to the pin in such a manner that it shall secure the assembly in place.

Nail securing systems may be used as an anchoring device on hot bituminous stabilized subbase. The nail shall be no less than 1/8 inch in diameter, no less than 2 inches in length and the nail head or attached washer shall be not less than 1/2 inch outside diameter. The nail shall be driven through both ends of a metal strap after it has been placed around one of the lower transverse bars on the dowel bar assembly.

At least eight pins or nails shall be used for each 12 foot section (a lane width) of assembly. Sand plates, if required, shall be drilled to receive the pins.

The Contractor shall provide the equipment and personnel necessary to verify dowel bar location after the concrete is placed and has received the initial screeding.

931-4 Wire for Site Cage Machines.

The wires for site cage machines shall meet the requirements of ASTM A1064 or ASTM A706.

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SECTION 932
NONMETALLIC ACCESSORY MATERIALS
FOR CONCRETE PAVEMENT AND CONCRETE STRUCTURES

932-1 Joint Materials.

932-1.1 Preformed Joint Filler for Pavement and Structures: Preformed joint filler shall meet the requirements of AASHTO M 153, ASTM D8139, AASHTO M 213, or cellulose fiber types meeting all the requirements of AASHTO M 213 (except for the asphalt content) is acceptable provided they contain minimums of 0.2% zinc borate as a preservative and 1.5% waterproofing wax. For AASHTO M 153, unless a particular type is specified, either Type I, Type II or Type III may be used.

Preformed joint fillers shall have a thickness equal to the width of the joint required, and shall be furnished in lengths equal to the widths of the slabs in which they are to be installed, except strips which are of a length not less than the distance between longitudinal joints, or between longitudinal joint and edge, may be used if laced or clipped together in a manner approved by the Engineer. The depth and shape of the joint filler shall conform to the dimensions shown in the Plans. For doweled joints, proper provision shall be made for the installation of the dowels.

932-1.1.1 Certification: The Contractor shall submit to the Engineer a certification confirming that the preformed joint filler meets the requirements of this Section. The certification shall conform to the requirements of Section 6.

932-1.2 Joint Sealer for Pavement and Structures:

932-1.2.1 General: This Specification covers joint sealer intended for use in sealing joints in asphaltic concrete pavement and portland cement concrete pavement. These materials may also be used to seal joints in portland cement concrete bridges and other structures.

932-1.2.2 Material: The joint sealant shall be composed of a mixture of materials, typically but not limited to bituminous based, that will melt when heated for application and then solidify to form a resilient and adhesive compound capable of sealing joints in portland cement concrete and asphaltic concrete against the infiltration of moisture and foreign materials throughout normal pavement conditions and at ambient temperatures. The manufacturer shall have the option of formulating the material according to their Specifications. However, the requirements delineated in this Specification shall apply regardless of the type of formulation used. The material shall cure sufficiently to not flow from the joint or be picked up by vehicle tires after 3 hours at 77°F. The material shall be capable of a uniform application consistency suitable for filling joints without the inclusion of large air holes or discontinuities and without damage to the material.

Materials for pavement joints shall be tested according to ASTM D5329.

932-1.2.2.1 Physical Requirements of Joint Sealants for Portland Cement Concrete Only:

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Table 932-1	
Parameter	Limits
Pour Point	At least 20°F lower than the safe heating temperature as stated by the manufacturer.
Cone-Penetration, Non-immersed at 77°F, 150 g, 5 s	Less than or equal to 90 mm
Flow at 140°F, 5 h	Less than or equal to 5.0 mm
Bond, Non-immersed, 0°F for 5 cycles*	No cracking, separation, or opening that at any point is over 1/4 inch deep, in the sealant or between the sealant and the substrate.
*The depth of a crack, separation or opening shall be measured perpendicular to the side of the sealant showing the defect. At least two test samples in a group of three representing a given sample of sealant shall meet this requirement.	

932-1.2.2.2 Physical Requirements of Joint Sealants for Portland Cement Concrete and/or Asphaltic Concrete:

Table 932-2	
Parameters	Limits
Pour Point	At least 20° lower than the safe heating temperature as stated by the manufacturer.
Cone-Penetration, Non-immersed at 77°F, 150 g, 5 s	Less than or equal to 90 mm
Flow at 140°F, 5 h	Less than or equal to 3.0 mm
Bond, Non-immersed, -20°F for 3 cycles, 50% extension*	No cracking, separation, or opening that at any point is over 1/4 inch deep, in the sealant or between the sealant and the substrate.
Resilience at 77°F	Recovery greater than or equal to 60%
Asphaltic Concrete Compatibility at 140°F	No failure in adhesion, formation of an oily exudates at the interface between the sealant and the asphaltic concrete, or softening or other deleterious effects on the asphaltic concrete or sealant.
*The depth of a crack, separation or opening shall be measured perpendicular to the side of the sealant showing the defect. At least two test samples in a group of three representing a given sample of sealant shall meet this requirement.	

932-1.2.3 Approved Product List (APL): The joint sealant materials used shall be one of the products listed on the Department's APL. Manufacturers seeking evaluation of their products shall submit product datasheets, performance test reports from an independent laboratory showing the product meets the requirements of this section, and an APL application in accordance with Section 6. Information on the APL application must identify the sealant type.

932-1.2.4 Shipment: The material shall be delivered in containers plainly marked with the manufacturer's name or trademark product name, LOT number and date of expiration.

932-1.2.5 Bond Breaker Rod: The bond breaker rod shall be a closed cell, expanded polyethylene foam rod of the size and dimensions shown in the Plans. It shall be compatible with the joint sealant and no bond or reaction shall occur between the rod and the sealant.

All bond breaker rods installed shall be covered by a sealant at the end of each workday.

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Bond breaker tape approved by the sealant manufacturer may be used in lieu of bond breaker rod when sealing random cracks.

932-1.3 Low Modulus Silicone Sealant Materials:

932-1.3.1 Low Modulus Silicone Sealants: Silicone sealant shall be furnished in a one part or pre-measured two-part formulation meeting the requirements specified herein.

Acetic acid cure sealants are not acceptable. A primer as specified in 932-1.4 for bonding sealant to concrete shall be used if required by the manufacturer. When a manufacturer's product is tested and approved by the Department using a primer, primer will be required for project installation.

Do not use Low Modulus Silicone Sealants Types A, B or C for bridge expansion joints.

Silicones shall be identified in the following manner:

Type A - A low modulus, non-sag (non-self-leveling) silicone formulation, used in sealing horizontal and vertical joints in cement concrete pavements and bridges (i.e., concrete-concrete joints). Tooling is required.

Type B - A very low modulus, self-leveling silicone formulation, used in sealing horizontal joints (including joints on moderate slopes) in cement concrete pavements and bridges (i.e., concrete-concrete joints). Tooling is not normally required.

Type C - An ultra-low modulus, self-leveling silicone formulation, used in sealing horizontal joints (including joints on moderate slopes) in cement concrete pavements and bridges (i.e., concrete-concrete joints). It can also be used to seal the joints between cement concrete pavements and asphalt concrete shoulders (including asphalt-asphalt joints). Tooling is not normally required.

Type D - An ultra-low modulus, self-leveling silicone formulation, cold-applied, rapid-cure, used to seal expansion joints that experience both thermal and/or vertical movements. The material must cure by chemical reaction and not by evaporation of solvent or fluxing of harder particles. Tooling shall not be required. Use in accordance with Standard Plans, Index 458-110 for bridge deck expansion joints with backer rods or as shown in the Plans for other joints with or without backer rods.

932-1.3.2 Physical Requirements:

Table 932-3

Silicone Sealant Type	Test Method	Type A	Type B	Type C	Type D
Flow	ASTM D5893	No Flow			
Slump (maximum)	ASTM D2202	0.3 inches			
Extrusion rate (minimum)	ASTM C1183, Procedure A	20 ml/min	20 ml/min	20 ml/min	20 ml/min
Tack-free time at 77 ± 3ºF and 45 to 55% Relative Humidity	ASTM C679	90 minutes maximum	180 minutes, maximum	180 minutes, maximum	20 – 60 minutes
Specific gravity	ASTM D792, Method A	1.1 to 1.515	1.10 to 1.40	1.1 to 1.5	1.26 to 1.34
Durometer hardness, Shore A (Cured seven days at 77 ± 3ºF and 50 ± 5% Relative Humidity)	ASTM D2240	10-25			

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Table 932-3					
Silicone Sealant Type	Test Method	Type A	Type B	Type C	Type D
Durometer hardness, Shore 00 (Cured 21 days at 77 ± 3ºF and 50 ± 5% Relative Humidity)	ASTM D2240		40-80	20-80	
Tensile stress (maximum) at 150% elongation	ASTM D412 (Die C)	45 psi	40 psi	15 psi	
Elongation (Cured seven days at 77 ± 3ºF and 50 ± 5% Relative Humidity)	ASTM D412 (Die C)	800% minimum			600% minimum
Elongation (Cured 21 days at 77 ± 3ºF and 50 ± 5% Relative Humidity)	ASTM D412 (Die C)		800% minimum	800% minimum	
Ozone and Ultraviolet Resistance	ASTM C793	No chalking, cracking or bond loss after 5,000 hours, minimum.			
Bond to cement mortar briquets (primed if required) (Cured seven days at 77 ± 3ºF and 50 ± 5% Relative Humidity)	AASHTO T 132	50 psi minimum			
Bond to cement mortar briquets (Cured 21 days at 77 ± 3ºF and 50 ± 5% Relative Humidity)	AASHTO T 132		40 psi minimum	35 psi minimum	
Movement Capability	ASTM C719	No adhesive or cohesive failure and adhesion, 10 cycles at -50 to +100%			No adhesive or cohesive failure and adhesion, 10 cycles at +100/-50 %

Portland Cement Mortar: Briquets shall be molded and cured 28 days minimum in accordance with AASHTO T 132. Saw cut cured briquets in half, clean, and dry at 230°, plus or minus 5ºF. Bond the two halves together with a thin section of sealant. After cure of sealant, briquets shall be tested in accordance with AASHTO T 132.

932-1.3.3 Field Cure: Six-inch samples of the sealant shall be taken by the Engineer from the joint at the end of a two-week curing period and tested for durometer hardness (by FM ANSI/ASTM D2240), except that the requirements of a 1-inch sample width shall not apply. A minimum hardness of 7.0 is required as evidence of adequate cure.

932-1.3.4 Approved Product List: The low modulus silicone sealant used shall be one of the products listed on the APL. Manufacturers seeking evaluation of their products shall submit product datasheets, performance test reports from an independent laboratory

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showing the product meets the requirements of this Section, an infrared identification curve (2.5 to 15 µm) and an APL application in accordance with Section 6. Information on the APL application must identify the sealant type.

932-1.3.5 Shipment: The material shall be delivered in containers plainly marked with the manufacturer's name or trademark product name, LOT number and date of expiration.

932-1.3.6 Primer: When required by the manufacturer's product, a primer shall be used.

The manufacturer shall perform quality control tests on each LOT of sealant primer material furnished to each project and submit a certified report that each LOT of primer material furnished to a project meets the company's specifications for that product and the primer is suitable for its intended use.

Sealant primer material shall be delivered in containers plainly marked with the manufacturer's name or trademark and product name, LOT number and date of expiration.

932-1.3.7 Backer Rod and Tape Bond Breakers: Backer rods and tape shall be compatible with the joint sealant and approved by the sealant manufacturer. No bond or reaction shall occur between the rod and the sealant.

932-1.3.8 Installation: Installation, material selection, joint dimensions, bond breaker suitability (by type and project) shall be in agreement with the requirements of Standard Plans, Indexes 350-001 and 458-110. Any modifications or exceptions to these requirements shall be shown in the Plans.

For new construction projects or general use where the joints to be sealed have uniform width, a closed cell, expanded polyethylene foam backer rod bond breaker shall be required. For rehabilitation projects and similar joint seals where the joints to be sealed have irregular width, an open cell, expanded polyethylene foam backer rod bond breaker with an impervious skin shall be required.

The backer rod shall be compatible with the joint sealant. No bond or reaction shall occur between the rod and the sealant.

Tape bond breaker approved by the sealant manufacturer may be used in lieu of backer rod bond breaker when sealing joints and/or random cracks, as required.

Type D Silicone sealant shall be placed when the ambient temperature is rising and is between 55°F and 85°F and the temperature is expected to rise for the next three hours minimum to provide to adequate joint opening and compression of the sealant during curing.

All installed bond breakers shall be covered by sealant at the end of each workday.

A tolerance in cross-sectional height at midpoint of minus 1/16 inches to plus 3/16 inches will be allowed to the nominal values shown for each joint width on the plan sheet. The Engineer shall check one joint for each 1,000 feet of roadway by cutting out specimens. If the cross section of the cut specimen is out of the allowable range, additional specimens shall be taken as follows:

One joint every 100 feet of pavement, not to exceed 500 feet.

If the average of the specimens is out of tolerance, the Contractor shall remove and replace the entire 500-foot section at no additional expense to the Department.

Installation tolerance shall be verified at 1,000-foot intervals.

932-1.4 Pre-cured Silicone Sealant:

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932-1.4.1 General: Pre-cured silicone sealants are intended for sealing vertical joints on concrete surfaces. Type V1 sealant is intended for contraction joints or joints with movements less than 1/4 inches. Type V2 sealant is intended for expansion joints not exceeding 200% of the nominal joint opening. Type V2 sealant may be substituted for Type V1 sealant. The joint sealant must be listed on the APL.

932-1.4.2 Physical Requirements: Sealant material shall be a nominal 1/16 inches thick, available in standard widths from 1 inch to 6 inches, colored to match the finish surface coating of the concrete, and meet the following minimum testing requirements:

Table 932-4

Test Property Description	Test Method	Type V1	Type V2
Minimum Movement, Cohesion/Adhesion	ASTM C1523	100%	200%
Dry/Room Temperature Loss of Adhesion/Cohesion	ASTM C1523	None	None
Water Immersion Loss of Adhesion/Cohesion	ASTM C1523	None	None
Frozen Loss of Adhesion/Cohesion	ASTM C1523	None	None
Heat Loss of Adhesion/Cohesion	ASTM C1523	None	None
Artificial Weathering Loss of Adhesion/Cohesion	ASTM C1523	None	None
Tear Propagation	ASTM C1523	NT or PT (No Tear or Partial/Knotty Tear)	NT or PT (No Tear or Partial/Knotty Tear)
Ultimate Elongation	ASTM D412	250%	500%

932-1.4.3 Approved Product List: The pre-cured silicone sealant used shall be one of the products listed on the APL. Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6. Applications must include test results, an infrared identification curve (2.5 to 15 µm), and a product data sheet with the recommended adhesive and installation requirements.

932-1.5 Compression Seals and Adhesive Lubricant

932-1.5.1 Preformed Elastomeric Compression Seals: Preformed Elastomeric Compression Seals shall meet the requirements of ASTM D2628 except that immersion oil IRM 903 may be substituted for Oil No. 3 in the Oil Swell test procedure.

932-1.5.2 Compression Seal Adhesive Lubricant: Compression seal adhesive lubricant shall meet the requirements of ASTM D4070. The material shall be fluid from 5°F to 120°F (-15°C to 49°C).

932-1.5.3 Certification: The manufacturer shall submit a certified test report for each LOT of material furnished to each project along with a statement certifying that the material

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conforms to this specification and identifying the project number and manufacturer's LOT number.

932-1.5.4 Verification Samples: Provide verification samples in accordance with Section 6.

932-2 Structural Bearing Pads.

932-2.1 General: Provide bearing pads from producers who have a "Compliant" audit status with the AASHTO Product Evaluation & Audit Solutions for "Elastomeric Bridge Bearing Pads". Furnish elastomeric structural bearing pads as shown in the Contract Documents. Elastomeric bearing pads as defined herein shall include plain pads (elastomer only) and laminated bearing pads (elastomer with steel laminate inserts). Perform marking, sampling, testing and certification per this Section.

932-2.2 Materials and Sampling: Provide materials for plain and laminated bearing pads in accordance with this Table 932-5 and this Section. Provide steel that is melted and manufactured in the USA. Reclaimed material is not allowed in the finished product. External load bearing plates shall be finished or machined flat to within 0.01 inches. The bottom surfaces of external load plates (masonry plates) designed to rest on bearing pads shall not exceed an out of flatness value of 0.0625 inches. External load bearing plates (e.g., galvanized, or metalized) shall be protected from rust until all exposed surfaces can be welded. Any rust inhibitor shall be removed from all surfaces prior to welding.

Bearings with steel laminates shall be cast as a unit in a mold and bonded and vulcanized under heat and pressure. Bearings with steel laminates which are designed to act as a single unit with a given shape factor must be manufactured as a single unit. The mold shall have a standard shop practice mold finish. The internal steel laminates shall be blast cleaned to a cleanliness that conforms to SSPC-SP6 at the time of bonding. Plates shall be free of sharp edges and burrs and shall have a minimum edge cover of 0.25 inches. External load plates (sole plates) shall be hot bonded to the bearing during vulcanization.

Edges of the embedded steel laminates, including the laminate restraining devices and around holes and slots shall be covered with not less than 0.25 inches of elastomer or the minimum edge cover specified in the Plans. All exposed laminations or imperfections that result in less than the specified elastomer cover of any surface of the steel laminations shall be repaired by the manufacturer at the point of manufacture. The repair shall consist of sealing the imperfections flush on the finished pads with a bonded vulcanized patch material compatible with the elastomeric bearing pad. Repairs employing caulking type material or repairing the bearings in the field will not be permitted.

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Table 932-5 Material Requirements for Structural Bearing Pads					
Product	Process	Material	Standard	Grade	Reportable Properties
Plain Pad	Molded Vulcanization or Extruded Vulcanization	Elastomer 100% virgin polychloroprene (neoprene)	AASHTO M 251 ARPM MO-1 F3-T.063 (Molded), F2-T (Extruded)	2, 3, 4, 5	Finish, Dimensions, Shear Strength, Tensile Strength, Shear Modulus, Elongation
Laminated Pad (Steel inserts)					
	Hot Rolled	10 gage Steel (Laminates)	ASTM A36	Any	Designation Grade
			ASTM A1011	Min. SS Gr. 36 Type 1	Yield, Tensile, Elongation, Killed

932-2.3 Dimensional Tolerances: Fabricate elastomeric bearings within the dimensional tolerances specified in AASHTO M 251, as modified below or as designated in the Plans. If any of the dimensions are outside the limits specified, the bearing pad shall be rejected.

Table 932-6 Dimensional Tolerances for Bearing Pads		
Measurement		Tolerance (inches)
Overall vertical dimensions	Design thickness ≤1.25 inches	-0, +0.125
	Design thickness >1.25 inches	-0, +0.25
Overall horizontal dimensions	measurements ≤36 inches	-0, +0.25
	measurements >36 inches	-0, +0.50
Thickness of individual layers of elastomer (laminated bearings only) at any point within the bearing		±0.125
Variation from a plane parallel to the theoretical surface (as determined by measurements at the edge of the bearings)	Top (slope relative to bottom)	≤0.005 radians
	Sides	0.25
Position of exposed connection members		±0.125
Edge cover of embedded laminates of connection members		-0, +0.125
Position and size of holes, slots, or inserts		±0.125

932-2.4 Marking: Each elastomeric bearing pad shall be permanently marked in indelible ink or flexible paint. The marking shall consist of the order number, LOT number, pad identification number, elastomer type, and shear modulus or hardness (when shear modulus is

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not specified). Where possible, the marking shall be on a face of the bridge bearing pad that will be visible after erection of the structure.

932-2.5 Sampling: A sampling LOT shall consist of a maximum of 100 bearing pads of a single type of bearing (plain or steel laminated), of the same design, materials, thickness, and manufacturer, referred to here as "like pads", delivered to the project site or to an offsite storage facility within the State of Florida in reasonable proximity to the project site as determined by the Engineer. Organize stockpiled pads into groups of like pads by LOT so that they can be readily identified and sampled by the Engineer.

When the total number of like pads, as defined in 932-2, consists of a LOT of 10 or less, sampling is not required, and acceptance is by certification, as stated in 932-2.7.

For LOT sizes of like pads that exceed 10, two bearing pads per LOT will be selected by the Engineer, one for testing and one for verification in the event of a failing test result. LOT's will be sampled only after all like pads in the LOT are at the project site or in an offsite storage facility. Samples shall consist of complete pads as detailed in the Plans. Furnish additional complete bearing pads to replace those selected for testing. Bearing pads shall be available for sampling a minimum of three weeks prior to their installation. Submit the sample bearing pads to a Department approved independent laboratory for testing. Shipping and testing will be at the Contractor's expense.

932-2.6 Testing: Test bearing pads in accordance with Florida Method FM 5-598. Laminated bearings must meet a minimum compressive strength of 2,400 psi and non-laminated (plain) pads must meet a minimum compressive strength of 1,200 psi. The shear modulus of the elastomer shall be minimum 80 psi unless otherwise noted in the Contract Plans. If any properties are identified as noncompliant with the criteria specified, the bearing shall be rejected, and the verification sample tested. If the verification sample test results are also noncompliant, the LOT shall be rejected. A list of approved testing laboratories can be found on the Department's website. The URL for obtaining this information, if available, is: https://mac.fdot.gov/reports.

932-2.7 Certification: For Lot sizes ≤ 10, the Contractor shall submit to the Engineer a certification statement from the manufacturer that materials provided conform to the requirements of Section 6 and this Section, and the bearings in the LOT were manufactured in a reasonably continuous manner from the same batch of elastomer and cured under the same conditions. The certification shall identify the production facility, material, quantity, grade, and reportable properties as defined in Table 932-5 for each LOT.

For Lot sizes > 10, the Contractor shall submit to the Engineer a certification statement from the manufacturer that materials provided conform to the requirements of Section 6 and this Section, and the bearings in the LOT were manufactured in a reasonably continuous manner from the same batch of elastomer and cured under the same conditions. The certification shall identify the production facility. Additionally, the Contractor shall submit to the Engineer complete certified test results as required in FM5-598, from an independent laboratory.

932-3 Ancillary Bearing Pads.

932-3.1 General: Provide bearing pads from producers who have a "Compliant" audit status with the AASHTO Product Evaluation & Audit Solutions for "Elastomeric Bridge Bearing Pads". Structural bearing pads certified to meet 932-2 may be substituted for ancillary pads. Provide materials for ancillary plain pads in accordance with this section and Table 932-7. Perform testing and certification per this Section.

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932-3.2 Plain Pads: Cutting shall not heat the material and shall produce a smooth finish with a maximum roughness average (Ra) of 6.3 µm (0.248 mils) measured in accordance with ASME B46.1. Plying pads of lesser thickness together shall not be permitted. External load plates (e.g., galvanized, or metalized), when used, shall be protected from rusting and shall be hot bonded by vulcanization during the primary molding process.

Table 932-7
Requirements for Ancillary Pad Material

Product	Manufacturing	Material	Standard	Grade	Properties
Plain Pad	Molded Vulcanization or Extruded Vulcanization	Elastomer 100% virgin polychloroprene (neoprene)	AASHTO M251 ARPM MO-1 F3-T.063 (Molded), F2-T (Extruded)	2, 3, 4, 5	Compressive Strength 1,200 PSI per FM 5-598

932-3.3 Testing and Certification: The Contractor shall provide a certification to the Engineer for all ancillary pads used outside of a railing application, confirming that each LOT of material meets the requirements of Section 6 and this Section and that the bearings were produced in a continuous manner from the same batch of elastomer and cured under the same conditions. The certification shall also the production facility, material, grade, and compressive strength for each LOT.

For bearing pads to be used under metal railings, submit a certification indicating the production facility and compliance with either of the following standards:

1. A certification stating that each LOT of material was reviewed, sampled, tested, and meets the requirements of Section 6 and this Section, and the bearings in the LOT were manufactured in a reasonably continuous manner from the same batch of elastomer and cured under the same conditions.

2. A certification stating that the pads were tested and meet ASTM D2000 M1 BC (suffix grade 1 - basic requirements, type B, class C).

932-4 Fiber Reinforced Polymer (FRP) Reinforcing Bars.

932-4.1 General: Obtain FRP reinforcing bars from producers currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.

Use only solid, round, thermoset basalt fiber reinforced polymer (BFRP), glass fiber reinforced polymer (GFRP) or carbon fiber reinforced polymer (CFRP) reinforcing bars. Single or multi-wire CFRP strands are permitted as spirals for reinforcing in concrete piling where specified in the Contract Documents. Bars shall be manufactured using pultrusion, variations of pultrusion, or other suitable processes noted in the producer's Quality Control Plan, subject to the approval of the State Materials Office (SMO). For BFRP and CFRP bars only vinyl ester or epoxy resin systems are permitted. For GFRP, use only bars manufactured using vinyl ester resin systems and glass fibers classified as E-CR or R that meet the requirements of ASTM D578.

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932-4.2 Bar Sizes and Loads: The sizes and loads of FRP reinforcing bars shall meet the requirements in Table 932-8. The measured cross-sectional area, including any bond enhancing surface treatments, shall be determined according to Materials Manual Section 12.1 Volume II.

Table 932-8
Sizes and Tensile Loads of FRP Reinforcing Bars

Bar Size Designation	Nominal Bar Diameter (in)	Nominal Cross Sectional Area (in^2)	Measured Cross-Sectional Area (in^2)		Minimum Guaranteed Tensile Load (kips)			
			Minimum	Maximum	BFRP & GFRP Bars (Type 0)	BFRP & GFRP Bars (Type III)	CFRP (Type II) Single & 7-Wire Strands	CFRP (Type I) Bars
2.1-CFRP	0.21	0.028	0.026	0.042	-	-	7.1	-
2	0.250	0.049	0.046	0.085	6.1	7.4	-	10.3
2.8-CFRP	0.280	0.051	0.048	0.085	-	-	13.1	-
3	0.375	0.11	0.104	0.161	13.2	16.0	-	20.9
3.8-CFRP	0.380	0.09	0.087	0.134	-	-	23.7	-
4	0.500	0.20	0.185	0.263	21.6	27.9	-	33.3
5	0.625	0.31	0.288	0.388	29.1	40.8	-	49.1
6	0.750	0.44	0.415	0.539	40.9	57.3	-	70.7
6.3-CFRP	0.630	0.19	0.184	0.242	-	-	49.8	-
7	0.875	0.60	0.565	0.713	54.1	75.8	-	-
7.7-CFRP	0.770	0.29	0.274	0.355	-	-	74.8	-
8	1.000	0.79	0.738	0.913	66.8	94.9	-	-
9	1.128	1.00	0.934	1.159	82.0	115.0	-	-
10	1.270	1.27	1.154	1.473	98.2	138.7	-	-
11	1.410	1.56	1.500	1.700	105.8	160.0	-	-

932-4.3 Material Acceptance: Submit to the Engineer a certificate of analysis for each production LOT from the producer of the FRP reinforcing bars, confirming compliance with the requirements of this Section.

932-4.3.1 Sampling: The Engineer will select a minimum of six straight bars with minimum lengths of 7 feet each and a minimum of five bent bars or spiral bends/revolutions from each shipment, representing a random production LOT, per bar size of FRP reinforcing for testing in accordance with Table 932-9. Testing shall be conducted, at the Contractor's expense, by a Department approved independent laboratory. Each test shall be replicated a minimum of three times per sample. Submit the test results to the Engineer for review and approval prior to installation. Testing will not be required for bars to be used solely as reinforcement for sheet pile bulkheads, but LOT samples will still be selected and retained by the Engineer until final acceptance of the work.

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Table 932-9 Testing Requirements for Project Material Acceptance of FRP Reinforcing Bars				
Property	Test Method	Requirement	Test Required for Straight Bar	Test Required for Bent Bar
Fiber Mass Fraction	ASTM D2584 or ASTM D3171	≥70%	Yes	Yes – bent portion[b]
Short-Term Moisture Absorption	ASTM D570, Procedure 7.1; 24 hours immersion at 122°F	≤0.25%	Yes	Yes – bent portion[b]
Glass Transition Temperature	ASTM D7028 (DMA) or ASTM E1356 (DSC; T_m)/ ASTM D3418 (DSC; T_{mg})	≥230°F ≥212°F	Yes	Yes – bent portion[b]
Degree of Cure	ASTM E2160	≥95% of Total polymerization enthalpy	Yes	Yes – bent portion[b]
Measured Cross-sectional Area	ASTM D7205	Within the range listed in Table 932-6	Yes	Yes – straight portion
Guaranteed Tensile Load[a]		≥ Value listed in Table 932-6	Yes	No
Tensile Modulus		≥6,500 ksi for BFRP and GFRP (Type 0) ≥8,500 ksi for BFRP and GFRP (Type III) ≥18,000 ksi for CFRP (Type I) Bars ≥22,400 ksi for CFRP (Type II) Strands	Yes	No

a – Guaranteed tensile load shall be equal to the average test result from all three LOTs minus three standard deviations.
b – Bent portion specimens shall be extracted from a central location within a 90° bend.

932-5 FRP Spirals for Concrete Piling.

FRP Spirals for reinforcing in concrete piling shall be CFRP conforming to the requirements of Section 933 or 932-4 for CFRP (Type II).

932-6 Polymer Slurries for Drilled Shafts.

932-6.1 General Requirements: Provide synthetic polymer slurry products to facilitate the construction of drilled shafts. Products must contain long chain-like hydrocarbon molecules which interact with each other, with the soil, and with the water to effectively increase the viscosity of the fluid and meet the requirements of the Materials Manual, Volume 2 Section 2.4. Products may be formulated in powder, granular or liquid forms. Products shall be capable of being mixed with potable water prior to introducing it to the drilled shaft excavation.

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932-6.2 Product Acceptance: All materials shall be one of the products listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of products for inclusion on the APL shall submit an application in accordance with Section 6 and including documentation that meets the requirements of Table 932-10. A separate application must be submitted for each product type to be evaluated, showing that the product meets the applicable requirements.

Table 932-10
Documentation Requirements

Documentation	Requirements
Installation Instructions	Include mixing and disposal instructions and the Safety Data Sheet (SDS).
Product Photo	Displays the significant features of the product as required in this section. Displays location of Manufacturer name and model number.
Product Label Photo	Displays the Product Name
Technical Data Sheet	Uniquely identifies the product and includes product specifications, storage instructions, and recommended installation materials and equipment as applicable.
Test Reports	Submit test results and reports as required by Materials Manual, Vol 2 Section 2.4

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SECTION 933
PRESTRESSING STRAND AND BAR

933-1 Strands for Prestressing.

933-1.1 Carbon Steel Strands for Prestressing: The carbon-steel strands for prestressing concrete members shall be Grade 270, low-relaxation seven wire strand conforming to the requirements of ASTM A416.

933-1.2 Stainless-Steel Strands for Prestressing: The stainless-steel strands for prestressing concrete members shall be a high strength stainless-steel (HSSS, Grade 240), low-relaxation seven wire strand conforming to the requirements of ASTM A1114.

933-1.3 Carbon-Fiber-Reinforced Polymer (CFRP) Strands for Prestressing: Obtain CFRP prestressing strands from producers currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105. CFRP strand shall meet the requirements of this Section.

Table 933-1
Typical Sizes and Loads of CFRP Prestressing Strands and Bars

Type	Nominal Diameter (in)	Nominal Cross Sectional Area (in^2)	Nominal Ultimate Load (P_u) (kips)	Nominal Ultimate Tensile Stress (ksi)
Single Strand - 5.0mm Ø	0.20	0.025	9.1	364
7-strand - 7.9mm Ø	0.31	0.048	17.8	370
7-strand - 10.8mm Ø	0.43	0.090	33.1	367
Single Strand (Bar) - 9.5mm Ø	0.38	0.110	35.0	318
7-strand - 12.5mm Ø	0.49	0.117	43.3	370
Single Strand (Bar) - 12.7mm Ø	0.50	0.196	59.0	301
7-strand - 15.2mm Ø	0.60	0.179	66.2	369
7-strand - 17.2mm Ø	0.68	0.234	86.6	370
7-strand - 19.3mm Ø	0.76	0.289	106.9	370

933-1.4 Shipping and Storage: Protect carbon-steel, stainless-steel, and CFRP strands for prestressing against mechanical damage and contamination during shipping and storage.

933-2 Steel Bars for Prestressing.

The steel bars for prestressing concrete members shall conform to the requirements of ASTM A722, Type II.

933-3 Steel Parallel Wire Assemblies for Prestressing.

The wire assemblies for prestressing concrete members shall consist of parallel wires of the number and size shown in the Plans and shall conform to the requirements of ASTM A421.

933-4 Anchorages for Prestressing.

933-4.1 For Strands and Bars:

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933-4.1.1 Steel Strands and Bars: Meet the requirements of Section 960.

933-4.1.2 Carbon Fiber Reinforced Polymer (CFRP) Strands: Meet the requirements of ACI 440.3R, B.10 – Test method for performance of anchorages of FRP bars.

933-4.2 For Steel Parallel Wire Assemblies: Anchorage for parallel wire assemblies may be provided by Type BA (Button Anchorages) cold-end deformation of the wires bearing against suitable anchorage plates, or by Type WA (Wedge-type Anchorages) without cold end deformations, of the sandwich-plate or conical type. The anchorage device shall be capable of developing at least 90% of the specified ultimate strength of the total number of wires anchored.

Conical type anchorages shall be embedded within the ends of the concrete members unless otherwise specified. Anchorages shall generally bear against embedded grids of reinforcing steel of approved type.

Alternate type anchorages will be considered if proposed by the Contractor. Any alternate anchorage will be required to develop the full specified ultimate strength for bars or at least 90% of the specified ultimate strength for parallel wire assemblies.

933-5 Required Tests for Prestressing Strand and Bar.

933-5.1 General: Tests shall be performed to determine the physical characteristics of prestressing reinforcement. For tests specified to be made by the producer, submit certified test results to the Engineer prior to use.

933-5.2 Strands:

933-5.2.1 Steel Strands: Acceptance of carbon-steel and stainless-steel prestressing strands shall be based on samples taken by the Department and the producer's certified mill analysis certifying that the test results meet the specification limits of ASTM, AASHTO, or FDOT as specifically designated. Prior to use, submit to the Engineer the producer's certified mill analysis for each heat or production LOT per shipment of strand.

Certified mill analyses for steel prestressing strand shall contain, for each heat number or production LOT, all test results required by ASTM A416 and ASTM A1114. Include the modulus of elasticity expressed in psi or the stress-strain curve with units identified.

The Engineer will select samples and certified mill analysis representing each shipment at a frequency of one sample per producer, per size of strand, per shipment.

933-5.2.2 Carbon-Fiber-Reinforced Polymer (CFRP) Strands:

933-5.2.2.1 Material Acceptance: Submit to the Engineer a certificate of analysis for each production LOT from the producer of the CFRP strand, confirming compliance with the requirements of this Section.

933-5.2.2.2 Sampling: The Engineer will select a minimum total of 42 feet from each shipment, representing a random production LOT, per size of CFRP strand for testing in accordance with Table 933-2. The minimum discrete sample length shall be 7 feet. Testing shall be conducted, at the Contractor's expense, by a Department approved independent laboratory. Each test shall be replicated a minimum of three times per sample. Submit the test results to the Engineer for review and approval prior to installation.

Table 933-2
Testing requirements for Project Material Acceptance of CFRP Prestressing Strand

Property	Test Method	Requirement
Fiber Mass Fraction	ASTM D2584 or	≥70%

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Table 933-2 Testing requirements for Project Material Acceptance of CFRP Prestressing Strand		
Property	Test Method	Requirement
	ASTM D3171	
Short-Term Moisture Absorption	ASTM D570, Procedure 7.1; 24 hours immersion at 122°F	≤0.25%
Glass Transition Temperature	ASTM D7028 (DMA) or ASTM E1356 (DSC; T_m)/ASTM D3418 (DSC; T_{mg})	≥230°F ≥212°F
Degree of Cure	ASTM E2160	≥95% of Total polymerization enthalpy
Actual Cross Sectional Area	ASTM D7205	Within -5% to +10% of nominal values listed in Table 933-1
Ultimate Tensile Strength		≥ Value listed in Table 933-1
Tensile Modulus		≥18,000 ksi for Bar; ≥ 22,400 ksi for 7-strand & 5mm Ø

933-5.3 Steel Bars: Acceptance of steel prestressing bar shall be based on samples taken by the Department and the producer's certified mill analysis certifying that the test results meet specification limits of the ASTM or AASHTO as specifically designated. Prior to use, submit to the Engineer the producer's certified mill analysis for each heat or production LOT and size per shipment of bars. Certifications of steel prestressing bar shall contain, for each heat number or production LOT, all test results required by ASTM A722, and the modulus of elasticity expressed in psi or the stress-strain curve with units identified.

The Engineer will select samples and certified mill analysis representing each shipment at a frequency of one sample per heat or production LOT, per size of bar, per shipment.

933-5.4 Steel Wires: Acceptance of steel wires shall be based on the producer's certified mill analysis of test results meeting the specification limits of the ASTM or AASHTO as specifically designated. Prior to use, submit to the Engineer the producer's certified mill analysis for each heat or production LOT per shipment of wire. Certifications of steel prestressing wire shall contain, for each heat number or production LOT, all test results required by ASTM A421.

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SECTION 934
NON-SHRINK GROUT

934-1 Scope.

This Section covers only prepackaged non-shrink cementitious grout for structural use.

934-2 Type Permitted.

Only non-metallic formulations of grouts are allowed. Gas producing, metal oxidizing and expansive aggregate grouts are not allowed.

934-3 Sampling and Testing Methods.

Perform concrete sampling and testing in accordance with the following methods:

Making and Curing Concrete Test Specimens in the Laboratory.....ASTM C192
Time of Setting Concrete Mixtures by Penetration Resistance .....ASTM C403
Determining Low-Levels of Chloride in Concrete and Raw Materials ..... FM 5-516
Compressive Strength of Hydraulic Cement Mortars.....ASTM C109
Flow of Grout for Preplaced Aggregate Concrete (Flow Cone Method).....ASTM C939
Measuring Changes in Height of Cylindrical Specimens from Hydraulic Cement Grout.....ASTM C1090
Expansion and Bleeding of Freshly Mixed Grout for Preplaced Aggregate Concrete in the Laboratory.....ASTM C940

934-4 Requirements.

When tested as provided in 934-3, the grout shall meet the following requirements:

Table 934-1	
Property	Test Value
Compressive strength	
one day	2,500 psi minimum
3 days	5,000 psi minimum
Time of set, final	8 hours maximum
Chloride Content	0.40lb/yd3 maximum
Hardened Height Change at 1, 3, 14, and 28 Days	0.0% to 0.3%
Hardened Height Change at 1, 3, and 14 Days	≤ Height Change @ 28 Days
Expansion	≤ 2.0% @ 3 Hours
Bleeding, Final	0.0% @ 3 Hours

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934-5 Product Acceptance on the Project.

Non-shrink grout used shall be one of the products listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6.

Acceptance will be made in accordance with the products listed on the APL.

934-6 Rejection.

Materials shall be rejected at the point of use if the materials are caked, lumpy, or show any signs of deterioration. Materials shall be rejected if the grout does not achieve the design fluidity or consistency when mixed according to the manufacturer's recommendations.

All broken or open packages shall be rejected.

934-7 Packaging.

Cementitious materials for grouts must be packaged in suitable moisture resistant containers and clearly labeled. Where applicable, manufacturers recommendations, limitations and cautions shall be clearly visible on each label.

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SECTION 937
POST-INSTALLED ANCHOR SYSTEMS FOR STRUCTURAL APPLICATIONS IN CONCRETE ELEMENTS

937-1 General.

Post-installed anchor systems intended for structural applications in concrete elements consist of adhesive-bonded anchor systems.

937-2 Approved Product List (APL).

Manufacturers of post-installed anchor systems may apply for inclusion of individual products on the Department's Approved Product List (APL). The application shall be made in accordance with Section 6 and shall include certified test reports from an independent testing laboratory which shows the material system meets all the requirements of this Section.

937-3 Certification.

The Contractor shall provide the Engineer with certification from the manufacturer of the anchor system, confirming that the requirements of this Section are met. The certification shall conform to the requirements of Section 6. Each certification shall cover only one LOT of anchoring materials.

937-4 Adhesive Bonding Material Systems.

937-4.1 General: Adhesive bonding material systems for structural applications shall consist of pre-packaged, 2-part chemical components. The material systems shall be specifically intended for use in structural applications for bonding anchors and dowels to hardened concrete. Applications are limited to anchors and dowels installed in positions ranging from vertically downward to horizontal.

Do not use material from containers which are damaged or have been previously opened. Use only full packages of components. Combining of adhesive bonding components from bulk supplies is not permitted.

Material systems shall be pre-packaged to automatically proportion and mix the materials for use. Manual proportioning of the components will not be permitted.

937-4.2 Minimum Performance Requirements (FM 5-568): When tested in accordance with FM 5-568, the adhesive bonding material system, for general use, shall meet the following requirements:

Table 937-1
Uniform Bond Stress

	Type HV	Type HSHV
Confined Tension	2,290 psi	3,060 psi
Damp-Hole Installation	1,680 psi	1,830 psi
Elevated Temperature	2,290 psi	3,060 psi
Horizontal Orientation	2,060 psi	2,060 psi
Short Term Cure	1,710 psi	1,710 psi
Specified Bond Strength	1,080 psi	1,830 psi

Maximum Coefficient of Variation for Uniform Bond Stress: 20%.

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Long Term Load (Creep):

1. The rate of displacement shall decrease during the 42 day application of load.

2. At 42 days, the total displacement due to creep (with load still applied) shall be less than 0.03 inches and during the last 14 days of the 42 day load duration, the total displacement due to creep shall be less than 0.003 inches.

3. After removal of the 42 day load, the uniform bond Stress from a subsequent Confined Tension Test shall not be less than 1,826 psi.

937-4.3 Product Identification (Fingerprint) Properties (FM 5-569): References for comparison including infrared absorption, density or average weight, gel time or setting time, and bond strength shall be determined in accordance with FM 5-569.

937-4.4 Packaging and Marking: The adhesive bonding material system shall be delivered to the project site in original unopened containers with the manufacturer's label identifying the product. Each package shall be clearly marked with the following information:

Manufacturer's name and address
Product Name
Date of Manufacture
Expiration Date
LOT Identification Number
Storage and Handling Requirements

Each package shall include the manufacturer's instructions for anchor and dowel installation. The instructions shall include the following information:

Diameters of drilled holes for applicable anchor and dowel sizes.

Cleaning procedure for drilled holes, including a description of permitted and prohibited equipment and techniques.

Allowable temperature ranges for storage, installation and curing.

Identification of acceptable mixing/dispensing nozzles.

Fabrication requirements for anchors and dowels.

Description of tools permitted or required for installation.

Method of identifying properly proportioned and mixed adhesive materials.

Time and temperature schedule for initial set and full-strength cure.

Special requirements for special installation conditions such as damp holes, or horizontal or near horizontal orientation of the anchor or dowel.

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SECTION 938
DUCT FILLER FOR POST-TENSIONED STRUCTURES

938-1 Description.

This Section covers filler materials used to fill voided areas within ducts to protect post-tensioning steel. Grout applications are differentiated into three applications: horizontal, vertical and repair. There is no differentiation for flexible fillers.

938-2 Approved Product List.

Only post-tensioning grouts and flexible filler material listed on the Department's Approved Product List (APL) shall be used. Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6 and include certified test reports from an independent AASHTO R18 or ISO 9001 approved laboratory showing that the material meets all the requirements specified herein. A written certification from the manufacturer that the product meets the requirements of this Section must be submitted.

Any change of materials or material sources requires new testing and certification of the conformance of the grout with this Specification.

Grout products will be qualified by application (horizontal, vertical or repair).

938-3 General Requirements.

938-3.1 Grout: Grouts shall exhibit thixotropic properties and shall be prepackaged in clearly labeled moisture proof containers. The containers shall indicate application type, date of manufacture, LOT number and mixing instructions. The manufacturer's Quality Control Data Sheet for each lot number and shipment sent to the job site shall be provided to the Contractor and submitted to the Engineer.

938-3.2 Flexible Filler - Microcrystalline Wax: The flexible filler shall be a petroleum based microcrystalline wax delivered to the project site in clearly labeled prepackaged containers and stored in accordance with the manufacturer's recommendations as applicable for the particular project. The manufacturer's Quality Control Data Sheet for each shipment sent to the job site shall be provided to the Contractor and submitted to the Engineer.

938-4 Grout.

938-4.1 Mixing: The material shall be mixed in accordance with the manufacturer's recommendations except when additional water is indicated for particular tests.

938-4.2 Grout Physical Properties:

938-4.2.1 Gas Generation: The grout shall not contain aluminum or other components which produce hydrogen, carbon dioxide or oxygen gas.

938-4.2.2 Laboratory Testing: The grout shall meet or exceed the specified physical properties stated herein as determined by the following standard and modified ASTM and FM test methods conducted at normal laboratory temperature (65°F-90°F) and conditions. Prepare all laboratory test specimens using 110 percent of the maximum water allowed by the manufacturer unless otherwise noted in Table 938-1. Tests A, B, N, and O will be conducted by the Department.

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Table 938-1			
Test ID	Property	Test Value	Test Method
A	Total Chloride Ions	Max. 1.0 lb/yd^3	FM 5-516 (1)
B	Total Sulfate Ions	Max. 30 ppm	FM 5-618 (1)
C	Gradation	99% passing the No. 50 95% passing the No. 100 90% passing the No. 170	ASTM C136(2)
D	Hardened Height Change @ 24 hours and 28 days	0.0% to + 0.2%	ASTM C1090
E	Expansion	≤ 2.0% for up to 3 hours	ASTM C940
F	Wet Density - Laboratory	Report maximum and minimum obtained test value lb/ft^3	ASTM C138
G	Wet Density - Field	Report maximum and minimum obtained test value lb/ft^3	ASTM C138 or ASTM D4380
H	Compressive Strength 28 day (Average of 3 cubes)	≥7,000 psi	ASTM C942
I	Initial Set of Grout	Min. 3 hours Max. 12 hours	ASTM C953
J	Time of Efflux immediately after mixing	Max. 12 seconds	ASTM C939(3)
K	Bleeding @ 3 hours	0.0 percent	ASTM C940(4)
L	Pressure Induced Bleeding	0.0 percent	ASTM C1741
M	Surface Resistivity@ 28 days	≥16 kOhms-cm	AASHTO T 358
N	Relative Viscosity, RV_f, determined from Dynamic Sheer Rheometry	< 1.15	FM 5-605
O	Inclined Tube Test		FM5-619
	Amount of Bleed	≤ 0.0%	
	Allowable Difference in Moisture	≤ 2.0%	
	Penetration at 500 psi	≤ 1 mm	

(1) Obtain test sample from upper vent of inclined tube test specimen after 7 days curing.

(2) Use ASTM C117 procedure to determine the percent passing after washing the sieve.

(3) The time of efflux is the time to fill a one liter container placed directly under the flow cone. Modify the ASTM C939 test by filling the cone to the top instead of to the standard level. Use the midrange of the water content indicated in the manufacturer's technical data sheet to produce the time of efflux.

(4) Use ASTM C940 to conform with the wick induced bleed test as modified by the Post-Tensioning Institute specification PTI M55.1-12.

938-4.3 Accelerated Corrosion Test Method (ACTM): Perform the ACTM as outlined in Appendix B of the Specification for Grouting of Post-Tensioning Structures published by the

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Post-Tensioning Institute. Report the time to corrosion for both the grout being tested and the control sample using a 0.45 water-cement ratio neat grout.

A grout that shows a longer average time to corrosion in the ACTM than the control sample and the time to corrosion exceed 1,000 hours is considered satisfactory.

938-4.4 Variation in Testing for Specific Applications.

938-4.4.1 Horizontal Applications: Horizontal grout applications are defined as grouting of all superstructure tendons and transverse substructure tendons in caps, struts, etc. All physical requirements defined in 938-4.2 and 938-4.3 are applicable for grouts used in horizontal applications.

938-4.4.2 Vertical Applications: Vertical grout applications are defined as grouting of substructure column tendons. All physical requirements defined in 938-4.2 and 938-4.3 are applicable for grouts used in vertical applications.

938-4.5 Repair Applications: Repair applications are used to augment grouting operations which did not completely fill the duct or anchorage. For new construction, repairs may be made with the same filler approved for use in the tendon as long as the volume of the void is less 0.5 gal. In all other cases, use a non-sanded grout meeting the requirements of 938-4.2 and 938-4.3.

938-5 Flexible Filler - Microcrystalline Wax.

938-5.1 Storage and Preparation: Store and prepare wax in accordance with Section 462. Reject wax that shows any sign of segregation or decomposition prior to application even though it conforms to these Specifications. Use equipment designed for pumping the wax in a fluid state to fill the tendon ducts. Manufacturers shall include the recommended pumping temperature in the material technical data sheet.

938-5.2 Laboratory Testing: The wax shall meet the specified physical properties stated herein as determined by the following standard and modified ASTM and FM test methods conducted at normal laboratory temperature (65°F-78°F) and conditions. Prepare and test all laboratory test specimens as noted in Table 938-2.

Table 938-2

Property	Test Value	Test Method
Salt Fog – 168 hours@35°C	No corrosion	ASTM B117(1)
Chlorides	≤ 50 ppm (total)	ASTM D512(2)
Sulfate	≤ 100 ppm	ASTM D516(2)
Congealing Point	≥ 65°C	ASTM D938
Cone Penetration at 25°C	≤ 260 d-mm	ASTM D937
Bleeding at 40°C	≤ 0.5%	ASTM D6184
Resistance to Oxidation 100 hours at 100°C	≤ 0.03 MPa	ASTM D942
Kinematic Viscosity at 100°C	10 – 30mm^2/s	ASTM D445

(1) Test sample consists of a 4-inch x 6-inch steel panel blast cleaned to a NACE surface preparation SP5 or equivalent, with a 2 to 2.5 mil surface profile. The plate is covered with a layer of wax equivalent to 0.5 grams wax per square inch of panel.

(2) Prepare sample in accordance with NF M07-023, sections 6a through 6c or equivalent. Other analytical methods are acceptable as long as equivalency to the above methods has been established by the Department.

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SECTION 942
PRECAST CONCRETE PIPE GASKETS

942-1 Round Rubber Gaskets for Pipe Joints.

Except where O-ring type gaskets are specified for special cases and for special type pipe, round rubber gaskets for use in concrete pipe joints shall meet the requirements of ASTM C443, with the additional requirements that the gasket used shall be of such cross sectional area and perimeter as to properly fit the space provided in the pipe joint in which it is to be used.

Prior to use, the gasket shall be stored in as cool a place as practicable.

942-2 Cold Adhesive Preformed Plastic Gaskets (For Sealing Elliptical Concrete Pipe Joints).

942-2.1 General: Cold adhesive preformed plastic gaskets shall be of a material, shape and size so as to effect a permanent water tight seal in joints of elliptical concrete pipe. A minimum of two pieces of gasket material shall be used in each joint.

The gasket material shall be protected by a 2-piece removable wrapper. To facilitate application, the 2-piece wrapper shall be so designed that one-half may be removed longitudinally without disturbing the other half.

The size of the gasket shall be in accordance with the manufacturer's recommendation for the particular joint in which it is to be used. However, the minimum size for each of the gaskets used in a joint shall be in accordance with the following:

Table 942-1

Pipe Size (Inches)	Nominal Gasket Size (Inches)	Minimum Cross-Section (In^2)
Up to 19 by 30	1-1/2	1.75
19 by 30 to 53 by 83	1-3/4	2.5
Over 53 by 83	2	3.25

The above minimum size requirements are based on a joint designed with a maximum taper of 10 degrees and an in-place annular space of approximately 1/4 inch.

942-2.2 Composition: The gasket sealing the joints shall be produced from blends of refined hydrocarbon resins and plasticizing compounds reinforced with inert mineral filler. The material shall contain no solvents and shall not produce irritating fumes or obnoxious odors. The gasket shall not depend on oxidizing, evaporation or chemical action for its adhesive or cohesive strength.

The chemical composition of the gasket material shall meet the following requirements:

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Table 942-2		
	Minimum	Maximum
Bitumen (petroleum plastic content) (% by weight)	50	70
Ash-Inert Mineral Matter (% by weight)	30	50
Volatile Matter (@ 325ºF) (% by weight)		2.0

The gasket joint sealing compound when immersed for 30 days at ambient room temperature separately in 5% solution of caustic potash, a mixture of 5% hydrochloric acid, a 5% solution of sulfuric acid, and a saturated hydrogen sulfide solution shall show no visible deterioration.

The physical properties of the gasket joint sealing compound as shipped shall meet the following requirements:

Table 942-3		
	Minimum	Maximum
Specific Gravity @ 77ºF	1.2	1.35
Ductility @ 77ºF	50 mm	
Softening Point @ 77ºF	320ºF	
Penetration (0.1 mm) 77ºF @ (150 gms) five seconds	50	120

942-2.3 Certification: The manufacturer of the gasket material shall submit to the Engineer certified test results covering each shipment of material to each project.

942-3 Resilient Connectors for Sealing Precast Structures to Pipe Joints.

942-3.1 General: Resilient connectors shall meet the requirements of ASTM C923. The connectors shall also be compatible with the precast structure and pipe.

942-3.2 Approved Product List (APL): All resilient connectors shall be listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6.

942-4 Profile Rubber Gaskets for Concrete Pipe Joints.

(a) Round Pipe: The gaskets shall meet the requirements of ASTM C443.

(b) Elliptical Pipe: The gaskets shall meet the requirements of ASTM C443.

Additionally, the gaskets used shall be of such cross sectional area and perimeter as to properly fit the space provided in the pipe joint in which it is to be used.

The gaskets shall be stored in as cool a place as practicable prior to use.

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SECTION 943
CORRUGATED STEEL PIPE AND PIPE ARCH
(INCLUDING UNDERDRAIN)

943-1 General Requirements.

Corrugated steel pipe, including round culvert pipe, pipe arch and underdrain and coupling bands for each type shall conform to AASHTO M 36 and shall include plant certification from AASHTO Product Evaluation & Audit Solutions. Except for underdrain, corrugated steel pipe including pipe arch shall be fabricated with helical corrugations with a minimum of two annular corrugations formed on each end of each pipe to accommodate a coupling band. Annular fabrication is not permitted unless specifically called for in the Plans or Specifications. Provide, as part of the shipping ticket, the actual mean inside diameter and total measured lengths of each LOT of pipe shipped to the project. Include the minimum and maximum inside diameters used to calculate the actual mean inside diameter.

943-2 Round Culvert Pipe.

For round culvert pipe used as sidedrain, unless shown otherwise in the Plans, the minimum thickness of the metal (including galvanizing - AASHTO M 218, or aluminum coating - AASHTO M 274), shall be as specified below. Alternatively, if no future maintenance concerns exist, the Contractor may propose the pipe gage based on the Department's Drainage Manual and Culvert Service Life Estimator for approval by the Engineer.

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Table 943-1 Thickness of Metal for Sidedrain Pipe		
Nominal Diameter (Inches)	Metal Sheet Gauge No.	Mean Thickness Metal (Inches)
6	18	0.0516
8	16	0.0635
10	16	0.0635
12	16	0.0635
15	16	0.0635
18	16	0.0635
21	16	0.0635
24	16	0.0635
30	14	0.0785
36	14	0.0785
42	12	0.1084
48	12	0.1084
54	12	0.1084
60	10	0.1382
66	10	0.1382
72	10	0.1382
78	8	0.1681
84	8	0.1681
90	8	0.1681
96 and over	8	0.1681

Table 943-2 Permissible Variation in Thickness of Metal for Pipe and Connecting Bands		
Metal Sheet Gauge No	Mean Thickness of Metal (Inches)	Permissible Variation (Inches)
18	0.0516	0.007
16	0.0635	0.007
14	0.0785	0.008
12	0.1084	0.009
10	0.1382	0.009
8	0.1681	0.009

943-3 Pipe Arch.

For corrugated metal pipe arch, in addition to the requirements shown in AASHTO M 36, thickness of the metal shall be as shown for the equivalent size round pipe in Tables 943-1 and 943-2, above, and the fabrication of the pipe arch sections shall be such as to insure a substantially flat invert.

943-4 Alternate Connecting Bands.

In addition to the connecting bands as specified in AASHTO M 36, alternate types of connecting bands are specified in 430-8.1.3, for use with the types of installations as shown.

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943-5 Bituminous Coating and Paved Invert.

When bituminous coating is specified, the pipe, or pipe arch, shall be coated in accordance with the requirements of AASHTO M 190, for Type A (Fully Bituminous Coated).

When bituminous coated and paved invert are specified the pipe or pipe arch shall be coated and paved in accordance with AASHTO M 190, for Type C (Fully Bituminous Coated and Paved). The temperature of the asphalt at the time of coating and the duration of the pipe submerged time shall be optimized such that excess coating does not adhere to the pipe.

943-6 Paved Interior.

When bituminous coated and paved interior are called for, the coating and paving shall meet the requirements specified above for bituminous and paved invert (Type C), with the following additions and exceptions:

1. The smooth pavement formed by the asphalt cement shall extend over the entire interior of the pipe.
2. The exterior coating and the interior paving shall be applied.
3. No markings will be required on the outside of the pipe to designate the center line of the top of the pipe.
4. Lifting lugs shall be attached to the pipe, and shall be suitably placed to facilitate moving the pipe without damage to the exterior or interior bituminous material.

943-7 Basis of Acceptance of Bituminous Coating and Paving.

The acceptance of the bituminous coating, paved invert, and paved interior will be based on the raw materials manufacturer’s certification of compliance with AASHTO M 190.

943-8 Underdrain Pipe.

Corrugated metal pipe for underdrain shall conform to the requirements of AASHTO M 36 except that Class IV pipe, as specified in Section 18.1.1.4 therein, shall not be used.

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SECTION 944
STRUCTURAL PLATE STEEL PIPE AND PIPE ARCH

944-1 Description.

This Section covers the materials for corrugated galvanized steel structural plate pipe and pipe arch, including the necessary bolts and nuts for connecting plates and for assembling the pipe or pipe arch at the point of destination when so specified. The sizes of the pipe or pipe arch shall be as shown in the Plans.

944-2 Materials.

Structural plate pipe and pipe arch shall be of galvanized steel, mill certified to the requirements of AASHTO M 167, with the additional requirement that the minimum thickness of the plates shall be as shown in the Plans. Hardware must comply with the requirements of AASHTO M 167.

944-3 Tolerance in Span and Height.

A tolerance of plus or minus 4% will be allowed in the specified span and height of pipe arches. A tolerance of minus 2 inches to plus 4 inches will be allowed in the specified diameter of round pipe.

944-4 Bituminous Coating.

When bituminous coating is specified, all plates shall be fully coated on both sides with asphalt cement. The bituminous coating shall conform to the requirements of AASHTO M 190, for Type A.

944-5 Mill Analysis and Certification.

Provide a Mill Test Report for all metal components. Report the average and minimum zinc coating mass for the pipe. When bituminous coatings are used, provide a statement of compliance for bituminous coatings meeting AASHTO M 190, Type A.

944-6 Assembly Diagrams.

Diagrams for assembling shall be furnished unless the pipe or pipe arch is furnished completely assembled.

944-7 Fabrication.

The fabrication of the pipe and pipe arch shall comply with the applicable requirements of Section 23, of the AASHTO LRFD Bridge Construction Specifications. Unless otherwise specified, the pipe and pipe arch shall be of full section for the entire length.

944-8 Assembly.

When purchase contracts stipulate that the pipe be assembled, the dealer shall furnish the pipe and pipe arch completely assembled at the point of destination, or at the site, as specified, and in lengths as specified.

944-9 Direct Purchases by the Department.

When the Department purchases the pipe or pipe arch direct from the dealer, the quantity to be paid for shall be the number of feet of pipe and of pipe arch, as ordered, provided that

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sufficient materials meeting the requirements of these specifications shall be furnished to construct the pipe and pipe arch of the length and sizes shown.

The quantity shall be the net length as ordered, with no allowance for length in excess thereof.

The price per foot for direct purchases shall be full compensation for furnishing the complete materials for the pipe or pipe arch, including all bolts and nuts required for connecting the plates. When assembling of the pipe or pipe arch is specified, such price shall also include all labor, equipment, tools and incidentals required for completely assembling the pipe or pipe arch.

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SECTION 945
ALUMINUM PIPE, INCLUDING UNDERDRAIN, PIPE ARCH AND STRUCTURAL PLATE PIPE AND PIPE ARCH

945-1 General Requirements.

Aluminum-alloy culvert pipe and underdrains shall meet the requirements of AASHTO M 196 and shall include plant certification from AASHTO Product Evaluation & Audit Solutions and compliance with the additional provisions contained herein. Except for underdrain, corrugated aluminum pipe including pipe arch shall be fabricated with helical corrugations with a minimum of two annular corrugations formed into each end of each pipe to accommodate a coupling band. Annular fabrication is not permitted unless specifically called for in the Plans or specifications. Provide, as part of the shipping ticket, the actual mean inside diameter and total measured lengths of each lot of pipe shipped to the project. Include the minimum and maximum inside diameters used to calculate the actual mean inside diameter.

For sidedrains, unless shown otherwise in the Plans the minimum thickness of the metal shall be as specified below. Alternatively, if no future maintenance concerns exist, the Contractor may propose the pipe gage based on the Department's Drainage Manual and Culvert Service Life Estimator for approval by the Engineer.

Table 945-1
Thickness of Metal for Sidedrain Pipe

Nominal Diameter or Equivalent (inches)	Sheet Gauge No.	Mean Thickness of Metal (inches)
6	18	0.048
8	16	0.060
10	16	0.060
12	16	0.060
15	16	0.060
18	16	0.060
21	16	0.060
24	16	0.060
30	14	0.075
36	14	0.075
42	12	0.105
48	12	0.105
54	12	0.105
60	10	0.135
66	10	0.135
72 and over	8	0.164

Where bituminous coated aluminum pipe is specified the bituminous coating shall meet the requirements as specified for corrugated steel pipe in 943-5. Bituminous coated and paved aluminum pipe shall meet the additional requirements specified in 943-6 and 943-7, as applicable.

Class IV pipe shall not be used.

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945-2 Aluminum Alloy Structural Plate Pipe, Pipe Arch and Arches.

945-2.1 General Requirements: Aluminum alloy structural plate pipe, pipe arch, and arches shall conform to AASHTO M 219, with the exceptions and additions specified herein. The nominal thickness of the plate shall be as shown in the Plans.

945-2.2 Bolts and Nuts: In lieu of shaped bolts and nuts, standard type bolts and nuts, with special shaped washers, may be used. For aluminum bolts and nuts the material shall conform to the chemical requirements shown in Table I of ASTM B211, for Alloy 6061. Nuts shall be lubricated at the factory, with a suitable wax compound. The bolts may be sampled and tested before erection or may be accepted on the basis of the manufacturer's certification.

For steel bolts and nuts, the material shall meet the requirements of either ASTM A307 or ASTM F3125, Grade A325, as appropriate, and shall be hot double-dipped galvanized. Aluminized steel bolts, or other equally suitable devices for connecting the plates, may be used if approved by the Engineer.

945-2.3 Certification of Tests: Submit to the Engineer, prior to installation, a certified mill analysis and certification verifying that the aluminum parts and components are of the alloys specified and comply with the requirements of this Section.

945-2.4 Direct Purchases by the Department: The provisions of 944-9 shall also apply to Departmental purchases of aluminum alloy structural plate pipe, pipe arches and arches.

945-2.5 Pipe Markings: In lieu of the coined markings required by AASHTO M 196, Section 14, information may be ink stamped on the pipe at the time of manufacture. A QC label with the pipe fabricator's identity, the date of corrugating or forming into pipe, and the date of final QC inspection shall be applied to the inside walls of pipe using indelible ink. The pipe markings must be clearly legible upon arrival at the jobsite and at the time of installation. Pipe with illegible or incomplete markings may be rejected.

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SECTION 946
CAST IRON PIPE

946-1 Cast Iron Culvert Pipe.

Cast iron culvert pipe of diameter 12 inches and over shall conform with the requirements of AASHTO M 64, including the requirements for the coating as specified in Article 7.1. Cast iron culvert pipe smaller than 12 inches in diameter shall meet ANSI A21.51, and the joints shall meet ANSI A21.11.

Unless a particular type or class of pipe is designated in the plans the Contractor may furnish any class included in the above specifications. Only one class or type shall be furnished for any one Contract. The pipe shall be smooth bore pipe.

946-2 Cast Iron Soil Pipe.

Cast iron soil pipe, for roof drains or for other purposes where such pipe is designated, shall meet the requirements of either of the following:

1. ASTM A74, for service-type pipe.
2. The building code of the municipality or other governmental authority having jurisdiction within the area of the installation.

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SECTION 948
OPTIONAL DRAINAGE PRODUCTS AND REPAIR SYSTEMS

948-1 Polyvinyl-Chloride (PVC) Pipe, or Acrylonitrile-Butadiene-Styrene (ABS) Plastics Pipe.

948-1.1 For Bridge Drains: PVC pipe shall conform to the requirements of ASTM D1785, for Type I, Grade 1, Schedule 80 PVC pipe with a minimum polymer cell classification of 12454 per ASTM D1784 and a minimum of 1.5% by weight of titanium dioxide for UV protection.

948-1.2 Pressure Pipe: Pressure pipe for direct burial under pavement shall conform to the requirements of ASTM D1785, for Type I, Grade I, Schedule 40, for sizes up to and including 2-1/2 inches, and Schedule 80 for sizes up to 4 inches. Pressure pipe 4 inches in diameter and larger shall conform to the requirements of AWWA C900-75, DR18, and ASTM D1785, Type I, Grade I or other types as may be specifically called for in the Plans or Special Provisions.

948-1.3 Pipe Marking: All PVC pipe shall be marked as required by Article 8 of ASTM D1785, and acceptance of the pipe may be based on this data.

948-1.4 Nonpressure Pipe: PVC pipe and ABS pipe intended for direct-burial or concrete encasement, shall meet the following requirements:

1. PVC Pipe: ASTM D3034, SDR-35, or ASTM F949, profile wall without perforations.
2. ABS Pipe: ASTM D2680.

The manufacturer of the PVC or ABS pipe shall submit to the Engineer the mill analysis covering chemical and physical test results.

948-1.5 Underdrain: PVC pipe for use as underdrain shall conform to the requirements of ASTM F758 or ASTM F949. Also, PVC underdrain manufactured from PVC pipe meeting ASTM D3034, perforated in accordance with the perforation requirements given in AASHTO M 36 or AASHTO M 196 will be permitted.

948-1.6 Edgedrain: PVC pipe for use as edgedrain shall conform to the requirements of ASTM F758, ASTM F949 or ASTM D3034 pipe shall be perforated in accordance with the perforation requirements given in AASHTO M 36 or AASHTO M 196. Additional perforations will be required as indicated in Standard Plans, Index 446-001 for pipes designated under ASTM F758 and ASTM D3034. PVC pipe intended for direct burial in asphalt shall meet the following requirements:

1. ASTM D3034, SDR-35, or ASTM F949
2. NEMA TC-2 (pipe material and compounds) and NEMA TC-3 (pipe fittings) for PVC (90ºC electrical conduit pipe) NEMA ECP-40 and NEMA ECP-80. Underwriter Laboratory Specifications referenced under NEMA specifications for electrical conductivity are not required.
3. Pipe shall withstand asphalt placement temperatures specified without permanent deformation.
4. Perforations shall be in accordance with AASHTO M 36 or AASHTO M 196.

948-1.7 PVC Pipe (12 Inches to 48 Inches): PVC pipe for side drain, cross drain, storm drain and other specified applications shall conform to AASHTO M 278 for smooth wall PVC pipe or ASTM F949 and AASHTO M 304 for PVC ribbed pipe with plant certification from

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AASHTO Product Evaluation & Audit Solutions. Resin shall contain a minimum of 1.5% by weight of titanium dioxide for UV protection. Post-consumer and post-industrial recycled resins are not allowed. Mitered end sections are not to be constructed of PVC.

PVC pipe shall be installed within two years from the date of manufacture.

Obtain pipe from a production facility that is listed on the Department's Production Facility Listing. Producers seeking inclusion shall meet the requirements of Section 105.

948-1.7.1 Material Acceptance: Prior to use, submit to the Engineer a material certification from the manufacturer confirming that the requirements of this Section are met. The certification shall conform to the requirements of Section 6.

Project sampling shall be performed in accordance with 430-9.

948-2 Corrugated Polyethylene Tubing and Pipe.

948-2.1 General: For underdrain, corrugated polyethylene tubing and fittings shall meet the requirements of AASHTO M 252. For edgedrain, corrugated polyethylene tubing and fittings shall meet the requirements of AASHTO M 252, except as modified in 948-2.2. For storm drain side drain, french drain and cross drain corrugated polyethylene pipe shall meet the requirements of AASHTO M 294 and 948-2.3.

The tubing or pipe shall not be left exposed to sunlight for periods exceeding the manufacturer's recommendation.

948-2.2 Edgedrain (4 Inches to 10 Inches): The requirements for edgedrain as specified in AASHTO M 252 are modified as follows:

1. Coiling of tubing 6 inches in diameter or greater is not permitted. Tubing shall have a minimum pipe stiffness of 46 psi at 5% deflection.

948-2.3 Corrugated High Density Polyethylene (HDPE) Pipe (12 Inches to 60 Inches):

948-2.3.1 General: Class I (50-year design service life) corrugated HDPE pipe used for side drain, storm and cross drain or french drain shall meet the requirements of AASHTO M 294(V) with plant certification from the AASHTO Product Evaluation & Audit Solutions. Corrugations shall be annular. Pipe resin shall conform to ASTM D3350 with a minimum cell classification 435400C and between 2% to 4% carbon black. Post-consumer and post-industrial recycled resins are not allowed. Mitered end sections are not to be constructed of polyethylene.

Obtain pipe from a production facility that is listed on the Department's Production Facility Listing. Producers seeking inclusion shall meet the requirements of Section 105.

948-2.3.2 Additional Requirements for Class II (100-Year Design Service Life), Type S HDPE Pipe: Class II HDPE pipe shall meet the requirements in Table 948-1 in addition to those in 948-2.3. Perforations will not be allowed. Manufacturers may only use ground Class II HDPE pipe for reworked plastic.

948-2.3.2.1 Requirements for Use in Structures with Resilient Connectors: Use gasketed corrugated pipe sleeve adapters to completely seal to and cover the pipe corrugations. Corrugated pipe sleeve adapters shall be an elongated bell with a smooth outer wall, manufactured at a minimum of 12-inches in length and inserted over the double gasketed corrugations. The sleeve adapters shall be manufactured from polypropylene resin compounds in accordance with ASTM F2881. Upon installation, the connection with the resilient connector shall meet the requirements of ASTM F2510.

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Table 948-1 Stress Crack Resistance of Pipes			
Pipe Location	Test Method	Test Conditions	Requirement
Pipe Liner	FM 5-572, Procedure A	10% Igepal solution at 122°F and 600 psi applied stress, 5 replicates	Average failure time of the pipe liner shall be ≥18.0 hours, no single value shall be less than 13.0 hours.
Pipe Corrugation[1], (molded plaque)	ASTM F2136	10% Igepal solution at 122°F and 600 psi applied stress, 5 replicates	Average failure time shall be ≥24.0 hours, no single value shall be less than 17.0 hours.
Junction	FM 5-572, Procedure B and FM 5-573	Full Test[2][3] Test at 3 temperature/stress combinations: 176°F at 650 psi 176°F at 450 psi 158°F at 650 psi; 5 replicates at each test condition	Determine failure time at 500 psi at 73.4°F ≥ 100 years (95% lower confidence) using 15 failure time values[4] The tests for each condition can be terminated at duration equal to or greater than the following criteria: 110.0 hr at 176°F 650 psi 430.0 hr at 176°F 450 psi 500.0 hr at 158°F 650 psi
		Single Test[5]: Test temperature 176°F and applied stress of 650 psi.; 5 replicates	The average failure time must be equal to or greater than 110.0 hr
Longitudinal Profiles[6]	FM 5-572, Procedure C, and FM 5-573	Full Test[2][3]: Test at 3 temperature/stress combinations: 176°F at 650 psi 176°F at 450 psi 158°F at 650 psi; 5 replicates at each test condition	Determine failure time at 500psi at 73.4°F ≥ 100 years (95% lower confidence) using 15 failure time values[4]. The tests for each condition can be terminated at duration equal to or greater than the following criteria: 110.0 hr at 176°F 650 psi 430.0 hr at 176°F 450 psi 500.0 hr at 158°F 650 psi
		Single Test[5]: Test temperature 176°F and applied stress of 650 psi.; 5 replicates	The average failure time must be equal to or greater than 110.0 hr (no value shall be less than 55.0 hours)

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Table 948-1 Stress Crack Resistance of Pipes			
Oxidation Resistance of Pipes			
Pipe Location	Test Method	Test Conditions	Requirement
Liner and/or Crown(7)	OIT Test (ASTM D3895)	2 replicates (to determine initial OIT value) on the as manufactured (not incubated) pipe.	25.0 minutes, minimum
Liner and/or Crown(7)	Incubation test FM 5-574 and OIT test (ASTM D3895)	Three samples for incubation of 265 days at 176°F(8) and applied stress of 250 psi. One OIT test per each sample	Average of 3.0 minutes(9) (no values shall be less than 2.0 minutes)
Liner and/or Crown(7)	MI test (ASTM D1238 at 190ºC/2.16Kg)	2 replicates on the as manufactured (not incubated) pipe.	< 0.4 g/10 minutes
Liner and/or Crown(7)	Incubation test FM 5-574 and MI test (ASTM D1238 at 190°C/2.16Kg)	2 replicates on the three aged sampled after incubation of 265 days at 176°F(8) and applied stress of 250 psi	MI Retained Value(9)(10) shall be greater than 80% and less than 120%.

Note: FM = Florida Method of Test.
(1) Required only when the resin used in the corrugation is different than that of the liner.
(2) A higher test temperature (194°F) may be used if supporting test data acceptable to the State Materials Engineer is submitted and approved in writing.
(3) Full test shall be performed on alternative pipe diameter of pipe based on wall profile design, raw material cell classification, and manufacturing process. Full test must be performed on maximum and minimum pipe diameters within a manufacturing process.
(4) Computer program to predict the 100 year SCR with 95% lower confidence can be obtained from FDOT.
(5) Single test for the junction and longitudinal profile may be used on alternating pipe sizes within a manufacturing process. Single point tests may not be used on maximum and minimum pipe sizes within a manufacturing process except by approval of the Engineer. Single point tests may be used for quality assurance testing purposes.
(6) Longitudinal profiles include vent holes and molded lines.
(7) OIT and MI tests on the crown are required when resin used in the corrugation is different than that of the liner.
(8) The incubation temperature and duration can also be 196 days at 185°F.
(9) The tests for incubated and "as-manufactured" pipe samples shall be performed by the same lab, same operator, the same testing device, and in the same day.
(10) The MI retained value is determined using the average MI value of incubated sample divided by the average MI value of as-manufactured pipe sample.

948-2.3.3 Material Acceptance: Meet the requirements of 948-1.7.1.

948-2.3.4 Laboratory Accreditation: Manufacturers seeking evaluation of a product in accordance with Departmental procedures must submit test reports conducted by a laboratory qualified by the Geosynthetic Accreditation Institute-Laboratory Accreditation Program (GAI-LAP) or qualified by ISO 17025 accreditation agency using personnel with actual experience running the test methods for Class II HDPE pipe. Submit the test reports to the State Materials Office.

948-2.4 Steel Reinforced Polyethylene Ribbed Pipe:

948-2.4.1 General: Steel reinforced polyethylene ribbed pipe used for side drain, storm and cross drain, or french drain shall meet the requirements of AASHTO M 335 with plant certification from the AASHTO Product Evaluation & Audit Solutions and the testing

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requirements for stress crack and oxidation resistance in Table 948-1. Pipe resin shall conform to ASTM D3350 with a minimum cell classification 435400C and between 2% to 4% carbon black. Post-consumer and post-industrial recycled resins are not allowed. Mitered end sections are not to be constructed of steel reinforced polyethylene ribbed pipe.

Obtain pipe from a production facility that is listed on the Department's Production Facility Listing. Producers seeking inclusion shall meet the requirements of Section 105.

948-2.4.2 Material Acceptance: Meet the requirements of 948-1.7.1.

948-2.4.3 Laboratory Accreditation: Meet the requirements of 948-2.3.4 except use personnel with actual experience running the test methods for steel reinforced polyethylene ribbed pipe.

948-2.5 Steel Reinforced Polyethylene Corrugated Pipe:

948-2.5.1 General: Class I (50-year design service life) steel reinforced polyethylene corrugated pipe used for side drain, storm and cross drain must meet the requirements of AASHTO MP 42 with plant certification from the AASHTO Product Evaluation & Audit Solutions, provided such certification for this category of pipe is available. Pipe resin must conform to ASTM D3350 with a minimum cell classification of 334452C or E and between 2% to 4% carbon black. Thermosetting polyurethane materials used for pipe joints must be polyester-based and meet the requirements of Table 948-2. Post-consumer and post-industrial recycled resins are not allowed. Perforations are not allowed. Mitered end sections are not to be constructed of steel reinforced polyethylene corrugated pipe.

Obtain pipe from a production facility that is listed on the Department's Production Facility Listing. Producers seeking inclusion to the listing shall meet the requirements of Section 105.

Table 948-2
Polyurethane Component Requirements

Test Methods	Test Conditions	Requirement
ASTM D2240 Durometer Hardness 1-inch Thick Specimens	Initial	≥60
	After 6 Months Exposure to Each Condition*	No more than 10% reduction from measured initial value
ASTM D695 Compressive Properties 0.1 inch per minute Load Rate	Initial	≥200 psi
	After 6 Months Exposure to Each Condition*	No more than 10% reduction from measured initial value
ASTM D1623 Yield Tensile Strength Type B Specimens 0.1 inch per minute Load Rate	Initial	≥300 psi
	After 6 Months Exposure to Each Condition*	No more than 30% reduction from measured initial value

*Exposure Conditions:

Solution pH	Resistivity (Ohm-cm), Minimum	Chloride Content (ppm), Maximum	Temperatures (°C)
5.5	1,000	300	60, 80, 90
7	1,000	300	60, 80, 90
12	1,000	300	60, 80, 90

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948-2.5.2 Project Material Acceptance: Prior to use, submit to the Engineer a material certification from the manufacturer confirming that the requirements of this Section are met. The certification shall conform to the requirements of Section 6.

948-2.5.3 Laboratory Accreditation: Manufacturers seeking evaluation of a product in accordance with Departmental procedures must submit test reports conducted by a laboratory qualified by the Geosynthetic Accreditation Institute-Laboratory Accreditation Program (GAI-LAP) or qualified by ISO 17025 accreditation agency using personnel with actual experience performing the test methods for steel reinforced polyethylene pipe. Submit the test reports to the State Materials Office.

948-3 Fiberglass Reinforced Polymer Pipe.

948-3.1 For Bridge Drains: Fiberglass pipe shall conform to the requirements of ASTM D3262, ASTM D2996 or ASTM D2310, for Type I, Grade 2, Class E, using polyvinyl ester as the only resin. The minimum hoop stress designation shall be A. The resin shall contain UV stabilizers or a two-part 100% solids polyurethane coating.

948-4 Ductile Iron Pipe.

948-4.1 For Bridge Drains: Ductile iron pipe shall conform to the requirements of AWWA C151.

948-5 Hot Dip Galvanized Steel Pipe.

948-5.1 For Bridge Drains: Hot dip galvanized steel pipe shall conform to the requirements of ASTM A53.

948-6 Flexible Transition Couplings and Pipe.

948-6.1 For Bridge Drains: Flexible transition couplers and pipe shall conform to the requirements of ASTM C1173.

948-7 Profile Wall Polypropylene (PP) Pipe (12 Inches to 60 Inches).

948-7.1 Class I PP: Class I (50-year design service life) PP pipe used for side drain, cross drain, storm drain, and french drain shall meet the requirements of AASHTO M 330 with plant certification from the AASHTO Product Evaluation & Audit Solutions. Corrugations shall be annular. Polypropylene compound shall conform to the requirements of ASTM F2881. Post-consumer and post-industrial recycled resins are not allowed. Mitered end sections are not to be constructed of polypropylene.

Obtain pipe from a production facility that is listed on the Department's Production Facility Listing. Producers seeking inclusion shall meet the requirements of Section 105.

948-7.2 Additional Requirements for Class II (100-Year Design Service Life) PP Pipe: Meet the requirements in Table 948-3 in addition to those in 948-7.1. Manufacturers may only use ground Class II PP for reworked plastic.

948-7.2.1 Requirements for Use in Structures with Resilient Connectors: For PP pipe 24 inches and less in diameter, use gasketed corrugated pipe sleeve adapters to completely seal to and cover the pipe corrugations. Corrugated pipe sleeve adapters shall be an elongated bell with a smooth outer wall, manufactured at a minimum of 12-inches in length and inserted over the double gasketed corrugations. The sleeve adapters shall be manufactured from polypropylene resin compounds in accordance with ASTM F2881. Upon installation, the connection with the resilient connector shall meet the requirements of ASTM F2510.

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For PP pipe 30 inches or greater in diameter, use at least one section of AASHTO M330-Class II Type D (triple wall) pipe at the pipe to structure connection.

Table 948-3
Stress Crack Resistance

Pipe Location	Test Method	Test Conditions	Requirement
Pipe Liner	FM 5-572, Procedure A	10% Igepal solution at 50°C and 600 psi applied stress, 5 replicates	Average failure time of the pipe liner shall be ≥100 hours, no single value shall be less than 71 hours.(1)
Oxidation Resistance			
Pipe Location	Test Method	Test Conditions	Requirement
Pipe Liner and/or Crown(2)	OIT Test (ASTM D3895)	2 replicates (to determine initial OIT value) on the as manufactured (not incubated) pipe.	25.0 minutes, minimum
Pipe Liner and/or Crown(2)	Incubation test FM 5-574 and OIT test (ASTM D3895)	Three samples for incubation of 264 days at 85°C(3). One OIT test per each sample	Average of 3.0 minutes(4) (no values shall be less than 2.0 minutes)
Pipe Liner and/or Crown(2)	MI test (ASTM D1238 at 230°C/2.16Kg)	2 replicates on the as manufactured (not incubated) pipe.	< 1.5 g/10 minutes
Pipe Liner and/or Crown(2)	Incubation test FM 5-574 and MI test (ASTM D1238 at 230°C/2.16Kg)	2 replicates on the three aged sampled after incubation of 264 days at 85°C(3)	MI Retained Value(4)(5)(6) shall be greater than 80% and less than 120%.

Note: FM = Florida Method of Test.

(1) If due to sample size this test cannot be completed on the liner then testing shall be conducted on a molded plaque sample. Samples can be removed if test time exceeds 100 hours without failure.
(2) OIT and MI tests on the crown are required when resin used in the corrugation is different than that of the liner.
(3) The incubation temperature and duration can also be 192 days at 90°C or 140 days at 95°C.
(4) The tests for incubated and "as-manufactured" pipe samples shall be performed by the same lab, same operator, the same testing device, and in the same day.
(5) Within each replicate set of tests, the discrepancy range shall be within 9%. If an out-of-range discrepancy occurs, repeat the two MI tests on the same pipe sample. If insufficient material is available, a repeat of one test is acceptable.
(6) The MI retained value is determined using the average MI value of incubated sample divided by the average MI value of as-manufactured pipe sample.

948-7.3 Material Acceptance: Meet the requirements of 948-1.7.1.

948-7.4 Laboratory Accreditation: Meet the requirements of 948-2.3.4 except use personnel with actual experience running the test methods for profile wall polypropylene pipe.

948-8 Filter Fabric Sock for Use with Underdrain.

For Type I underdrain specified in Standard Plans, Index 440-001, filter sock shall be an approved strong rough porous, polyester or other approved knitted fabric which completely

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covers and is secured to the perforated plastic tubing underdrain in such a way as to prevent infiltration of trench backfill material.

The knitted fabric sock shall be a continuous one-piece material that fits over the tubing like a sleeve. It shall be knitted of continuous 150 denier yarn and shall be free from any chemical treatment or coating that might significantly reduce porosity and permeability.

The knitted fabric sock shall comply with the following physical properties:

Table 948-4		
Weight, applied (oz/sq. yd.)	3.5 min	ASTM D3887
Grab tensile strength (lbs.)	50 min.*	ASTM D5034
Equivalent opening size (EOS No.)	25 min.**	Corps of Engineers CW-02215-77
Burst strength (psi)	100 min.**	ASTM D3887
*Tested wet. **Manufacturer's certification to meet test requirement.		

The knitted fabric sock shall be applied to the tubing in the shop so as to maintain a uniform applied weight. The tubing with knitted fabric sock shall be delivered to the job site in such manner as to facilitate handling and incorporation into the work without damage. The knitted fabric sock shall be stored in UV resistant bags until just prior to installation. Torn or punctured knitted fabric sock shall not be used.

948-9 Repair Systems for Rehabilitation of Pipe and Other Drainage Structures.

948-9.1 General: Repair systems shall have at least the minimum stiffness required for the intended application in accordance with the AASHTO LRFD Bridge Design Specifications.

948-9.2 Folded Liner: Folded liner shall be manufactured in an out of form state, usually collapsed circumferentially, and folded on the long axis. After installation in a host structure, the liner is formed by means of heat and pressure to fit the host structure. When installed, folded liner shall extend from one structure to the next in one continuous length with no intermediate joints.

948-9.2.1 Polyethylene: Folded polyethylene liner shall meet the requirements of ASTM 2718 or ASTM F714 with a minimum cell classification of 335420 and between 2% to 4% carbon black.

948-9.2.2 PVC: Folded PVC liner shall meet the requirements of ASTM F1504 (meet all the requirements for cell classification 12334 or 13223) or ASTM F1871 (meet all the requirements for cell classification 12111).

948-9.2.3 Cured-In-Place: Folded resin impregnated flexible tubing shall meet the requirements of ASTM F1216 and ASTM D5813.

948-9.3 Prefabricated (Slip) Pipe Liner: When used in slip lining applications, prefabricated liner shall be round, flexible or semi-rigid liner, manufactured in lengths that may be joined in a manhole or access pit before insertion in a host pipe.

948-9.3.1 Polyethylene:

1. Solid wall polyethylene pipe liner shall meet the requirements of ASTM F714 or AASHTO M 326 and shall have a minimum cell classification of 345464 and between 2% to 4% carbon black.

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2. Profile wall polyethylene pipe liner shall meet the requirements of AASHTO M 294 and shall have a minimum cell classification of 435400 and between 2% to 4% carbon black.

3. Steel reinforced polyethylene pipe liner shall meet the requirements of AASHTO MP 20-13, ASTM F2562 or ASTM F2435 and shall have a minimum cell classification of 334452 and between 2% to 4% carbon black.

948-9.3.2 PVC:

1. Solid wall PVC pipe liner shall meet the requirements of ASTM D2729 and shall have a minimum cell classification of 12454.

2. Profile wall PVC pipe liner shall meet the requirements of ASTM F794, ASTM F949, or AASHTO M 304 and shall have a minimum cell classification of 12454.

948-9-3.3 Fiberglass: Prefabricated fiberglass pipe liner shall meet the requirements of ASTM D3262.

948-9.4 Spiral-Wound Liner: Spiral-wound liner shall consist of coils of profile strips or one piece profile strips that are wound directly into a host pipe helically

948-9.4.1 Polyethylene: Polyethylene spiral-wound liner shall meet the requirements of ASTM F1697 or ASTM F1735, except the resin shall conform to ASTM D3350 with a minimum cell classification of 335420 and between 2% to 4% carbon black.

948-9.4.2 PVC: PVC spiral-wound liner shall meet the requirements of ASTM F1697 or ASTM F1735 and shall have a minimum cell classification of 12454.

948-9.4.3 Steel Reinforced: Steel reinforced spiral-wound liner shall meet the requirements of ASTM F1697 or ASTM F1735, except the resin shall conform to ASTM D3350 with a minimum cell classification of 335420 and between 2% to 4% carbon black. The steel reinforcement shall be fully encapsulated to prevent exposure to corrosive elements.

948-9.5 Segmental Panel Liner: Segmental panel liner consists of custom fit flat or curved panels that are formed to the inside wall of a host structure.

948-9.5.1 Polyethylene: Polyethylene segmental panel liner shall meet the requirements of ASTM F1735, except the resin shall conform to ASTM D3350 with a minimum cell classification of 345464 and between 2% to 4% carbon black.

948-9.5.2 PVC: PVC segmental panel liner shall meet the requirements of ASTM F1735 and shall have a minimum cell classification of 12454.

948-9.6 Point Repair Systems: Point repair systems may be used to repair and rehabilitate an isolated portion of an existing structure and may consist of any materials covered by this specification. Materials that shall be used as primary components of point repair apparatus are:

1. Stainless steel, which shall meet the requirements of AASHTO M 167M, ASTM A167, or ASTM A240

2. Aluminum, which shall meet the requirements of AASHTO M 196

3. Rubber, which shall meet the requirements of ASTM C923.

948-9.7 Spray Applied Repair Systems: Spray applied repair systems consist of liquid, slurry, foam or gel that is sprayed over the interior surface or injected into specific locations of an existing structure or pipe to rehabilitate it, with or without fiber reinforcement. Spray applied repair system installers shall submit to the Department proof of experience for on-site supervision and previously completed contracts including the following:

1. Project name and location

2. Names of contracting parties

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3. Owner's names
4. A brief description of the work
5. Dates of completion of spray applied liner work

Materials that may be used for spray applied lining are:

1. Hydrophilic urethane-based foams or gels which shall meet the requirements of ASTM F2414.
2. Epoxy resins and unsaturated styrene-based resins which shall meet the resin material requirements of ASTM F1216.
3. Cementitious materials, as recommended by the manufacturer, including: annular backfill, low density cellular concrete, shotcrete, gunite, centrifugally cast, and pre-packaged grout.
4. High-strength, low-porosity geopolymer materials, as recommended by the manufacturer.

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SECTION 949
MISCELLANEOUS COMPONENTS FOR MANHOLES, INLETS AND OTHER STRUCTURES

949-1 Clay Brick and Shale Brick.

This brick shall meet the requirements of ASTM C62, Grade MW or ASTM C32, Grade MM.

949-2 Concrete Brick.

Concrete brick shall meet the requirements of ASTM C55.

949-3 Concrete Masonry Units.

Concrete masonry units for use in manholes, inlets and similar structures shall meet the requirements of ASTM C139.

949-4 Precast Grade Adjustment Rings.

Precast grade adjustment rings shall meet the requirements of ASTM C478.

949-5 Composite Rubber Adjustment Rings.

Composite rubber adjustment rings shall meet the following minimum material requirements:

Table 949-1

Physical Properties	Requirements	Test Method
Density, lb./ft3	65 ± 5%	ASTM D3574-05, Test A
Durometer Hardness, Molded Surfaces, Shore A	75A ± 10	ASTM D2240-05
Tensile Strength, psi	145 (minimum)	ASTM D412-06
Ultimate Elongation %	15 ± 5	ASTM D412-06
Compression Deformation %, Initial	6 ± 2	ASTM D575-91(01)
Compression Deformation %, Final	6 ± 2	ASTM D575-91(01)
Coefficient of Thermal Expansion	10x10-5 ± 5x10-5	ASTM E831-05

949-6 Acceptance.

Submit to the Engineer a certification from the manufacturer stating that the bricks, concrete masonry units, precast grade adjustment rings or composite rubber adjustment rings meet the requirements of this Section. Acceptance of materials will be in accordance with Section 6.

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SECTION 951
INSPECTION OF TIMBER PRODUCTS

951-1 Control of Quality.

All timber products manufactured for incorporation into the work shall be produced by a producer/treater approved through one of the following third-party audit programs:

1. Southern Pine Inspection Bureau (SPIB)
2. Timber Products (TPI)

Products produced under this QC Plan will not relieve the Contractor of his responsibility for unsuitable materials or workmanship, which might become apparent at the job site, nor of the necessity of his replacing any material which might be determined upon subsequent inspection to be unsuitable.

951-2 Certification.

Each order/shipment to the job site must be delivered with a ‘quality mark’ stamped by the third party quality assurance company. For material not eligible to be marked, the timber producer must produce a ‘certificate of inspection’ by the third party quality assurance company. Each order/shipment to the job site must be accompanied with a notarized certification indicating compliance to the appropriate specifications. The certification shall include: the project/order number, timber species, charge numbers, and assay retention results.

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SECTION 952
STRUCTURAL TIMBER

952-1 General Specifications for All Structural Timber.

This Section specifies the requirements for pine timber to be used as structural members in the Department's work, including untreated timber as well as timber to be treated. All such timber shall be manufactured and graded in accordance with the current edition of the Standard Grading Rules for Southern Pine Timber, of the Southern Pine Inspection Bureau. The timber shall meet the requirements of No. 1 grade or as otherwise specified in the Plans.

952-2 Timber for Other Specific Uses.

952-2.1 Specification Grade: For timber to be used for columns, sills, wheelguards, bulkhead, sheeting, bracing, fender wales, or any other purpose for which the grade is not specified otherwise, the specification grade shall be as follows:

Table 952-1

Nominal Thickness	Nominal Width	Grade
1 to 1.5 inches	2 inches and wider	No. 1 Boards
2 to 4 inches	2 inches and wider	No. 1 Dimension
5 inches and larger	5 inches and larger	No. 2 Timbers

952-2.2 Permissible Knot Sizes for Fender Wales: For timber used as fender wales, the maximum permissible size of knot (at any point on any face) shall be as follows:

For nominal width of face of 10 - 3-3/4 inches.
For nominal width of face of 12 - 4-1/2 inches.

952-3 Untreated Pine Timber - Specific Requirement for Heartwood.

In addition to meeting all of the requirements of 952-1 and 952-2, pine timber which is to be used as untreated timber will be required to show at least 85% of heartwood on any girth.

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SECTION 953
TIMBER PILING
(INCLUDING TIMBER SHEET PILING)

953-1 General.

Piles shall be of timber which will stand the driving for which they are intended. They shall be sound and solid. Piling cut from southern pine shall contain at least 30% of summer wood.

Cypress piles used for purposes other than as foundation piling shall have, at the butt, a diameter of red or black heart of at least 12 inches.

Douglas fir used for timber piling shall be Pacific Coast Douglas Fir.

Piles shall be cut above the ground swell, shall have a form taper, and shall not vary more than plus or minus 6 inches from the specified length.

Specific requirements for timber sheet piles are contained in 953-6.

953-2 Diameter of Butt and Tip.

For round piles the minimum butt diameter shall be 12 inches, measured at a section 3 feet from the end.

For piles up to 50 feet in length, the minimum tip diameter shall be 8 inches. For lengths in excess of 50 feet, a graduated reduction in tip diameter at the rate of 1 inch for each 10 feet of length in excess of 50 feet will be permitted. This reduction will correspond to 7 inch tips for 60 foot piles and 6 inch tips for 70 foot pile; at which length these allowable reductions shall cease. As an exception to the above, when so shown in the Plans, 7 inch diameter tips on timber piles less than 60 feet in length will be accepted. No piles shall have tips less than 6 inches in diameter. The maximum diameter at the cut-offs shall be 20 inches.

953-3 Straightness Requirements.

A straight line drawn from the center of the butt to the center of the tip shall not, at any point, fall further away from the center of the pile than a distance equal to 1% of the length of the pile.

The surface of the pile shall not contain kinks greater than 1 inch in 5 feet, as measured by a straightedge.

953-4 Peeling and Trimming.

The pile shall be peeled soon after cutting. In the operation of removing the bark from the pile, not more than three annual rings of the solid wood shall be removed. All knots shall be trimmed close to the body of the pile.

953-5 Permissible Knots and Other Defects.

The diameter of sound knots shall not exceed one-third of the diameter of the pile at the point where the knot occurs.

In these Specifications, a sound knot shall be defined as a knot which is solid across its face, is as hard as the surrounding wood and shows no indication of decay. It may vary in color from red to black and may contain a pith hole not more than 1/4 inch in diameter.

An unsound knot may or may not be as hard as the surrounding wood, but contains decay, and will be allowed only in accordance with the restrictions in ASTM D25.

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Any defect, or combination of defects, which would be more injurious than the maximum allowable knot will not be acceptable.

Turpentine cuts will be allowed on all timber piles provided that no single cut shall exceed one-half of the circumference of the pile, and that the length of the cut shall not be more than 15% of the length of the pile. Piles to be used as outside piles in timber bents shall not have more than one turpentine cut.

953-6 Timber Sheet Piles.

Unless a particular species of timber is called for in the Plans, timber sheet piles may consist of any species which will satisfactorily stand driving. They shall be sawn square and shall be free from worm holes, loose knots, wind shakes, decayed or unsound portions, and other defects which might impair the strength or tightness

The piles shall be of the dimensions shown in the Plans and shall be treated in accordance with Section 955.

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SECTION 954
TIMBER FENCE POSTS AND BRACES

954-1 Types of Timber and Treating Requirements.

Timber fence posts and braces shall be of southern yellow pine and shall be treated in accordance with Section 955.

Prior to the treatment, all knots on the posts shall be trimmed close to the body of the post.

954-2 Requirements for Cutting.

Round or sawn posts will be permitted but all posts on a single project shall be the same. Sawn post shall comply with AASHTO M 168, have a minimum Fb of 1,350 psi, be grade-stamped by an inspection agency accredited by the American Lumber Standards Committee (ALSC), and shall meet the requirements of 954-6. Round posts shall be cut from sound and solid trees and shall contain no unsound knots. The butt shall be cut at a sufficient distance above the ground swell of the tree that there will be no abrupt change in cross-section of the post.

The butts shall be sawn square. The post tops shall be sawn neatly and at right angles to the vertical axis of the post.

954-3 Knots, etc.

Sound knots will be permitted provided the diameter of the knot does not exceed one-third of the diameter of the piece at the point where it occurs.

Peck (in cypress posts) shall be limited as provided for knots; the area of permissible peck not exceeding the area occupied by permissible knots, and a combination of peck and knots not exceeding the aggregate of knots allowed.

The posts shall be free from decayed wood, rot, and red heart, and of ring shake or season checks which penetrate at any point more than one fourth the diameter of the piece, or are greater than 1/4 inch wide.

954-4 Peeling.

All posts shall be peeled for their full length, and all inner and outer bark removed, except that isolated strips of inner bark which do not exceed 1/2 inch in width or 3 inches in length will be permitted.

954-5 Straightness.

The straightness of the post shall be such that for any 8 foot post (or for any 8 feet of length, for longer posts) a straight line from the center of the tip to the center of the butt (or from center of the cross sections at the extremes of the 8 foot lengths) shall not fall outside the center of the mid-section of the 8 foot length by more than 2 inches.

954-6 Dimensions.

954-6.1 Minimum Lengths Allowable:

Line posts - 8 feet.

Corner and pull posts - 8 feet, 6 inches.

Braces - As required by the Plans.

(A tolerance of minus 1 inch to plus 2 inches will be allowed in the lengths shown for the posts.)

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954-6.2 Minimum Allowable Cross Section:

Round line posts - 4 inch diameter.

Round braces, corner and pull posts - 5 inch diameter.

Square line posts - 4 inches by 4 inches.

Square braces, corner and pull posts - 5 inches by 5 inches.

The minimum diameters specified for round posts are applicable before preservative treatment. When the treated post is inspected at the job site a tolerance of 3/8 inch under such diameters will be allowed, to compensate for shrinkage resulting from treatment and storage.

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SECTION 955
TIMBER TREATMENT
(INCLUDING TREATING MATERIALS)

955-1 General.

The work specified in this Section is the treating of structural timber, timber piling and timber posts, bracing and railing. The method of treatment and determination of assay results for all such timber materials shall be in accordance with American Wood Protection Association (AWPA) Use Category System (UCS) - U1, with the exceptions and additions as specified herein. All timber products manufactured for incorporation into the work shall be produced by a producer/treater approved through one of the following third-party audit programs:

1. Southern Pine Inspection Bureau (SPIB)
2. Timber Products (TPI)

955-2 Preservative.

955-2.1 Guardrail Post, Fence Post, Bracing and Railing on Pedestrian Bridges, Buildings, and Rest Areas in Above Ground, Ground Contact, Fresh Water Immersion Applications (Pedestrian Use): Provide guardrail post, fence post, bracing and railing in accordance with Table 955-1. Approved producers should provide a certification showing the timber species, treatment, and assay results with every shipment.

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Table 955-1				
Product	Type / Species	Category	Treatment	Assay Results
Guardrail Posts, Fence Post, Bracing, & Railing	Southern Yellow Pine	UC4A	Micronized Copper Azole (MCA)	≥ 2.4 kg/m^3 or ≥ 0.15 pcf
			Copper Azole Type C (CA-C)	
			Copper Azole Type B (CA-B)	≥ 3.3 kg/m^3 or ≥ 0.21 pcf
			Alkaline Copper Quat Type A, (ACQ-A)	≥ 6.4 kg/m^3 or ≥ 0.40 pcf
			Alkaline Copper Quat Type B, (ACQ-B)	
			Alkaline Copper Quat Type C, (ACQ-C)	
			Alkaline Copper Quat Type D, (ACQ-D)	

955-2.2 Guardrail Posts, Fence Posts, Bracing and Sheet Piling in Above Ground, Ground Contact or Fresh Water Immersion Applications (Non-Pedestrian Use): Provide guardrail post, fence post, bracing and sheet piling in accordance with Table 955-2. Approved producers should provide a certification showing the timber species, treatment, and assay results with every shipment.

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Table 955-2				
Product	Type / Species	Category	Treatment	Assay Results
Guardrail Posts, Fence Post, Bracing	Southern Yellow Pine	UC4A	MCA	≥ 2.4 kg/m^3 or ≥ 0.15 pcf
			CA-C	
			CA-B	≥ 3.3 kg/m^3 or ≥ 0.21 pcf
			Ammoniacal Copper Zinc Arsenate (ACZA)	≥ 6.4 kg/m^3 or ≥ 0.40 pcf
			Chromated Copper Arsenate Type C (CCA)	
			ACQ-A ACQ-B ACQ-C ACQ-D	
Piling	Cypress		None	N/A
	Southern Yellow Pine	UC4B UC4C	ACZA	≥ 9.6 kg/m^3 or ≥ 0.60 pcf
			CCA	≥ 9.6 kg/m^3 or ≥ 0.60 pcf
	Pacific Coast Douglas Fir		ACZA	≥ 9.6 kg/m^3 or ≥ 0.60 pcf

955-2.3 Guardrail Post, Fence Post, Bracing and Sheet Piling for Salt and Brackish Water Applications (Non-Pedestrian): Provide guardrail post, fence post, bracing and sheet piling in accordance with this section and Table 955-3. Approved producers should provide a certification showing the timber species, treatment, and assay results with every shipment.

Table 955-3				
Product	Type / Species	Category	Treatment	Assay Results
Guardrail Posts, Fence Post, Bracing	Southern Yellow Pine	UC4C	CCA	≥ 9.6 kg/m^3 or ≥ 0.60 pcf
Piling	Cypress	UC5C	None	N/A
	Southern Yellow Pine		CCA	Zone 1 (Outer): ≥ 40 kg/m^3 or ≥ 2.50 pcf Zone 2 (Inner): ≥ 24 kg/m^3 or ≥ 1.50 pcf
	Pacific Coast Douglas Fir		ACZA	40 kg/m^3 or ≥ 2.50 pcf

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955-2.4 Structural Timber: Provide structural timber in accordance with this section and Table 955-4. Approved producers should provide a certification showing the treatment and assay results with every shipment.

Table 955-4				
Product	Type / Species	Category	Treatment	Assay Results
Boards, Dimensional, Timber	Southern Yellow Pine	UC4B	CCA	≥ 9.6 kg/m^3 or ≥ 0.60 pcf

955-3 Handling Waterborne Preservative Treated Piling.

In handling of piles that have been treated with chromated copper arsenate (CCA) or ammoniacal copper zinc arsenate (ACZA), cable slings shall be used. Mechanical grabbers or pointed tools shall not be permitted. Rough or careless handing shall be avoided at all times.

955-4 Identification of Treating Plants for Round Piling.

The treating plant shall brand, or place a distinctive permanent mark, on each round pile, approximately 6 feet from the butt end, such that the plant responsible for the treatment can be readily determined at any time during the service life of the piling.

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SECTION 960
POST-TENSIONING COMPONENTS

960-1 Description.

This Section covers all post-tensioning (PT) systems and components remaining in a completed structure, including temporary erection PT left in-place and permanent PT for design capacity.

The submittal for approval of PT systems must use materials and components meeting the requirements of this Section and Section 462. Submit PT system shop drawings to the Engineer for review and acceptance in accordance with Section 5. The PT system shop drawings must include component drawings, system drawings, and test reports. The acceptance of a PT system for use on the project is based on the exact major components, as defined in 960-2, that were used in system testing and that are shown on the approved PT system shop drawings.

960-1.1 Material References: Meet the requirements of this Section and the following:

Epoxy Compounds*	Section 926
Bar (post-tensioning)	Section 933
Duct Filler for Post Tensioned Structures*	Section 938
Reinforcing Steel (mild)	Section 415
Parallel Wire (post-tensioning)	Section 933
Strand (post-tensioning)	Section 933

*Use products listed on the Department's Approved Product List (APL).

960-2 Component Standards.

All PT system components must be materials compatible with the filler material and installation process used to encapsulate the tendons. The component materials must not chemically degrade during the service life of the structure. The service life of the structure is 75-years unless specified otherwise in the Contract Documents.

The following are major components and must be marked with the manufacturer's name, trademark, model number, and size corresponding to catalog designation: anchorages, bearing plates, trumpets, caps, duct couplers, connections, "O"-rings, heat shrink tubing, duct, and local zone reinforcement. Any of these items that cannot be marked must be contained in packaging or appropriately tagged with the necessary information.

The following are examples of common off-the-shelf accessories and need not be stamped: bolts, washers, inlets, outlets, drains, ports, valves, plugs, nipples, hose adapters, and grease.

Substitution, modification, or deletion of any major component of the PT system, excluding local zone reinforcement, after system testing and approval by the Engineer is not permitted.

Provide only PT systems utilizing tendons completely encapsulated in grout or flexible filler filled anchorages and ducts. Do not use systems transferring prestress force by bonding prestress steel strand directly to concrete. Embedded anchorages for bars are permitted. Strand or strand-tendon couplers are not permitted.

960-2.1 Anchorage Assembly:

1. Construct anchorages from ferrous metal.

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2. Anchorages shall develop at least 95% of PT steel actual ultimate strength when tested in an unbonded state, without exceeding anticipated anchor set.

3. Average concrete bearing stress shall be in compliance with AASHTO LRFD Bridge Design Specifications and AASHTO LRFD Bridge Construction Specifications.

4. Test anchorages with typical local zone reinforcement shown in system drawings.

5. Test anchorages in accordance with AASHTO LRFD Bridge Construction Specifications, or the European Assessment Document Post-Tensioning Kits for Prestressing of Structures (EAD 160004-00-0301, September 2016 Edition) with the exception that the design concrete strength used in the testing will be 6,500 psi. For anchorages that will be used for tendons with flexible filler, test anchorages in accordance with EAD 160004-00-0301 Section C.3 Resistance to Fatigue.

6. Anchorages with grout or flexible filler outlets shall be suitable for inspection from either top or front of anchorage. Anchorages may be fabricated to facilitate both inspection locations or may be two separate anchorages of the same type, each providing singular inspection entry locations.

7. Geometry of grout and flexible filler outlets must facilitate access for borescope inspection directly behind wedge plate using a straight 3/8 inch diameter drill bit.

8. Ferrous metal components of an anchorage that are to be embedded in concrete shall be galvanized in accordance with Section 962. Other anchorage assembly components, including wedges, wedge plates, and local zone reinforcement need not be galvanized.

9. All anchorages shall have a permanent vented anchorage cap bolted to the anchorage.

960-2.1.1 Trumpets:

1. Trumpets associated with anchorages shall be constructed from ferrous metal galvanized per ASTM A123, high-density polyethylene or polypropylene.

2. For connections between the trumpet and corrugated duct, the trumpet thickness at transition location shall be the thickness of the corrugated duct or greater.

3. For connections between the trumpet and smooth plastic duct, the trumpet thickness at the transition location shall be the minimum thickness provided in Table 960-1 or greater.

Table 960-1
Trumpet Thickness at the Transition Location

System Size	Minimum Trumpet Thickness at the Transition Location
4-Strand	0.08 inch
7-Strand	0.08 inch
12-Strand	0.10 inch
19-Strand	0.12 inch
27-Strand	0.14 inch
31-Strand	0.16 inch

960-2.1.2 Wedges and Wedge Plates:

1. Wedge plate shall be ferrous metal.

2. Wedge plates must have centering lugs or shoulders to facilitate alignment with bearing plate.

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3. For longitudinal tendons greater than four strands, design system with separate wedge plate and anchorage plate.

960-2.2 Filler Containment Assembly:

960-2.2.1 Duct and Pipe:

1. Use plastic duct, steel pipe, or a combination of plastic duct and steel pipe in accordance with this Section.

2. Ducts shall be manufactured by a seamless fabrication method. Fabricate all duct splices to prevent kinks during all phases of construction.

3. Do not alter the natural duct color that results from UV protected polymer.

4. Corrugated ferrous metal ducts are prohibited.

960-2.2.1.1 Corrugated Plastic Duct:

1. PT systems with duct injected with grout shall use corrugated polypropylene material except where steel pipe is required.

2. Furnish ducts with minimum wall thickness as follows:

Table 960-2
Corrugated Plastic Duct Minimum Wall Thicknesses

Duct Shape	Duct Diameter*	Duct Minimum Wall Thickness
Flat	Any Size	0.08 inch
Round	0.9 inch	0.08 inch
Round	2.375 inch	0.08 inch
Round	3.0 inch	0.10 inch
Round	3.35 inch	0.10 inch
Round	4.0 inch	0.12 inch
Round	4.5 inch	0.14 inch
Round	5.125 inch	0.16 inch
Round	5.71 inch	0.16 inch

*The diameter is the nominal inner diameter of the duct.

960-2.2.1.2 Smooth Plastic Duct:

1. PT systems with duct injected with flexible filler shall use smooth high-density polyethylene duct.

2. Duct shall have a maximum dimension ratio (DR) of 17 as established by either ASTM D3035 or ASTM F714, as appropriate for manufacturing process used.

3. Duct shall have a minimum pressure rating of 125 psi.

960-2.2.1.3 Steel Pipe: Steel pipes shall be ASTM A53, Type E, Grade B, Schedule 40 and galvanized in accordance with Section 962.

960-2.2.1.4 Minimum Internal Diameter:

1. For prestressing bars, duct shall have a minimum internal diameter of 1/2 inches larger than bar outside diameter, measured across deformations.

2. For prestressing bars with couplers, duct shall have a minimum internal diameter of 1/2 inches larger than largest dimension of the largest enclosed element.

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3. For multi-strand tendons, ducts must have a minimum cross-sectional area 2-1/2 times PT steel cross-sectional area.

960-2.2.1.5 Connections, Fittings, and Tolerance:

1. Devices or methods for all duct connections (e.g., splices, joints, couplers, connection to anchorages), shall produce smooth interior alignment with no lips or kinks.

2. Use of tape, caulking, epoxy, or other sealants is not permitted to join or repair duct, to make connections, or for any other purpose.

3. Use a reducer when adjacent sections of duct are directly connected to each other and the outside diameters vary more than plus or minus 0.08 inch.

4. Provide all connections that are external to the concrete with a minimum pressure rating of 150 psi.

5. Use heat shrink sleeves and circular sleeve couplers made from high-density polyethylene or polypropylene material, or duct couplers made from high-density polyethylene or polypropylene material with O-rings or seals to make connections between sections of corrugated plastic duct or between corrugated plastic duct and trumpets.

6. Use heat shrink sleeves and circular sleeve couplers made from high-density polyethylene or polypropylene material to make connections between corrugated plastic duct and steel pipe.

7. Use heat shrink sleeves with or without circular sleeve couplers made from high-density polyethylene or polypropylene material to make connections between corrugated or smooth plastic duct and anchorages with integral trumpets that are internal to the concrete.

8. Use heat welding techniques, electrofusion duct couplers, or elastomer sleeves and stainless steel band clamps to make connections between sections of smooth plastic duct.

9. Use elastomer sleeves and stainless steel band clamps to make connections between smooth plastic duct and steel pipe.

10. Use welding or elastomer sleeves and stainless steel band clamps to make connections between sections of steel pipe that are external to the concrete.

11. Use welding, elastomer sleeves and stainless steel band clamps or heat shrink sleeves and circular sleeve couplers made from high-density polyethylene or polypropylene material to make connections between steel pipe and trumpets that are internal to the concrete.

12. Use elastomer sleeves with a minimum wall thickness of 3/8 inch and reinforced with a minimum of four ply polyester reinforcement. Use a 3/8-inch-wide stainless steel power seated band and clamps on each end of the elastomer sleeves to secure the sleeves to plastic ducts or steel pipes. Seat the bands with a 120-pound-force prior to clamping them in place.

960-2.2.1.6 Segmental Duct Couplers:

1. Include segmental duct couplers for permanent internal PT systems at joints between match cast precast segments.

2. Use “O”- rings or compression seals between adjoining sections of segmental duct couplers.

3. Plastic duct couplers shall be high-density polyethylene or polypropylene material.

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4. Metallic components shall be stainless steel per 960-2.4.3.

5. Segmental duct couplers shall mount perpendicular to the bulkhead at segment joints and provide for duct alignment.

6. Segmental duct couplers shall be able to receive duct at an angle of 6 degree deviation from perpendicular.

7. Segmental duct couplers must be able to accommodate angular deviation of duct without tendon strands touching duct or coupler on either side of segment joint.

8. Ducts for prestressing, used exclusively for temporary erection PT that is to be removed from structure, are not required to be coupled across segment joints.

960-2.2.1.7 "O"-Rings:

1. "O"-rings with cross section diameters less than or equal to 0.25 inches and compression seals with thicknesses less than or equal to 0.25 inches for use with segmental duct couplers, anchorage caps and other similar components shall conform to the requirements of Table 960-3.

Table 960-3 "O"-Ring and Compression Seal Material Properties (cross section diameter or thickness ≤ 0.25 in)	
Mechanical Properties	
Shore hardness, ASTM D2240	50-75
Ultimate elongation %, ASTM D412	250% min.
Tensile strength, ASTM D412	1400 psi min.
Accelerated Testing	
Thermal Deterioration 70 hours @ 257° F, ASTM D573	
Change in tensile strength	± 30%
Change of elongation	-50%
Change of hardness	± 15 points
Compression Set Method B 22 hours @ 257° F, ASTM D395	50%
Volume change due to absorption of H_2O, Method D, for 70 hours @ 212°F, ASTM D 471	+ 10%
Environmental Resistance	
Ozone Resistance Exposure Method B, ASTM D1171 or Method B- Procedure B4, ASTM D1149	Pass
Low Temp. Non-brittle after 3 Min. @ -40°F, ASTM D2137	Pass

2. "O"-rings with cross section diameters greater than 0.25 inches and compression seals with thicknesses greater than 0.25 inches for use with segmental duct couplers, anchorage caps and other similar components, shall conform to the requirements in Table 960-3 with the additions and modifications in Table 960-4.

Table 960-4 "O"-Rings and Compression Seal Material Properties (cross section diameter or thickness > 0.25 in)
Mechanical Properties

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Shore hardness, ASTM D2240	30-60
Tensile strength, ASTM D412	600 psi min.
Compression Set Method B 22 hours @ 257° F, ASTM D395	60%

3. Compression Force - Maximum force to compress an “O”-ring or compression seal to its final compressed position shall not be greater than 25 psi times the area encircled by “O”-ring or seal.

4. Voided Area - Compression seals must accommodate material flow within its own cross sectional area by using a hollow or voided design.

960-2.2.1.8 Heat Shrink Sleeves:

1. Heat shrink sleeves shall have unidirectional circumferential recovery and be sized specifically for the duct size being coupled.

2. Use sleeves with a crosslinked polymer, typically polyolefin backing for grouted applications and sleeves with a high-density polyethylene or polypropylene backing for flexible filler applications.

3. Use adhesive with the same bond value to steel and high-density polyethylene or polypropylene materials.

4. Heat shrink sleeves shall have an adhesive layer that meets the requirements of the following table:

Table 960-5
Heat Shrink Sleeve Adhesive Layer Minimum Requirements

Property	Test Method	Minimum Requirements	
		Grouted Applications	Flexible Filler (Internal and External Applications)
Softening Point	ASTM E28	162ºF	256ºF
Lap Shear at 73ºF	ISO 21809-3	87 psi	44 psi
Tensile Strength	ASTM D638	2,900 psi	3,190 psi
Hardness	ASTM D2240	46 Shore D	55 Shore D
Elongation	ASTM D638	600%	600%
Volume Resistivity	ASTM D257	3.9 x 10^16 ohm-inch	3.9 x 10^16 ohm-inch
Adhesion Strength at 73ºF	ISO 21809-3	5-20 lbf/inch	28 lbf/inch
Impact Resistance	ISO 21809-3	Pass	15 J
Indentation Resistance	ISO 21809-3	Pass	0.026 inch
Cathodic Disbondment @ 73ºF, 28 days	ISO 21809-3	0.5 inch*radian	< 0.4 inch
Backing Thickness	-	0.025 inch	0.035 inch
Adhesive Thickness	-	0.035 inch	0.055 inch
Operating Temperature	-	122°F	212°F

5. Install heat shrink sleeves using procedures and methods specified in the manufacturer’s instructions.

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6. Do not use heat shrink sleeves with properties meeting the requirements for grouted applications for applications using flexible filler.

7. Do not use heat shrink sleeves with properties meeting the requirements for flexible filler applications for applications using grout.

960-2.2.2 Attachments:

960-2.2.2.1 Anchorage Caps:

1. Provide permanent anchorage caps made of stainless steel, nylon, polyester, or Acrylonitrile Butadiene Styrene (ABS).

2. Seal Anchorage cap with "O"-ring seals or precision fitted flat gaskets placed against the bearing plate.

3. Provide holes of 3/8 inch minimum diameter at the top and bottom of the cap. The holes must be suitable for filler venting, draining water, and inspection of the content inside the anchorage cap from the top, bottom or front of the anchorage cap as appropriate (e.g. anchorage caps not accessible from the front after filler injection must have a vent at the top of the cap). Anchorage caps may be fabricated with top/bottom holes on both the front face and outside perimeter the cap to facilitate venting, draining, and inspection.

4. Anchorage caps shall have a minimum pressure rating of 150 psi.

5. Stainless steel bolts shall be used to attach cap to anchorage.

6. Certified test reports documenting steel chemical analysis shall be submitted when stainless steel anchorage caps are used.

960-2.2.2.2 Inlets, Outlets, Drains, Ports, Valves, and Plugs:

1. Provide permanent inlets, outlets, drains, ports, valves, and threaded plugs made of nylon, high-density polyethylene or polypropylene materials, or stainless steel.

2. For unbonded post-tensioning systems using flexible filler, provide permanent inlets, outlets and drains made from steel. Provide temporary inlets, outlets, drains and valves made from brass or steel.

3. All inlets, outlets, drains and ports shall have pressure rated mechanical shut-off valves or plugs. Mechanical shut-off valves must be 1/4 turn ball valves.

4. Inlets, outlets, drains, ports, valves, and plugs shall have a minimum pressure rating of 150 psi.

5. Inlets, outlets and ports shall have a minimum inside diameter of 3/4 inches for strand and 3/8 inches for single bar tendons and four-strand ducts.

6. Drains shall have a minimum inside diameter of 3/8 inches. Locate drains, and inlets and outlets serving as drains, at the bottom of the duct cross section.

7. Specifically designate temporary items, not part of the permanent structure, on the PT system shop drawings.

960-2.3 Steel Reinforcing:

960-2.3.1 Mild:

1. Reinforcing steel shall conform to Section 415 and Section 462.

2. Test typical local zone reinforcement for compliance with AASHTO LRFD Bridge Design Specifications and AASHTO LRFD Bridge Construction Specifications, as applicable. Include reinforcement details in the PT system shop drawings submitted for approval.

960-2.3.2 Prestressing:

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960-2.3.2.1 Strand: Prestressing strands shall be in accordance with Section 933.

960-2.3.2.2 Bar:

1. Prestressing bars shall be in accordance with Section 933.
2. Bar couplers shall be in compliance with AASHTO LRFD Bridge Design Specifications and AASHTO LRFD Bridge Construction Specifications.
3. Test bar couplers in accordance with AASHTO LRFD Bridge Construction Specifications or the European Assessment Document Post-Tensioning Kits for Prestressing of Structures (EAD 160004-00-0301, September 2016 Edition). For bar couplers that will be used for tendons with flexible filler, test bar couplers in accordance with the EAD 160004-00-0301 Section C.3 Resistance to Fatigue.
4. Use only spherical nuts to anchor bars at bearing plates.

960-2.4 PT System Materials:

1. Use material specifications in this Section for all PT system components and subcomponents.
2. Use only virgin material for all non-ferrous components.
3. Test only samples taken from finished product as applicable.

960-2.4.1 Nylon: Use one of the following cell classes according to ASTM D5989:

1. S-PA0141 – weather resistant.
2. S-PA0231 – heat stabilized.
3. S-PA0401 – ultimate strength not less than 10,000 psi with UV stabilizer added.

960-2.4.2 Stainless Steel: Conform to the following:

1. ASTM A240 Type 316 - for metallic components other than bolts.
2. ASTM F593 Type 316 - for bolts.

960-2.4.3 Polypropylene: Conform to all of the following:

1. Non-colored, unfilled polypropylene according to ASTM D4101 with a cell class range of PP0340B44541 to PP0340B67884.
2. Contains antioxidants with a minimum Oxidative-Induction Time (OIT) according to ASTM D3895 of not less than 20 minutes.
3. Contains a non-yellowing light stabilizer.
4. Remolded finished material has a minimum failure time of 100 hours when tested for stress crack resistance using ASTM F2136 at an applied stress of 600 psi.

960-2.4.4 High-density Polyethylene: Conform to all of the following:

1. Smooth pipe is to meet the requirements of ASTM D3350 with a minimum cell class of 445574C. All other HDPE components are to meet the requirements of ASTM D3350 with the values of the first four digits of the cell class meeting a minimum of 4455, be composed of a resin listed in the Plastic Pipe Institute's Technical Report 4 for Hydrostatic design basis and have a code letter designation of "C" per ASTM D3350.
2. Contains antioxidants with a minimum Oxidative-Induction Time (OIT) according to ASTM D3895 of 40 minutes.
3. Remolded finished material has a minimum failure time of 24 hours when tested for stress crack resistance using ASTM F2136 at an applied stress of 600 psi.

960-2.4.5 Elastomer Sleeves: Conform to all of the following:

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1. Meet requirements of ASTM D1171 using Ozone Chamber Exposure Method B (no cracks permitted under 2X magnification) or ASTM D1149 Method B- Procedure B4 (no cracks permitted under 2X magnification). Do not include polyester reinforcement in the test specimen.

2. Manufactured using an elastomeric polymeric material that is compatible with concrete, the PT system components to which the sleeves will be attached, and the filler material and filler material installation process. Identify the applicable ASTM specifications that the sleeve material complies with.

960-3 System Approval Requirements.

960-3.1 Independent Testing: Use independent laboratories meeting the credentials described in this Section to perform all testing, other than field testing, and to submit certified test reports for materials and components. Certification may be performed by a qualified independent laboratory outside of the United States, only if the facility is pre-approved by the State Materials Office.

Conform all testing procedures used for materials or components to applicable American Society of Testing and Materials (ASTM) and International Federation of Structural Concrete (fib) Specifications or as modified in this Section.

960-3.1.1 Material Laboratory: Test plastic components in a certified independent laboratory accredited through the laboratory accreditation program of the Geosynthetic Accreditation Institute (GAI), the American Association for Laboratory Accreditation (A2LA) or qualified by an ISO 17025 accreditation agency using personnel with documented experience running the required test methods.

960-3.1.2 Component and System Laboratory: Test individual components and the PT system as a whole witnessed by and/or performed in a certified independent laboratory audited by the AASHTO Materials Reference Laboratory (AMRL), or with an AASHTO R18 Accreditation as set forth by the AASHTO Highway Subcommittee on Materials or qualified by an ISO 17025 accreditation agency using personnel with documented experience running the required test methods.

960-3.1.3 System Testing: In lieu of performing PT system tests witnessed by and/or performed in a certified independent laboratory, the PT system tests may be performed at the project site and witnessed by the Engineer.

960-3.2 Testing Requirements:

960-3.2.1 Component and System Tests: Corrugated duct, smooth duct and all associated components that are used for both internal and external PT systems, e.g. couplers, anchorages, inlets, outlets, drains, ports, valves, plugs, etc., shall meet the requirements of fib Technical Report Bulletin 75 titled, Polymer-Duct Systems for Internal Bonded Post-Tensioning, Performance Level 2 (PL2), with modifications as shown in Table 960-6.

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Table 960-6 Required Component and System Tests					
Reference to fib Bulletin 75			Required Tests for each PT System Type[1]		
Procedures	Appendix	Test Description	Internal PT System with Grout	Internal PT System with Flexible Filler	External PT System with Flexible Filler
Component Assessment	A.1	Dimensional requirement	Yes	No	No
	A.2	Stiffness of duct	Yes[2]	No	No
	A.3	Longitudinal load resistance	Yes	Yes	Yes
	A.4	Lateral load resistance	Yes	No	No
	A.5	Flexibility of duct system	Yes	Yes	No
	A.6	Leak tightness of duct system	Yes	Yes	No
	A.7	Concrete pressure on duct	Yes[3]	No	No
	A.8	Wear resistance of duct	Yes	No	No
	A.9	Wear resistance of duct under sustained load	Yes	No	No
	A.10	Bond behavior of duct	Yes	No	No
	A.11	Precast segmental duct coupler system	Yes[4]	Yes[4]	No
	A.12	Fracture resistance of duct	No	No	No
System Assessment	B.1	Leak tightness of anchorage-duct assembly	Yes[5]	Yes[5]	Yes[5]
	B.2	EIT performance of duct system	No	No	No
	B.3	EIT performance of anchorage-duct assembly	No	No	No
	B.4	Full scale duct system assembly	Yes[5][6]	Yes[5][6]	Yes[5][6]
	B.5	Leak tightness of assembled duct system	Yes[5][6]	Yes[5][6]	No

(1) Yes = Test is required; No = Test is not required.
(2) Do not preload strand into duct prior to testing.
(3) Identify duct as meeting Performance Class I or II criteria.
(4) Use an epoxy compound meeting the requirements of Section 926, Type AB.
(5) Perform tests on the largest assembly and the smallest assembly for each family of PT systems. A family of PT systems is defined a group of PT strand/bar assemblies of various sizes using common anchorage devices and design.
(6) For each test, use a PT system assembly consisting of at least one of each component and connection type required to install a tendon from anchorage cap to anchorage cap. For bar tendon systems, use between 15 and 50 feet of duct with a straight profile.

960-3.2.2 Filler Containment Assembly Pressure Test: In addition to the other testing specified in this Section, test all filler containment assemblies, i.e., anchorages, anchorage caps, inlets, outlets, drains, ports, valves, plugs, etc., for all system sizes as follows:

1. Assemble the anchorage and anchorage cap with all required filler injection attachments.
2. Seal the opening in the anchorage where the duct/trumpet connects.
3. Condition the assembly by maintaining a pressure of 150 psi in the system for three hours.

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4. After conditioning, lock off the air supply to the assembly.

5. After lock off, the assembly must sustain 150 psi internal pressure for five minutes with no more than 15 psi, or 10%, reduction in pressure.

This test may be combined with the External Duct Systems Pressure Test for external PT systems.

960-3.2.3 External PT Systems Pressure Test: In addition to the other testing specified in this Section, test all sizes of external PT systems as follows:

1. Prepare a system assembly consisting of at least one of each component and connection type required to install a tendon from anchorage cap to anchorage cap using between 15 and 50 feet of duct with a straight profile.

2. Condition the assembly by maintaining a pressure of 100 psi in the system for three hours.

3. After conditioning, lock off the air supply to the assembly.

4. After lock off, the assembly must sustain 100 psi internal pressure for five minutes with no more than 10 psi reduction in pressure.

960-3.2.4 Vacuum Test for Internal and External PT Systems with Flexible Filler: In addition to the other testing specified in this Section, test all sizes of internal PT systems with flexible filler and all external PT as follows:

1. Prepare a system assembly consisting of at least one of each component and connection type required to install a tendon from anchorage cap to anchorage cap using between 15 and 50 feet of duct Do not cast any component into concrete.

2. Condition the assembly by maintaining a 90% vacuum in it for 1 hour.

3. After conditioning, lock off the air supply to the assembly.

4. After lock off, the assembly must sustain a 90% vacuum for 5 minutes with no more than a 10% loss of vacuum.

960-3.3 Standard Tendon Sizes: Develop and test PT systems for the sizes and types shown in the Contract Documents.

960-3.4 System Modifications: Contact the Engineer for direction before changing any materials or components of a PT system that has been approved by the Engineer for use on the project. Repeat all appropriate material, component, and entire system tests if the manufacturer and/or model of any major component, as defined in 960-2, is modified or replaced, excluding local zone reinforcement.

960-3.5 Component Samples: Furnish all required material samples to laboratories for testing and to the Department as requested, at no cost to the Department.

960-3.6 Calculations, Shop Drawings, Test Reports, and Certification: Show fully detailed shop drawings of all component configurations, connections, anchorages, inlets, outlets, drains, high point inspection port details, anchorage inspection details, permanent anchorage caps, application limits of the PT system, and installation procedures of components. On the first page of each PT system shop drawing set, provide a list of all system components in tabular format that includes the following information, at a minimum: part/item number, description, material, manufacturer and model. The manufacturer need not be identified for common off-the-shelf accessories as defined in 960-2. Submit details of typical local zone reinforcement in the PT system shop drawings signed and sealed by a Specialty Engineer. Indicate that all major PT system components, as defined in 960-2, are stamped with the following:

1. Manufacturer’s name

2. Trademark model number

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3. Size corresponding to catalog description on PT system drawings.

For each PT system, submit a package that includes calculations, shop drawings, test reports, proof of current laboratory accreditations, and all material and component certifications required throughout this Section. Proof of current laboratory accreditation must specifically indicate applicable accreditation categories related to PT systems.

Include a cover letter with the package signed by an officer of the PT system supplier (vendor) certifying that:

1. The submitted PT system, as a whole and all of its individual components, meet or exceed all material and component/system requirements of this Section, as demonstrated by the submittal.

2. All testing required by this Section was performed as defined in 960-3.1 and that all tests were performed to applicable ASTM and fib Specifications.

3. The PT system meets the requirements of Section 462.

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SECTION 962
STRUCTURAL STEEL AND MISCELLANEOUS METAL ITEMS (OTHER THAN ALUMINUM)

962-1 General.

This Section covers the material and fabrication requirements for structural steel and miscellaneous metal components. All steel must be melted and manufactured in the United States and meet Section 6-5.2. All overhead cantilevers, monotubes, trusses and gantries, and bridge components (including steel castings, steel forgings, and bearing material) supplied under this Specification shall be from producers currently on the Department's Production Facility Listing. Producers seeking inclusion on the Department's Production Facility Listing must meet the requirements of Section 105. Provide certifications that meet the applicable section and 962-12.

962-2 Structural Steel.

962-2.1 Structural Steel Materials: Provide structural steel for bolted or welded construction that meets the requirements of Table 962-1.1 and 962-1.2 when impact testing is specified. Grade HPS 70W shall not be substituted for Grade HPS 50W. Weathering steel shall not be substituted for non-weathering steel without Engineer approval.

Do not apply heat treatment unless approved by the Engineer. When galvanizing is specified, provide galvanizing in accordance with 962-11.1.

Table 962-1
Structural Steel Materials

Product	ASTM	Grade/Style	Reportable Properties	Supplementary Requirements
Plate	A709	36	Composition, Yield Strength, Tensile Strength, Elongation, Killed	None
		50		
		50S		Carbon Equivalency
		50CR		Heat-treating temperatures
		50W	Composition, Yield Strength, Tensile Strength, Elongation, Killed, Fine Grain	Corrosion Resistance Index
		HPS 50W		Corrosion Resistance Index, Heat Treatment Temperatures
		HPS 70W		

962-2.2Impact Requirements: Structural steel subject to tensile stress for main load-carrying members shall meet the impact requirements listed in Table 962-2. Mill test reports shall identify average impact test values. Provide certifications that meet this section and 962-12.

For non-fracture and fracture critical tension components, provide structural steel in accordance with ASTM A709.

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Table 962-2 Requirements for Impact Testing Structural Steel					
Product	ASTM	Grade	Zone	Minimum Average Energy (ft*lbf)	
				Non-Fracture Critical	Fracture Critical
Structural Steel	A709	36	1	15 at 70°F	25 at 70°F
		50 50W 50S		15 at 70°F (≤ 2.0”t) 20 at 70°F (> 2.0”t)	25 at 70°F (≤ 2.0”t) 30 at 70°F (> 2.0”t)
		50CR		15 at 70°F	25 at 70°oF
		HPS 50W		20 at 10°F (≤ 2.0”t) 25 at 50°F (> 2.0”t)	30 at 10°F (≤ 2.0”t) 35 at 50°F (> 2.0”t)
		HPS 70W		25 at -10°F	35 at -10°F
Structural Steel Tubing	A500	B, C, D		15 at 70°F	25 at 70°F
	A501	A, B			
	A847	Round, Square, Rectangle, Special			
Note: If yield ≥15 ksi above specified grade, test temperature must drop 15°F for each 10 ksi above grade.					

962-3 Steel Castings.

Provide carbon steel and corrosion resistant castings in accordance with this section and Table 962-3.

962-3.1 Carbon Steel Castings: Perform heat treatments by annealing, normalizing, normalizing & tempering, or quenching & tempering after castings have been allowed to cool from the pouring temperature to below the transformation temperature range as regulated by the use of pyrometers. Class 1 castings shall be used if post-weld heat treatment is specified in the contract documents.

962-3.2 Corrosion Resistant Steel Castings:

Perform heat treatments by air cooling and tempering; or annealing as defined in ASTM A743 Table 1.

Table 962-3 Requirements for Steel Castings					
Product	Standard	Grade	Class	Reportable Properties	Supplementary Requirements
Carbon Steel	ASTM A27	65-35, 70-36	1, 2	Composition, Tensile, Class	None
Corrosion Resistant Steel	ASTM A743	CA 15M	All	Composition, Heat Treatment	S11, S12
	AASHTO M 163				

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962-4 Steel Forgings.

Provide carbon steel and alloy steel forgings from which pins, rollers, trunnions, shafts, gears, or other forged parts are fabricated in accordance with this section and Table 962-4.

The manufacturer may elect to choose from any of the class specific heat treatments identified in the Table 962-4, provided that the controlling cross-sectional thickness meets mechanical property test requirements. Retreatment by re-austenitizing a lot is allowed up to three times when the mechanical properties have not been met. Re-testing of the mechanical properties is required on any lot subject to retreatment.

Table 962-4
Requirements for Steel Forgings

Product	Standard	Class	Reportable Properties	Supplementary Requirements
Steel Forgings	ASTM A668	C, D, F, G	Composition, Tensile, Yield, Elongation, Hardness	S7
	AASHTO M 102			

962-5 Iron Castings.

Provide iron castings that conform to the requirements of this section and Table 962-5. When galvanizing is specified in the contract, galvanize in accordance with 962-11.

962-5.1 Gray Iron Castings: Provide gray iron castings that conform to the requirements of this section and Table 962-4. AASHTO HL-93 load testing may be substituted for tensile testing when specified in the contract documents. When Alternative G castings are specified, provide a composition that precludes the possibility of embrittlement during the normal thermal cycle of hot-dip galvanizing.

962-5.2 Ductile Iron Castings: Perform full ferritizing anneal to remove carbides or stabilized pearlite. AASHTO HL-93 load testing may be substituted for tensile testing when specified in the contract documents.

962-5.3 Malleable Iron Castings: Perform heat treatments in the same production furnace and in the same cycles as the castings they represent. Produce a microstructure consisting of temper carbon nodules distributed through a ferritic matrix and free of excessive pearlite, massive carbides, and primary graphite. When critical sections of the production castings differ appreciably from that of the central portion, the time cycle for tempering may be altered from that of the production lot in order to obtain similar microstructures, or hardness, or both.

When Alternative G castings are specified, provide a composition that precludes the possibility of embrittlement during the normal thermal cycle of hot-dip galvanizing, or provide heat treatment that immunizes the casting against embrittlement during the normal thermal cycle of hot-dip galvanizing.

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Table 962-5 Requirements for Iron Castings				
Product	Standard	Grade/Class	Reportable Properties	Supplementary Requirements
Gray Iron Traffic Service	AASHTO M 105 & AASHTO M 306	35B	Tensile*	None
Gray Iron Machinery	AASHTO M 105	30	Tensile	None
Ductile Iron	ASTM A536	60-40-18	Tensile*, Yield, Elongation, Heat Treatment	Additional Tensile test for castings > 1,000 lbs.
Malleable Iron	ASTM A47	30518 [24118]	Tensile, Yield, Elongation, Heat Treatment	None
*AASHTO HL-93 may be substituted for tensile testing of vaned gratings, when specified in the contract.				

962-6 Bolts, Nuts and Washers Not Designated as High-Strength.

Provide bolts, nuts, and washers not designated as high strength meeting the requirements listed in this Section and Table 962-6. When galvanizing is specified in the contract documents, provide galvanizing in accordance with 962-11.3.1.

Use double nuts, when ordinary rough or machine bolts are specified in the Contract Documents. Bolted assemblies shall be made of similar coating composition. When weathering material is used, provide the entire assembly in weathering steel. Bolts meeting the requirements of ASTM A193, washers meeting the requirements of ASTM F844 and nuts meeting the requirements of ASTM A194 or AASHTO M292 may be used with the Engineer's approval.

Table 962-6 Bolts, Nuts, and Washers Not Designated as High-Strength				
Product	Standard	Grade	Style	Reportable Properties
Bolts	ASTM A307	A, B	Heavy Hex, Threaded Rod	Size, Composition, Hardness, Tensile
	ASTM A449	1, 3	Hex, Threaded Stud	Size, Composition, Tensile, Proof Load, Hardness
	ASTM F593	Group 2 316 or 316L	Condition A CW1 or SH1	Alloy, Group, Condition
	ASTM A193*	B7, B16	Any	Size, Composition, Hardness, Heat

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Table 962-6 Bolts, Nuts, and Washers Not Designated as High-Strength				
Product	Standard	Grade	Style	Reportable Properties
				Treatment, Macroetch results
Nuts	ASTM A563	A	Hex	Size, Composition, Proof Load, Hardness
		C, C3, DH, DH3	Heavy Hex	
	ASTM F594	Group 2 316 or 316L	CW	Alloy, Group, Condition
	ASTM A194*	2, 2H	Hex, Heavy Hex	Composition, Hardness, Proof Load
	AASHTO M 292*	2, 2H	Hex, Heavy Hex	Size, Composition, Hardness, Heat Treatment, Macroetch results
Washers	ASTM F436	1, 3	Circular, Beveled, Clipped, Extra Thick	Size, Hardness
	N/A	316 or 316L	Any	Alloy, Size
	ASTM F844*	Plain	Round, Miscellaneous	Size
	ASTM A36	All	N/A	Killed, Thickness
Shims	ASTM A1011	Any	Any	None
	ASTM A109	Any	Any	None
	ASTM B36	Brass	Any	None

962-7 High-Strength Bolts, Nuts, Washers and Direct-Tension-Indicator (DTI) Devices.

Provide high-strength bolts, nuts, washers and DTI devices in accordance with this Section and Table 962-7. High-strength bolts shall have identifying marks meeting ASTM F3125 Table 2 and ASTM A563. High-strength bolted assemblies shall be made of similar coating composition. When galvanizing is specified in the contract documents, provide galvanizing in accordance with 962-11.3.2. Bolts meeting the requirements of ASTM F3125 Grade A490, washers meeting the requirements of ASTM F844, and nuts meeting the requirements of ASTM A194 or AASHTO M 292 may be used with the Engineer's approval.

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Table 962-7 Requirements for High-Strength Steel Fastener Assemblies					
Products	Standard	Grade	Type/ Style	Reportable Properties	Supplementary Requirements
Bolts	ASTM F3125	A325	Heavy Hex	Size, Composition, Tensile, Proof Load, Hardness,	None
		A490*		Size, Composition, Tensile, Proof Load, Hardness, Magnetic Particle, Carburization/ Decarburization	
	ASTM A193	B7, B16	Any	Size, Composition, Hardness, Heat Treatment, Macroetch results	S5
Nuts	ASTM A563	DH, DH3	Heavy Hex	Size, Composition, Proof Load, Hardness	S1, S2 min. 89 HRB or 180 HB
	ASTM A194*	2H	Heavy Hex	Size, Composition, Hardness	Max HRC32
	AASHTO M 292*	2H	Heavy Hex	Size, Composition, Hardness, Heat Treatment, Macroetch results	Max HRC32
Washers	F436	Circular, Beveled, Clipped, Extra Thick	1, 3	Size, Hardness	None
	F844*	Round, Miscellaneous	Plain	Size	None
	ASTM A709	36, 50	Any	Yield, Tensile, Elongation, Killed	None
DTI Devices	F959	A325	1	Size, Composition, Compression Load, Hardness	None
			3	Size, Composition, Compression Load, Hardness, Corrosion Resistance Index	
*Requires Engineer Approval.					

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962-8 Anchor Rods and Bridge Bearing Materials.

962-8.1 Bearing and Masonry Plate: Meet the requirements of Table 962-8. Masonry plates and bearings shall be welded in accordance with AASHTO/AWS D1.5 Bridge Welding Code. When galvanizing is specified meet the requirements of 962-11.1.

Table 962-8
Requirements for Bearings and Masonry Plate

Product	ASTM	Grade	Style	Reportable Properties	Supplementary Requirements
Plate	A709	50W	All	Yield, Tensile, Elongation, Killed, Fine Grain	Corrosion Resistance Index
Laminates	A240	316	Gage 16	Yield, Tensile, Elongation, Hardness	None
	A1011	36	HSLAS, Class 1	Designation, Style	None
	A36	All	All	Yield, Tensile, Elongation, Killed	None

962-8.2 Anchor Rods and Bearing Hardware: Provide anchor rods and other bearing hardware in accordance with this section and Table 962-9. All fastening components shall be made of similar composition. When galvanizing is specified in the contract documents, provide galvanizing in accordance with Section 962-11.3.1. Anchor rods meeting the requirements of ASTM A307, washers meeting the requirements of ASTM F844, and nuts meeting the requirements of ASTM A194 may be used with the Engineer's approval.

Table 962-9
Requirements for Anchor Rods and Bearing Hardware

Product	ASTM	Grade	Style	Reportable Properties	Supplementary Requirements
Bolts	F1554	36	Threaded Rod	Lot, Size, Tensile	None
		55		Lot, Size, Tensile, Carbon Equivalency	S1
		105		Lot, Size, Tensile, Carbon Equivalency	S3
	A307*	A, B	Threaded Rod	Size, Composition, Hardness, Tensile	S1
Nuts	A563	DH	Heavy Hex	Size, Composition, Proof Load, Hardness	None
	A194*	2H	Heavy Hex	Size, Composition, Hardness	None
Washers	F436	1, 3	Circular, Beveled,	Size, Hardness	None

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Table 962-9 Requirements for Anchor Rods and Bearing Hardware					
Product	ASTM	Grade	Style	Reportable Properties	Supplementary Requirements
			Clipped, Extra Thick		
	F844*	Plain	Round, Miscellaneous	Size	None
Plate	A36	All	All	Yield, Tensile, Elongation, Killed	None
Shim	A653	All	Min. G30	Grade	None
	A1008 A36	All	A153, F2329	None	None
*Requires Engineers Approval.					

962-9 Overhead Signs.

Provide overhead sign materials in accordance with this section Table 962-2, and Table 962-10. When galvanizing is specified, meet the requirements of 962-11.1. Produce welds using E7018 electrode, in accordance with AWS D1.1 Structural welding Code.

Table 962-10 Requirements for Overhead Signs					
Product	Standard	Grade	Type/ Style	Reportable Properties	Supplementary Requirements
Upright Pipe	API 5L	X42R, X42N, X42M, X46N, X46M, X52N, X52M, X56N, X56M, X60N, X60M, X65M, X70M	PSL2	Killed, Fine Grain, Tensile, CVN Test	N/A
	A500	B, C	Round Structural	Composition, Yield, Tensile, Elongation	UT Seam Weld, (per API 5L) CVN Test per 962-2
Chords	A500	B, C	Round Structural	Composition, Yield, Tensile, Elongation	N/A
Plate, Angles &	A709	50	Plates & Shapes	Composition, Yield, Tensile, Elongation	N/A
	A36	36			Yield > 50ksi

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Table 962-10 Requirements for Overhead Signs					
Product	Standard	Grade	Type/ Style	Reportable Properties	Supplementary Requirements
Handhole Frame					
Poles	A1011	50, 55, 60, 65	Any	Designation, Grade	N/A
	A572	50, 55, 60, 65	1, 2, 3, 5	Composition, Tensile, Type, Killed	N/A
	A595	A, B	Any	Composition, Tensile, Type, Killed	N/A

962-10 Miscellaneous Metal Items.

962-10.1 General: Unless otherwise specified in the contract documents, provide miscellaneous metal components in accordance with this section and Table 962-11, Table 962-12, Table 962-13, or Table 962-14. Structural tubing subject to tensile stresses, as defined in Section 460, shall meet Table 962-2.2 for tension components, Zone 1. Welding shall be done in accordance with the most current AWS D1.1 structural welding code. When galvanizing is specified in the contract documents, provide galvanizing in accordance with the contract documents.

Requirements for concrete reinforcement are contained in Section 931.

Requirements for steel guardrail are contained in Section 967.

Table 962-11 Requirements for Miscellaneous Metals				
Product	Standard	Grade	Type/ Style	Reportable Properties
Steel Sheet Piling	A328	All	Cold Rolled, Heat Treated	Composition, Tensile, Killed
	A572	42, 50, 55, 60, 65	1, 2, 3, 5	Composition, Tensile, Size, Killed
	A690	All	All	Composition, Tensile, Killed
Steel Pipe Piling	A252	3	All	Composition, Tensile, Size
	API 5L	X46, X52, X56, X60, X65, X70	PSL1	Tensile
			PSL2	Killed, Fine Grain, Tensile
Structural Tubing	A500	Round	B, C	Composition, Tensile, Flattening Test, Impact (Zone 1), Size
		Shaped		Composition, Tensile, Impact (Zone 1), Size
	A501	Square, Round, Rectangular, Special	A, B	Composition, Tensile, Impact (Zone 1), Size

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Table 962-11 Requirements for Miscellaneous Metals				
Product	Standard	Grade	Type/ Style	Reportable Properties
	A847	Round	Welded, Seamless	Composition, Tensile, Flattening, Impact (Zone 1), Size
		Square, Rectangle, Special	Welded, Seamless	Composition, Tensile, Impact (Zone 1), Size
Pipe Railing	A53	A, B	E, S	Composition, Mechanical Testing (Tensile, Bend, Flattening), Size

962-10.2 Field Splice Filler Materials: Provide field splice filler materials in accordance with the contract documents. If unspecified and less than 3/16 inches thick filler splice materials in accordance with this section and Table 962-12. Filler plates may also meet the appropriate grades specified in 962-2. When galvanized plate is specified, galvanize material in accordance with 962-11

Table 962-12 Requirements for Field Splice Filler Materials				
Product	Standard	Grade	Type/ Style	Reportable Properties
Filler Sheet	A1011	50	HSLAS, Class 1	Designation, Grade

962-10.3 Fencing Material: Provide fencing materials in accordance with this Section and Table 962-13. When galvanizing is specified, provide galvanizing in accordance with the contract documents.

Table 962-13 Material Requirements for Fencing				
Product	Standard	Grade / Type	Style	Reportable Properties
Fabric	A116	60	No. 9	Breaking Strength, Coating Weight
		175	No. 12-1/2	
	A584	175	No. 12-1/2	
	M181	1, 2, 4	No. 9	
	A392	All	No. 9	
	A491	All	No. 9	
	F668	All	No. 9	
Posts	A702	50	Carbon, Rail	Tensile or Hardness
Pipe, Tube	A53	A, B	E, F, S	Grade, Finish
	F1083	Schedule 40	High Strength	Schedule

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Table 962-13 Material Requirements for Fencing				
Product	Standard	Grade / Type	Style	Reportable Properties
	F1043	1C	All	Group, Coating, Type
		1A	High strength	
Beam	A36	36	All Shapes	Grade, Killed
	A572	42		
	A992	50		
Sheets	A1011	36, 45, 50	HSLAS, HSLAS-F, SS	Designation, Style

962-10.4 Steel Grates: Provide steel grating in accordance with this section and Table 962-14. When vaned gratings are specified, AASHTO HL-93 load testing may be substituted for tensile testing when specified in the contract documents. When Alternate G is specified, provide galvanizing in accordance with 962-11.1.

Table 962-14 Requirements for Steel Grating				
Product	Standard	Grade	Type/ Style	Reportable Properties
Steel Grating	A242	50	1	Composition, Tensile*, Killed
	A572		1, 2, 3, 5	Composition, Tensile*, Size, Killed
	A588		A, B, K	Composition, Tensile*, Fine Grain
	A1011	Any	SS, HSLAS, HSLAS-F	Designation, Style
* AASHTO HL-93 may be substituted for tensile testing for vaned gratings when specified.				

962-11 Galvanizing.

962-11.1 Plates, Structural Shapes, Bars, and Strip: When galvanizing is specified in the Contract Documents for ferrous metal products, provide galvanizing in accordance with the requirements of ASTM A123 or AASHTO M111. Zinc composition shall meet “Intermediate Grade” in accordance with ASTM B6 and Table 962-15.

Table 962-15 Requirements for Galvanizing Bath Composition			
Product	Zinc (Zn)	Lead (Pb)	Tin (Sn)
Galvanizing Bath	≥ 99.00%	≤ 0.50%	≤ 0.10%

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962-11.2 Castings: When Alternative G castings are specified in the contract documents, provide galvanizing in accordance with the requirements of ASTM A123 or AASHTO M111. Zinc composition shall meet 962-11.1.

962-11.3 Fasteners and Hardware:

962-11.3.1 Fasteners and Hardware Designated Not High-Strength: When zinc coating is required in the contract documents provide galvanizing of steel or malleable iron in accordance with the requirements of ASTM A153.

962-11.3.2 Fasteners and Hardware Designated as High-Strength: When zinc coating is required in the Contract Documents, provide galvanizing in accordance with Table 962-16. Coating of ASTM F3125, A490 bolts is prohibited. Bake all hot dipped or electroplated bolt, rod, or bar with a tensile strength greater than or equal to 150 ksi to remove any residual hydrogen.

Table 962-16
Coating Requirements for Fastener and Hardware Designated as High-Strength

Product	ASTM	Grade	Type/Style	Coating Finish
Bolts	F3125	A325	1	ASTM B695, Class 55 ASTM F2329
		A490	All	Do Not Galvanize
Anchor Rods	F3125	A325	1	ASTM B633 SC 3, Type II
		A490	All	Do Not Galvanize
	F1554	105	All	ASTM B633 SC 3, Type II
Anchor Rods	F1554	36, 55	All	ASTM B695 Class 55 ASTM F2329
Nuts	A563	A, C, D, C3, DH, DH3	Hex, Heavy Hex	
	A194	1, 2	All	
Washers	F436	Circular, Beveled, Clipped, Extra Thick	1	
	F844	Round, Miscellaneous	A	
DTI Devices	F959	A325	1	

962-12 Certifications and Verification.

962-12.1 General: Provide certifications for steel directly from the Mill. Mill certifications shall show compliance to the specification and include the reportable properties and supplementary requirements from the applicable sections listed above.

When secondary processing, or testing has occurred, in addition to the mill certificate, provide a certified mill analysis signed by a quality control representative that show compliance with and the test results of the applicable sections listed above.

When material meeting “Buy America” is specified, the mill certification or certified mill analysis shall identify that the included material meets the Source of Supply-Steel requirements in Section 6.

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SECTION 965
GENERAL PROVISIONS FOR ALUMINUM ITEMS (INCLUDING WELDING)

965-1 General.

This Section covers the material and fabrication requirements for aluminum components. Provide aluminum light poles and Gantry J-arms from Producers who are approved in one of the following fabrication categories:

1. American Institute of Steel Construction, Highway Component Manufacturer
2. American Welding Society, Certified Welding Fabricator
3. Canadian Welding Bureau, Fusion Welding of Aluminum (W47.2).

965-2 Fabrication.

Provide fabricated components in accordance with AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, the Design Plans, and this section. Verify the strength of each Lot by tensile test. Alternate testing will not be accepted. Protect against damage and marring during transit and delivery. Provide an anodic coating (minimum 0.0002 inch) and chromate seal all hardware.

An American Welding Society certified welding inspector must visually inspect all welds for final approval. A certifying statement from the welding inspector must be provided with the component. The document must identify the project information, date of inspection, welding inspector name, and inspector certification number.

Table 965-1
Material Requirements for Aluminum Components

Product	Test Method	Alloy/Temper	Reported Properties
Pole, Arm, Extrusions	ASTM B221	6061-T6	Alloy, Temper, Thickness, Tensile Strength
		6063-T6	
Pedestal, Posts	ASTM B429	6061-T6	
Bars, Plates, Stiffeners, Backing Ring, Shims, Shapes	ASTM B221	6063-T6 6061-T6	
	ASTM B209	6061-T6	
	ASTM B308		
Railing	ASTM B221	6351-T5	
		6061-T6	
	ASTM B241		
	ASTM B210		
	ASTM B429		
J-Arm Tube	ASTM B429	6061-T6	
	ASTM B221		
J-Arm Connection Plate	ASTM B209	6061-T6	
Sheet	ASTM B209	6061-T6 5154-H38 5052-H38	
Structural Shapes	ASTM B308	6061-T6	

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Table 965-1 Material Requirements for Aluminum Components			
Product	Test Method	Alloy/Temper	Reported Properties
	ASTM B221		
Single Column Ground Sign Sand Castings	ASTM B26	A356-T6	
	ASTM B108	A356-T61	
Washers	ASTM B221	7075-T6 2024-T4	
Button Head or Flat Head Bolts	ASTM F468	2024-T4 6061-T6	S2 Lot Testing, Alloy, Temper
Hex Nuts	ASTM F467	6061-T6 6262-T9 2024-T4	S2 Lot Testing, Alloy, Temper

965-2.1 Light Poles: Provide aluminum lighting poles in accordance with this section and Table 965-1. Weld arms and poles in the T4 condition, using the filler metal ER4043, ER4047, ER5183, ER5356, or ER5556 in accordance with AWS D1.2 Aluminum Structural welding Code. Weld to castings in accordance with 965-2.3. Heat treat the arm and pole, until aged to the T6 condition. Transverse welds are only allowed at the base. Equip poles with a vibration damper, when specified in the contract documents.

Provide exterior surface with a clean, uniform silvery appearance, free of dark streaks and discoloration. Finish the pole and arm with a satin rubbed finish.

965-2.2 Overhead Sign Components: Provide aluminum toll gantry J-arms in accordance with this section and Table 965-1. Weld tube to plate connections in the T4 or T6 condition, using the filler metal ER4043, ER4047, ER5183, ER5356, or ER5556 in accordance with AWS D1.2 Aluminum Structural welding Code. Heat treat tube and plate in the T4 condition until aged to the T6 condition.

Provide exterior surface with a clean, uniform silvery appearance, free of dark streaks and discoloration.

965-2.3 Castings: Provide aluminum castings in accordance with this section and Table 965-1. Weld aluminum castings to itself or aluminum tube to castings using the filler metal ER4043, in accordance with AWS D1.2 Aluminum Structural welding Code. Heat treat the castings, until aged to the T6 condition.

965-2.4 Railing: Provide aluminum railing in accordance with this section and Table 965-1. Weld aluminum railing using the filler metal ER4043, ER4047, ER5183, ER5356, or ER5556 in accordance with AWS D1.2 Aluminum Structural welding Code.

965-2.5 Static Sign Assemblies: Provide aluminum sheet, plate, and structural shapes in accordance with this section and Table 965-1. Weld structural profiles to itself or aluminum components using ER4043, ER4047, ER5183, ER5356 or ER5556 in accordance with AWS D1.2 Aluminum Structural Welding Code. Heat treat the structural profiles, until aged to the T6 condition.

965-2.6 Transformer Bases (Excluding Lighting):

965-2.6.1 Product Acceptance: Manufacturers seeking evaluation of products for inclusion on the APL shall submit an application in accordance with Section 6 and include the following documentation, showing that the product meets the applicable requirements.

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Table 965-2 Submittal Compliance Requirements	
Documentation	Requirements
Certified Test Report	Shows that product meets Moment Capacity
Installation Instructions	Include installation instructions
Product Identification Photo	Display's the manufacturer's name or logo and the model number.
Product Photo	Displays the significant features of the product as required in this section.
Technical Data Sheet or Product Drawing	Uniquely identifies the product and includes product details, notes, material specifications, dimensions, and sizes meeting the specification

965-2.6.2 Physical Requirements: Meet the requirements of Table 965-3.

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Table 965-3 Physical Requirements for Transformer Base		
Feature	Requirement	Documentation
Height	Base is 12 to 18 inches in height	Technical Data Sheet or Product Drawing
Base Material	ASTM B26, 356 T6 or 319	Technical Data Sheet or Product Drawing
Threaded Hub	Hub located at the top for mounting a nominal 4-inch Schedule 40 (4-1/2-inch outside diameter) aluminum pole. The threaded hub must be tapped to allow full pole engagement.	Technical Data Sheet or Product Drawing
Fastening	Provides for fastening to a foundation with four 3/4-inch anchor bolts located 90 degrees apart. The base design must allow for bolts that are placed off-center.	Technical Data Sheet or Product Drawing
Door Size	Provides a door opening of not less than 8 inches by 8 inches.	Technical Data Sheet or Product Drawing
Door Material	The door must be constructed of fiberglass or other non-combustible, non-aluminum material.	Technical Data Sheet or Product Drawing
Door Attachment	Attach the door to the base with cleats and one stainless steel socket button head screw or by other means suitable for NEMA 3 electrical enclosures.	Technical Data Sheet or Product Drawing
Moment Capacity	Supports an ultimate moment capacity of 10,000 foot-pounds, without breaking, cracking or rupturing in any manner.	Certified Test Report
Breakaway	Meets the requirements in the AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.	FHWA Eligibility Letter.

965-3 Paint for Poles, Pedestals, and Posts.

Paint systems used on aluminum poles, pedestals, and posts shall meet the color requirements as specified in the Contract Documents. All paint systems shall possess physical properties and handling characteristics that are compatible with the application requirements of Section 646. Materials shall be specifically intended for use over aluminum. Paint systems shall exhibit no loss of adhesion or total color difference (ΔE^*_{ab}) greater than 8.0 units for five years after final acceptance as specified in 5-11. An aluminum pole, pedestal, post, or sign panel that exhibits a cumulative surface area of delamination in excess of 50 square inches will constitute an adhesion failure. Delamination shall be defined as any area of exposed metal surface subsequent to hand tool cleaning. A ΔE^*_{ab} value exceeding 8.0 units per the International Commission on Illumination L*a*b* 1976 (CIELAB) space and color difference formula, measured in accordance with ASTM D2244, will constitute a color retention failure.

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The Department will measure and enter in the Department's database the CIELAB color chromaticity coordinates for the color of the top coat of sample coupons provided as required by 646-2.7 using a BYK-Gardner Handicolor colorimeter using D65 illuminant and 2-degree geometry settings. The Department-measured CIELAB chromaticity coordinates shall define the initial color and will be used for resolution of color retention failures and the resolution of color retention disputes.

965-4 Certification.

Produce a certificate of compliance for non-APL products, upon request of the Engineer. Certificates of compliance shall identify the reportable properties of Table 965-1.

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SECTION 967
COMPONENTS FOR GUARDRAIL

967-1 General.

This Section covers the material and fabrication requirements for guardrail components. All timber and steel components supplied under this Specification shall be from producers currently on the Department's Production Facility Listing. Producers seeking inclusion on the Department's Production Facility Listing must meet the requirements of Section 105.

967-2 Timber Posts and Timber Offset Blocks.

Timber products must have a minimum stress grade of 1200 psi and meet the material requirements of Section 954. Timber is to be dressed on four sides (S4S) and treated in accordance with the post requirements in Section 955. Timber posts and offset blocks shall be shaped and drilled prior to wood treatment. Posts shall not vary more than 1 inch and offset blocks shall not vary more than 0.25 inches from the specified dimensions shown in the Standard Plans.

967-3 Steel Components.

Steel materials must meet the requirements of Table 967-1 below.

Production facilities must submit certified mill analyses to the Department for review and approval. Certified mill analyses must be signed by a quality control representative, describe each LOT of components, and show compliance with Table 967-1.

All steel components must be melted and manufactured in the United States. The certified mill analysis must show that the included material meets the Buy America, Source of Supply-Steel requirements in Section 6.

Where specified, components must be welded in accordance with the American Welding Society Structural Welding Code ANSI/AWS D1.1 using material conforming to E60XX. Nondestructive testing of welds is not required.

Table 967-1
Material Requirements for Steel Guardrail Components

Product	Standard	Grade / Type	Style	Reportable Properties
Steel Panels	AASHTO M 180	Type 2 Class A (12 Ga.) Class B (10 Ga.)	W-Beam	Heat, Yield, Tensile, Elongation, Class, Type
			Thrie-Beam	
			Thrie-Beam Transition	
End Pieces	AASHTO M 180	Type 2 Class A (12 Ga.) Class B (10 Ga.)	All	Yield, Tensile, Class, Type
Steel Posts & Offset Blocks	ASTM A36	36	All	Killed, Yield, Tensile, Elongation
	ASTM A992	50	All	

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Table 967-1 Material Requirements for Steel Guardrail Components				
Rub Rail	AASHTO M 180	Type 2 Class B (10 Ga.)	All	Heat, Yield, Tensile, Elongation, Class, Type
Pipe Rail	ASTM A53	A, B	E, S	Grade, Finish
Steel Tube Foundations	ASTM A500	B	Round, Shaped	Composition, Yield, Tensile, Elongation
Brackets & Fixtures	ASTM A36	36	All	Killed, Yield, Tensile, Elongation
Bolts	ASTM A307	A, B	Button-Head	Size, Composition, Hardness, Tensile
			Hex	
			Heavy-Hex	
Nuts	ASTM A563	A, B, C, C3, D, DH, DH3	Heavy Hex	Size, Composition, Proof Load, Hardness
Washers	ASTM F436	1, 3	Circular, Beveled, Clipped, Extra Thick	Size, Hardness

967-3.1 Steel Posts, Special Steel Posts, Steel Offset Blocks, and Rub Rail: Posts must be fabricated from rolled sections with cross-sections defined in the American Institute of Steel Construction (AISC) Manual of Steel Construction. Complete all fabrication prior to galvanizing. Galvanizing shall have the composition that meets or exceeds “Prime Western Grade” in accordance with ASTM B6. Posts shall not vary more than 1 inch and offset blocks shall not vary more than 0.25 inches from the specified dimensions shown in the Standard Plans.

967-3.2 Steel Panels and End Pieces: W-beam, thrie-beam, and thrie-beam transitions must meet the requirements of Table 967-1 for steel panels. Terminal connectors, end shoes, end units, and all other compatible components must meet the requirements of Table 967-1 for end pieces.

Galvanize shall have a composition that meets or exceeds “Prime Western Grade” in accordance with ASTM B6. Type II zinc coating is required on all panels.

All w-beam and thrie-beam panels (with the exception of transition panels) must be marked by a pressed stamp showing production LOT information (e.g., AASHTO-approved brand registration, LOT number, production date, operator, etc.). Upon approval of the certified mill analysis by the Department, each LOT will be stored in the Department’s database with a reference to the stamped information.

967-3.3 Bolts, Nuts, Washers, and Steel Plates: Galvanize hardware in accordance with ASTM A153. Galvanize steel plates in accordance with ASTM A153.

967-3.4 Pipe Rail: Pipe is to be Schedule 40. If applicable, weld prior to galvanizing.

967-3.5 Steel Tube Foundations: Galvanize steel tube foundations, brackets, and fixtures after all punching, drilling, stamping, and welding is complete. Galvanize in accordance with ASTM A123.

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967-4 Barrier Delineators.

Barrier delineators must meet the requirements of Sections 705 and 993 and be listed on the APL.

967-5 End Delineators.

Retroreflective sheeting is to be yellow, Type IV or greater in accordance with Section 994 and listed on the APL.

967-6 Approved Products List.

967-6.1 Approach Terminal Assemblies: Approach terminals must be listed on the APL. Manufacturers seeking evaluation of their product for approval must submit:

1. A completed application in accordance with Section 6, including product drawings meeting the dimensions of Standard Plans, Index 536-001 and that is signed and sealed by a registered Florida P.E.
2. Independent test reports indicating that the product meets all crash test requirements of MASH.

967-6.2 Composite Offset Blocks: Composite offset blocks must be listed on the APL. Manufacturers seeking evaluation of their product for approval must submit an application in accordance with Section 6 and include the following:

1. Test reports from an independent laboratory showing the product meets all crash test requirements of MASH.
2. Test reports from an independent laboratory showing the composite material meets the following physical requirements:

Table 967-2

Composite Block	Test Method	Requirement
Durometer Hardness	ASTM D2240 Shore D	Minimum 50
Durometer Hardness after UV exposure	ASTM D5870	< 15 points change from initial after exposure per ASTM D4329, 1000 hours, cycle C, type UVB-313 lamps

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SECTION 970
MATERIALS FOR RAISED PAVEMENT MARKERS AND ADHESIVE

970-1 Raised Pavement Markers (RPMs).

Manufacturers seeking evaluation of their product for the Approved Product List (APL) must submit an application in accordance with Section 6 and provide documentation showing the product is in conformance with this section.

RPMs shall be classified in accordance with the following chart:

Table 970-1
RPM Class

Class	Description	Usage	Expected Normal Service	ASTM D4280 Surface Designation
B	Retroreflective	Temporary/Permanent	Long life	H, hard abrasion-resistant lens
D	Retroreflective	Temporary	One month	None
F	Internally Illuminated	Permanent	Long life	H, hard abrasion-resistant lens

970-2 Performance Requirements.

970-2.1 Class B RPMs: The RPMs shall meet the performance requirements specified in ASTM D4280, Section 6.2, for luminous intensity, flexural strength, compressive strength, resistance to cracking, and thermal cycling, as modified herein.

Submit product photo, product data sheet, and documentation from AASHTO Product Evaluation & Audit Solutions showing that the RPMs meet the requirements of this Section.

970-2.1.1 Composition: The RPM shall consist of materials conforming to ASTM D4280.

970-2.1.2 Physical Requirements: The physical size of the RPM shall conform to the requirements of ASTM D4280

The minimum area of each retroreflective face shall be 2.5 square inches. The minimum base size shall be 12 square inches.

970-2.1.3 Abrasion Resistant: Meet the coefficient of luminous intensity requirements of ASTM D4280 after abrasion.

970-2.1.4 In-Service Minimum Retroreflective Intensity: Class B RPMs shall retain a minimum coefficient of luminous intensity for 18 months of not less than 30% of the values shown in Table 1 of ASTM D4280, and a minimum luminous intensity of 0.2 cd/fc at the end of two years.

970-2.2 Class D RPMs: Submit product photo, product data sheet, and certified test reports from an independent laboratory showing that the RPMs meet the requirements of this Section.

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970-2.2.1 Body Requirements: Provide RPMs made of nonferrous material. RPM dimensions are based on an x and y axis where the y dimension is parallel to the centerline and the x axis is 90° to the y axis.

The base must be approximately 4 inches along the x axis and approximately 1 inch along the y axis (L-shaped).

The vertical wall must be a minimum of 4 inches long with a minimum height of 2 inches and a maximum height of 3 inches with retroreflective sheeting affixed to the upper portion of the vertical wall. The retroreflective sheeting must be a minimum of 0.25 inch in width and extend the full length of the vertical wall.

970-2.2.2 Color Requirements: The color of the body and the retroreflective strips must be yellow.

970-2.2.3 Flexibility and Deformation Resistance: The vertical wall of the tabs must be flexible to bend under normal traffic and resistant to permanent deformation for a minimum of one month.

970-2.2.4 Adhesion: Provide tabs that adhere to the pavement such that no tab dislodges.

970-2.2.5 Retroreflective Sheeting: Use a retroreflective sheeting meeting Type IV or greater and listed on the Department's Approved Product List (APL).

970-2.2.6 Removability: Ensure the entire RPM is removable without damaging the asphalt surface.

970-2.3 Class F RPMs: Submit product photo, product data sheet, and certified test reports from an independent laboratory showing that the RPMs meet the requirements of this Section.

970-2.3.1 Functional Requirements: RPMs must be steadily-illuminated.

970-2.3.2 Electrical Requirements: Electrical power for the RPM must be provided by solar power.

RPMs must meet the performance requirements for at least 16 hours of continuous duty without sunlight. Charging time must be less than 3 hours during sunny conditions and less than 8 hours during cloudy conditions. Operation must be controlled by a photoreceptor located inside the RPM.

970-2.3.3 Physical Requirements: RPMs must have a maximum width of eight inches. The depth of embedment of the RPM housing into pavement must be 2.5 inches or less, and the housing must project 0.75 inches or less above the pavement surface.

RPMs must have a compressive strength of 20,000 pounds.

RPMs must have an IP 68 rating.

970-2.3.4 Performance Requirements: The light source for RPMs must be light-emitting diodes (LEDs).

The light produced by the RPM must only be visible from the direction of traffic that it is intended to guide. No light produced by the RPM should be visible when viewed from a height of 3.5 feet above the pavement at a distance of 20 feet from the opposite quadrant or side quadrants of the RPM's LED projection quadrant.

RPMs must be capable of producing the following luminance values when measured at the LED source:

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Table 970-2 RPM Color and Luminance	
Color	Luminance (Foot-candle)
White	5.00
Yellow	1.00
Red	1.50
Blue	0.10

The RPM lenses must meet the abrasion-resistant requirements of ASTM D4280. After abrading the RPM, the luminance produced by the RPM must be 50% or greater than the values in the above table.

970-2.3.5 Warranty: The manufacturer must provide a five-year, non-prorated warranty on all components for five years from the date of final acceptance in accordance with Section 706.

970-3 Adhesive for Class B and F Raised Pavement Markers.

970-3.1 General: Adhesive as recommended by the RPM manufacturer shall be used for bonding the RPM to the pavement. Manufacturers seeking evaluation of their product for the APL must submit an application in accordance with Section 6 and provide documentation showing the product is in conformance with this Section.

970-3.2 Specific Requirements for Bituminous Adhesives: The bituminous adhesive shall meet the properties of adhesives per ASTM D4280 Section A1, including filler-free and filler alone properties. Manufacturers seeking evaluation of bituminous adhesive products shall submit field test data from the AASHTO Product Evaluation & Audit Solutions. The adhesive shall retain a minimum of 80% of RPMs at 18 months. Manufacturer to specify the recommended thickness of adhesive.

970-3.3 Specific Requirements for Epoxy Adhesives: The epoxy adhesive shall conform to the following requirements of AASHTO M 237 for Types I and II (Table 970-3).

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Table 970-3					
		Type I		Type II	
Property	Test Method	Min.	Max.	Min.	Max.
Viscosity: Component A (Resin) TD Spindle at 5 rev/min, poises	AASHTO T 237	3,500	5,000	1,000	3,000
Viscosity: Component B (Hardener) TD Spindle at 5 rev/min, poises		3,500	5,000	1,000	3,000
Shear Ratio (Each Component)		2.0		2.0	
Gel Time, Minutes	AASHTO T 237	6	10	6	10
Bond Strength to Concrete, max. time, minutes to reach 200 psi	AASHTO T 237		35		210
Density lbs/gal. Component A (Resin)	AASHTO T 237	11.7	12.2	10.6	10.9
Component B (Hardener)		11.7	12.2	11.3	11.6
Slant Shear Strength (Dry) 24 hr, psi	AASHTO T 237	1,000		2,000	
Slant Shear Strength (Wet) 24 hr, psi		800		1,500	

970-4 Packaging and Labeling.

970-4.1 Raised Pavement Markers: Shipment shall be made in containers which are acceptable to common carriers and packaged in a manner which ensures delivery in perfect condition. Each package shall be clearly marked with the APL number, name of the manufacturer, type, color, quantity enclosed and date of manufacture. Show the designation of the Class B marker in accordance with ASTM D4280.

970-4.2 Adhesives: Each package shall be clearly marked with the product name, name of the manufacturer, LOT number, adhesive type, quantity enclosed, and date of manufacture.

970-5 Product Acceptance on the Project.

Acceptance will be made in accordance with the requirements of Sections 102 and 706.

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SECTION 971
PAVEMENT MARKING MATERIALS

971-1 General Requirements.

971-1.1 Packaging and Labeling: The name and address of the manufacturer shall be shown on the label. The label must also show the color, date of manufacturer, lot number and APL number. The label shall warn the user of any special handling or precautions of the material, as recommended by the manufacturer. Any packaging and labeling not so marked will not be accepted.

971-1.2 Storage: All materials must have a container storage life of one year from date of manufacture. Any pavement marking materials, which although inspected and approved at the point of manufacture, hardens or livers in the containers will be rejected even though it conforms to these Specifications in all other respects.

971-1.3 Mixing: All paints shall be delivered to the project completely mixed, and ready to be used without additional oil or thinner. Thinners shall not be used under any circumstances.

971-1.4 Approved Product List (APL): All pavement marking materials shall be one of the products listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6 and include the documentation identified in the Table 971-1.

Table 971-1

Documentation	Requirements
Product Photo	Displays the significant features of the product.
Technical Data Sheet	Uniquely identifies the product and includes product specifications, storage instructions, and recommended installation materials and equipment as applicable. Include the following information as applicable: 1. Use on concrete surfaces 2. Use on asphalt surfaces (dense graded, open graded, HFST, etc) 3. Primers or sealers, friction elements, glass spheres, retroreflective elements
Product Label	For each component of the product system. Label shall meet the requirements in 971-1.1.
Safety Data Sheet (SDS)	Pavement marking materials shall be characterized as non-hazardous as defined by Resource Conservation and Recovery Act (RCRA) 40 CFR 261. Provide supporting independent analytical data or product material safety data sheets (SDS) identifying any components listed in Table 1 of 40 CFR 261.24.
AASHTO Product Evaluation & Audit Solutions Field Test Report	For standard paint, durable paint, two reactive component material, and permanent tape, manufacturers shall provide AASHTO Product Evaluation & Audit Solutions field test data meeting FDOT Specification requirements.

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Independent Laboratory Test Report	Submit independent laboratory test results meeting the requirements in 971.
Installation Instructions	Surface preparation and installation procedures for different substrates. Include the following information as applicable: 1. Sealer/primer application instructions when required 2. Application thickness 3. Application rates of glass spheres/retroreflective elements/ friction elements
Product Sample	Submit upon request from the Department. If the product is a system, a sample of each component must be submitted.

The Department will test hot-applied standard thermoplastic and profiled thermoplastic pavement marking materials in accordance with FM 5-541, Part B. The Department will test preformed thermoplastic and hot-applied high friction thermoplastic pavement marking materials in accordance with FM 5-622, Part A. A notation of the number of coats and the thickness of each coat at which the product passes testing may be placed on the APL. When listed, this will be the minimum criteria for application of the pavement marking material.

971-1.5 Samples: Field samples will be obtained in accordance with the Department's Sampling, Testing and Reporting Guide Schedule.

971-1.6 Color: Pavement markings shall meet color requirements when tested according to ASTM E2367 and E1349. Materials other than yellow shall meet the color requirements as identified in 23 CFR 665 Table 5 Appendix to Part 655, Subpart F.

Yellow materials for pavement markings shall meet the following performance requirements. The initial daytime chromaticity for yellow materials shall fall within the box created by the following coordinates:

Table 971-2				
Initial Daytime Chromaticity Coordinates (Corner Points)				
	1	2	3	4
x	0.530	0.510	0.455	0.472
y	0.456	0.485	0.444	0.400

The nighttime chromaticity for yellow materials shall fall within the box created by the following coordinates:

Table 971-3				
Nighttime Chromaticity Coordinates (Corner Points)				
	1	2	3	4
x	0.575	0.508	0.473	0.510
y	0.425	0.415	0.453	0.490

971-1.7 Additional Requirements:

Retroreflective elements shall contain no more than 200 ppm by weight of lead or arsenic when tested in accordance with the Environmental Protection Agency (EPA) Testing Methods 3052, 6010B, and 6010C.

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971-2 Glass Spheres.

971-2.1 General Requirements: Glass spheres shall be of a composition designed to be highly resistant to traffic wear and to the effects of weathering for the production of a retroreflective surface, without altering day visibility of the marking. The general requirements of 971-1 apply to glass spheres.

971-2.2 Specific Properties: The large (Type 3 or larger) glass spheres used for drop on beads shall have an adhesion coating. Type 1 glass spheres used for drop on beads shall have a dual coating. Glass spheres used in the intermix of materials are not required to be coated.

The following physical requirements apply:

Table 971-4		
Property	Test Method	Specification
Roundness*	AASHTO R 98	Min: 70% by weight
Roundness**	AASHTO R 98	Min: 80% by weight
Refractive Index*	ASTM C1648 -Becke Line Method (25+/-5C)	1.5 minimum
Refractive Index**	ASTM C1648 -Becke Line Method (25+/-5C)	1.9 minimum
*Type 1, 3, 4 and 5 beads **High Index beads		

Table 971-5					
Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO R 98)				
	Grading Designation				
	Type 1*	Type 3*	Type 4*	Type 5*	High Index**
No. 8				100	
No. 10			100	95 - 100	
No. 12		100	95 - 100	80 - 95	
No. 14		95 - 100	80 - 95	10 - 40	
No. 16	100	80 - 95	10 - 40	0 - 5	100
No. 18		10 - 40	0 - 5	0 - 2	
No. 20	95 - 100	0 - 5	0 - 2		95 - 100
No. 25		0 - 2			
No. 30	75 - 95				55 - 75
No. 40					15 - 35
No. 50	15 - 35				0 - 5
No. 80					
No. 100	0 - 5				
*AASHTO M247 ** Federal Specification TT-B-1325D17					

971-2.3 Sampling: A random 50-pound sample of glass spheres shall be obtained for each 50,000 pounds shipped. Send each 50-pound sample to the State Materials Office.

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971-2.4 Containers: The spheres shall be furnished in new 50-pound moisture-proof bags or 2,000-pound triwall boxes. All containers shall meet Interstate Commerce Commission requirements for strength and type.

971-3 Standard Paint.

971-3.1 General: Standard paints shall include water reducible products that are single packaged and ready mixed. The paint shall have the capability of being cleaned and flushed from the pavement marking machines using regular tap water and any required rust inhibitors. The manufacturer shall have the option of formulating the paint according to his own specifications. However, the requirements delineated in this Specification and Section 710 shall apply regardless of the type of formulation used. The paint shall be free from all skins, dirt, and foreign objects.

971-3.2 Composition:

Table 971-6		
Component	Test Method	Criteria
Total Solids, by weight	ASTM D2369	minimum 75%
Pigments, by weight	ASTM D3723	minimum 57%
Vehicle Solids % of Vehicle*		minimum 40%
TiO_2, Type II Rutile (white paint only)	ASTM D476	minimum 1.0 lb/gal
Volatile Organic Compound, (VOC)	ASTM D3960	maximum 150 g/L
*Vehicle Solids % of Vehicle = $\frac{(\%\ \text{total solids} - \%\ \text{pigment})}{(100 - \%\ \text{pigment})}$		

971-3.3 Physical Requirements:

Table 971-7			
Property	Test Method	Minimum	Maximum
Density	ASTM D1475	13.5 ± 1.4 lb/gal	-
Viscosity at 77ºF	ASTM D562	80 KU	100 KU
Fineness of Grind	ASTM D1210	3(HS)	
Dry Opacity at 5 mils WFT	ASTM D2805	0.92	-
Bleed Ratio	ASTM D868	0.95	-
Flexibility	ASTM D522 Method B	Pass	-
Abrasion Resistance	ASTM D4060	Pass	-

971-3.3.1 Set To Bear Traffic Time: The paint shall set to bear traffic in not more than two minutes.

971-3.3.2 Abrasion Resistance: Test four samples using a Taber Abrader. The paint shall be applied to specimen plates using a drawdown blade having a clearance of 20 mils. Clean with a soft brush and weigh each sample. Abrade samples for 1,000 cycles with a combined load of 500 g (arm plus auxiliary weight) on each arm and CS-10 wheels. Clean the samples with a soft brush and weigh again. The average weight loss for the four plates shall not exceed 75 mg per plate.

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971-3.3.3 Retroreflectivity: The white and yellow pavement markings shall attain an initial retroreflectance of not less than 300 mcd/m^2/lx and 250 mcd/m^2/lx, respectively. Black pavement markings shall have a retroreflectance of less than 20 mcd/m^2/lx. The retroreflectance of the white and yellow pavement markings at the end of the six-month period shall not be less than 150 mcd/m^2/lx.

971-3.4 Application Properties: Meet the requirements of Section 710 for application properties.

971-3.5 Packaging and Labeling: The paint shall be placed in 55 gallon open-end steel drums with a re-usable multi-seal sponge gasket or 275 gallon Intermediate Bulk Container (IBC). No more than 50 gallons of paint shall be placed in any drum or 250 gallons in any IBC to allow for expansion during transport and storage. Clearly mark the containers with the weight in pounds per gallon, the volume of materials in units of gallons.

971-4 Durable Paint.

971-4.1 General: Durable paints shall include water reducible products that are single packaged and ready mixed. The paint shall have the capability of being cleaned and flushed from the pavement marking machines using regular tap water and any required rust inhibitors. The manufacturer shall have the option of formulating the material according to his own specifications. However, the requirements delineated in this Specification and Section 710 shall apply regardless of the type of formulation used. The paint shall be free from all skins, dirt and foreign objects. The manufacturer shall provide the recommended thickness prior to installation.

971-4.2 Composition:

Table 971-8

Component	Test Method	Criteria
Total Solids, by weight	ASTM D2369	75% minimum
Pigments, by weight	ASTM D3723	57% minimum
Vehicle Solids, % on Vehicle*	-	40% minimum
TiO_2, Type II Rutile (white paint only)	ASTM D476	1.0 lb/gal minimum
Volatile Organic Compound, (VOC)	ASTM D3960	150 g/L maximum

*Vehicle Solids % of Vehicle = $\frac{(\%\text{ total solids} - \%\text{ pigment})}{(100 - \%\text{ pigment})}$

Vehicle solids shall be 100% acrylic emulsion polymer.

971-4.3 Physical Requirements:

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Table 971-9			
Property	Test Method	Minimum	Maximum
Density	ASTM D1475	13.5 ± 1.4 lb/gal	N/A
Viscosity at 77ºF	ASTM D562	80 KU	100 KU
Fineness of Grind	ASTM D1210	3(HS)	-
Dry Opacity at 5 mils WFT	ASTM D2805	0.92	-
Bleed Ratio	ASTM D868	0.95	-
Flexibility	ASTM D522 Method B	Pass	-
Abrasion Resistance	ASTM D4060	Pass	-

971-4.3.1 Set to Bear Traffic Time: The paint shall set to bear traffic in not more than ten minutes.

971-4.3.2 Abrasion Resistance: Test four samples using a Taber Abrader. The paint shall be applied to specimen plates using a drawdown blade having a clearance of 20 mils. Air dry each sample until fully cured based on the manufacturer's product recommendation. Clean with a soft brush and weigh each sample. Abrade samples for 1,000 cycles with a combined load of 500 g (arm plus auxiliary weight) on each arm and CS-10 wheels. Clean the samples with a soft brush and weigh again. The average weight loss for the four plates shall not exceed 75 mg per plate.

971-4.3.3 Retroreflectivity: The white and yellow pavement markings shall attain an initial retroreflectance of not less than 450 mcd/m^2/lx and 300 mcd/m^2/lx, respectively. The retroreflectance of the white and yellow pavement markings at the end of the 18 month period shall not be less than 150 mcd/m^2/lx.

971-4.4 Application Properties: Application properties shall meet the requirements of Section 710.

971-4.5 Packaging and Labeling: The paint shall be placed in 55 gallon open-end steel drums with a re-usable multi-seal sponge gasket or 275 gallon Intermediate Bulk Container (IBC). No more than 50 gallons of paint shall be placed in any drum or 250 gallons in any IBC to allow for expansion during transport and storage. Clearly mark the containers with the weight in pounds per gallon, the volume of materials in units of gallons.

971-5 Hot-Applied Standard Thermoplastic Material.

971-5.1 General: The manufacturer shall utilize alkyd based materials only and shall have the option of formulating the material according to his own specifications. However, the requirements delineated in this Specification and Section 711 shall apply regardless of the type of formulation used. The pigment, glass spheres, and filler shall be well dispersed in the resin.

971-5.2 Composition:

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Table 971-10			
Component	Test Method	White	Yellow
Binder	ASTM D4797	20% minimum	20% minimum
TiO_2, Type II Rutile	ASTM D476	10% minimum	-
Glass Spheres	ASTM D4797	40% minimum	40% minimum
Yellow Pigment		-	% minimum per manufacturer
Calcium Carbonate and Inert Filler (-200 mesh sieve)		30% maximum	37% maximum
Percentages are by weight.			

The alkyd/maleic binder must consist of a mixture of synthetic resins (at least one synthetic resin must be solid at room temperature) and high boiling point plasticizers. At least one-half of the binder composition must be 100% maleic-modified glycerol of rosin and be no less than 15% by weight of the entire material formulation.

971-5.3 Glass Spheres: The glass spheres in the intermix shall consist of 50% Type 1 and 50% Type 3 and meeting the requirements of this Section.

971-5.4 Sharp Silica Sand: Sharp silica sand shall meet the following gradation requirements:

Table 971-11	
Sieve Size	Percent by Mass Passing Designated Sieve (ASTM D1214)
20	100
50	0 to 10

971-5.5 Physical Requirements:

Table 971-12			
Property	Test Method	Minimum	Maximum
Water Absorption	ASTM D570	-	0.5%
Softening Point	ASTM D36	195ºF	-
Low Temperature Stress Resistance	AASHTO T 250	Pass	-
Specific Gravity	AASHTO T 250	1.9	2.3
Indentation Resistance	ASTM D7735* Type A Durometer	40	75
Impact Resistance	AASHTO T 250,	1.0 N·m	-
Flash Point	AASHTO T 250	475ºF	-
* The durometer and panel shall be at 115ºF with a 1,000 g load applied. Instrument measurement shall be taken after 15 seconds.			

971-5.5.1 Set to Bear Traffic Time: The thermoplastic shall set to bear traffic in not more than two minutes.

971-5.5.2 Retroreflectivity: The white and yellow pavement markings shall attain an initial retroreflectance of not less than 450 mcd/m^2/lx and not less than 350 mcd/m^2/lx,

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respectively. The retroreflectance of the white and yellow pavement markings at the end of the three-year APL testing period shall not be less than 250 mcd/m^2/lx.

971-5.6 Application Properties: Application properties shall meet the requirements of Section 711.

971-5.7 Packing and Labeling: The thermoplastic material shall be packaged in suitable biodegradable or thermo-degradable containers which will not adhere to the product during shipment and storage. The container of thermoplastic material shall weigh approximately 50 pounds. The label shall also warn the user that the material shall be heated in the range as recommended by the manufacturer.

971-6 Preformed Thermoplastic Material.

971-6.1 General: The manufacturer shall have the option of formulating the material according to his own specifications. However, the requirements delineated in this Specification and Section 711 shall apply regardless of the type of formulation used. The pigment, friction elements, glass spheres, and filler shall be well dispersed in the resin.

971-6.2 Composition: The preformed thermoplastic shall consist of high quality materials, pigments, friction elements, and glass spheres or other retroreflective material uniformly distributed throughout their cross-sectional area, with a retroreflective layer of spheres or other retroreflective material embedded in the top surface.

971-6.3 Color: Materials shall meet the performance requirements specified in 971--1.6 and the following additional requirements. The initial luminance factor, Cap Y, for white preformed shall not be less than 55.

971-6.4 Physical Requirements:

Table 971-13

Property	Test Method	Minimum	Maximum
Softening Point	ASTM D36	195ºF	-
Low Temperature Stress Resistance	AASHTO T 250	Pass	-
Indentation Resistance	ASTM D7735* Type A Durometer	40	75
Impact Resistance	ASTM D256, Method A**	1.0 N·m	-

*The durometer and panel shall be at 115ºF with a 1,000 g load applied. Instrument measurement shall be taken after 15 seconds.
**The test specimen for ASTM D256 shall be 1 in. x 1 in. x 6 in. and shall not be notched.

971-6.4.1 Retroreflectivity: The white pavement markings shall attain an initial retroreflectance of not less than 200 mcd/m^2/lx. Black pavement markings shall have a retroreflectance of less than 20 mcd/m^2/lx. The retroreflectance of the white pavement markings at the end of the three-year period shall not be less than 150 mcd/m^2/lx.

971-6.4.2 Friction Resistance: Initial performance of pavement markings shall provide a minimum Dynamic Friction Tester (DFT40) value of 45 or greater in accordance with FM 5-622 – Part A. In-service pavement markings shall maintain a DFT40 value of 40 or greater for a three-year period as tested per FM 5-622,Part B.

971-6.5 Application Properties: Application properties shall meet the requirements of Section 711.

971-6.6 Packing and Labeling: The thermoplastic material shall be packaged in suitable biodegradable or thermo-degradable containers which will not adhere to the product during

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shipment and storage. Clearly mark each container with the thickness of the preformed material in units of inches.

971-7 Permanent Tape Materials.

971-7.1 General: The materials for permanent tape pavement markings shall consist of white or yellow weather-resistant retroreflective film as specified herein. The pigment, glass spheres, and filler shall be well dispersed in the resin. However, the requirements delineated in this Specification and Section 713 shall apply.

971-7.2 Composition: Permanent tape pavement markings shall consist of high-quality plastic materials, pigments, and glass spheres uniformly distributed throughout their cross-sectional area, with a retroreflective layer of spheres embedded in the top surface.

971-7.3 Thickness: The APL will list the specified thickness of each approved product.

971-7.4 Durability and Wear Resistance: The film shall be weather resistant and, through normal wear, shall show no significant tearing, rollback or other signs of poor adhesion.

971-7.5 Conformability and Resealing: The pavement markings shall be capable of conforming to pavement contours, breaks and faults under traffic at pavement temperatures recommended by the manufacturer. The film shall be capable of use for patching worn areas of the same types of film in accordance with the manufacturer's recommendations.

971-7.6 Tensile Strength: The pavement markings shall have a minimum tensile strength of 40 psi when tested according to ASTM D638. A rectangular test specimen 6 inches by 1 inch by 0.05 inches minimum thickness shall be tested at a temperature range of 40 to 80ºF using a jaw speed of 0.25 inch/min.

971-7.7 Pigmentation: The pigment shall be selected and blended to provide a material which is white or yellow conforming to standard highway colors through the expected life of the pavement markings. Test laboratory samples in accordance with ASTM E811 and E1349.

971-7.8 Glass Spheres: The pavement markings shall have glass retention qualities such that, when at room temperature a 2 inches by 6 inches specimen is bent over a 0.5 inch diameter mandrel axis, a microscopic examination of the area on the mandrel shall show no more than 10% of the spheres with entrapment by the material of less than 40%. The bead adhesion shall be such that spheres are not easily removed when the film surface is scratched firmly with a thumbnail.

971-7.9 Retroreflectivity: The materials shall attain an initial retroreflectance of not less than 450 mcd/m^2/lx for white markings and not less than 350 mcd/m^2/lx for yellow markings. The pavement markings shall retain a minimum retroreflectance for two years of not less than 300 mcd/m^2/lx for white markings and not less than 250 mcd/m^2/lx for yellow markings. The retroreflectance of the white, yellow and contrast pavement markings at the end of the three-year period shall not be less than 150 mcd/m^2/lx.

971-7.10 Packaging and Labeling: Ship all permanent tape materials in containers which will not adhere to the product during shipment and storage. Clearly mark each container with the thickness of the preformed material in units of inches.

971-8 Two Reactive Component Material.

971-8.1 General: Two reactive component materials intended for use under this Specification shall include, but not be limited to, epoxies, polyesters and urethanes. The manufacturer shall have the option of formulating the material according to his own specifications. However, the criteria outlined in this Specification and Section 709 shall apply

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regardless of the type of formulation used. The material shall be free from all skins, dirt and foreign objects.

971-8.2 Composition:

Table 971-14		
Component	Test Method	Criteria
TiO_2, Type II Rutile (white material only)	ASTM D476	minimum 10% by weight
Volatile Organic Compound, (VOC)	ASTM D3960	maximum 150 g/L

971-8.3 Physical Requirements:

Table 971-15			
Property	Test Method	Minimum	Maximum
Adhesion to Concrete	ASTM D7234	Concrete Failure	-
Hardness	ASTM D7735, Type D	75	-
Abrasion Resistance	ASTM D4060	Pass	-

971-8.3.1 Set To Bear Traffic Time: The material shall set to bear traffic in not more than two minutes.

971-8.3.2 Abrasion Resistance: Test four samples using a Taber Abrader. The material shall be applied to specimen plates using a drawdown blade having a clearance of 15 mils. Clean with a soft brush and weigh each sample. Abrade samples for 1,000 cycles with a combined load of 500 g (arm plus auxiliary weight) on each arm and CS-10 wheels. Clean the samples with a soft brush and weigh again. The average weight loss for the four plates shall not exceed 60 mg per plate.

971-8.3.3 Retroreflectivity: The white and yellow pavement markings shall attain an initial retroreflectance of not less than 450 mcd/m^2/lx and not less than 350 mcd/m^2/lx, respectively. The retroreflectance of the white and yellow pavement markings at the end of the three-year period shall not be less than 150 mcd/m^2/lx.

971-8.4 Application Properties: Application properties shall meet the requirements of Section 709.

971-8.5 Packaging and Labeling: The two reactive component material shall be placed in 55 gallon open-end steel drums with a re-usable multi-seal sponge gasket or 275 gallon Intermediate Bulk Container (IBC). No more than 50 gallons of material shall be placed in any drum or 250 gallons in any IBC to allow for expansion during transport and storage. Clearly mark the containers with the volume of materials in units of gallons and the product name.

971-9 Profiled Thermoplastic Material.

971-9.1 General: The manufacturer shall utilize alkyd based materials only and shall have the option of formulating the material according to his own specifications. However, the requirements delineated in this Specification shall apply regardless of the type of formulation used. The pigment, retroreflective elements, and filler shall be well dispersed in the resin.

971-9.2 Composition:

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Table 971-16			
Component	Test Method	White	Yellow
Binder	ASTM D4797	20% minimum	20% minimum
TiO_2, Type II Rutile	ASTM D476	10% minimum	-
Retroreflective Elements	ASTM D4797	% minimum per manufacturer	% minimum per manufacturer
Yellow Pigment		-	% minimum per manufacturer
Calcium Carbonate and Inert Filler (-200 mesh sieve)		% minimum per manufacturer	% minimum per manufacturer
Note: Percentages are by weight.			

The alkyd/maleic binder must consist of a mixture of synthetic resins (at least one synthetic resin must be solid at room temperature) and high boiling point plasticizers. At least one-half of the binder composition must be 100% maleic-modified glycerol of rosin and be no less than 15% by weight of the entire material formulation.

971-9.3 Retroreflective Elements: The retroreflective elements in the intermix shall be determined by the manufacturer and identified for the APL.

971-9.4 Physical Requirements:

Table 971-17			
Property	Test Method	Minimum	Maximum
Water Absorption	ASTM D570	-	0.5%
Softening Point	AASHTO T 250	210ºF	-
Low Temperature Stress Resistance	AASHTO T 250	Pass	-
Specific Gravity	AASHTO T 250	1.9	2.3
Indentation Resistance	ASTM D7735* Type A Durometer	65	-
Impact Resistance	AASHTO T 250	1.0 N·m	-
Flash Point	AASHTO T 250	475ºF	-
*The durometer and panel shall be at 80ºF, with a 1,000 g load applied. Instrument measurement shall be taken after 15 seconds.			

971-9.4.1 Set To Bear Traffic Time: When applied at the temperatures and thickness specified by Section 701, the baseline material shall set to bear traffic in not more than two minutes. The bumps shall set to bear traffic in not more than 10 minutes at ambient air temperatures of 80ºF or less and in not more than 15 minutes for ambient air temperatures exceeding 80ºF.

971-9.4.2 Retroreflectivity: The white and yellow pavement markings shall attain an initial retroreflectance of not less than 300 mcd/m^2/lx and not less than 250 mcd/m^2/lx, respectively. The retroreflectance of the white and yellow pavement markings at the end of the three-year period shall not be less than 150 mcd/m^2/lx.

971-9.4.3 Durability: Durability shall include flattening of the profile or raised portions of the line. The flattening of the profile or raised portion of the line shall not exceed 25% at the end of the three-year period.

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971-9.5 Application Properties: Application properties shall meet the requirements of Section 701.

971-9.6 Packing and Labeling: The thermoplastic material shall be packaged in suitable biodegradable or thermo-degradable containers which will not adhere to the product during shipment and storage. The container of thermoplastic material shall weigh approximately 50 pounds. The label shall warn the user that the material shall be heated in the range as recommended by the manufacturer.

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SECTION 972
RECYCLED PLASTIC PRODUCTS

972-1 Description.

Recycled plastic products shall include certified test reports from an approved independent test laboratory that shows the material meets all specifications herein and the manufacturer shall certify the following:

1. The source of the recycled plastic waste, including the state (FL, GA, etc.) from which the recycled plastic was obtained, and type of waste (consumer or industrial).
2. The total percent of recycled plastic in the final product.

972-2 Definitions.

972-2.1 Recycled Plastic: Those plastics composed of post-consumer material or recovered industrial material only, or both, that may or may not have been subjected to additional processing steps designed to afford products such as regrind or reprocessed or reconstituted plastics.

972-2.2 Post-Consumer Materials: Those products generated by a business or consumer that have served their intended end use and that have since been separated or diverted from solid waste for the purpose of collection, recycling, and re-disposition.

972-2.3 Recovered Material: Materials and by-products that have been recovered or diverted from solid waste, but not including those materials and by-products generated from, and commonly used within, an original manufacturing process.

972-3 Materials.

The materials used for recycled plastic products shall consist of a minimum of 70% by weight of recycled plastic. The products shall exhibit good workmanship and shall be free of burns, discoloration, contamination, and other objectionable marks or defects which affect appearance or serviceability. Only chemicals, including fillers and colorants, designed to inhibit photo degradation, biological/biochemical decomposition, insect infestation, or burning will be permitted to enhance durability. The use of sufficient additives to inhibit photo degradation over the lifetime of the product is required.

972-4 Sampling.

One additional product per 1,000, or a minimum of one per order shall be included in the order for Department testing.

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SECTION 973
FIBER REINFORCED POLYMER (FRP) COMPOSITE STRUCTURAL SHAPES

973-1 Description.

This Section covers material and fabrication requirements for fiber reinforced polymer (FRP) composite structural shapes.

973-2 Product Acceptance.

Obtain FRP composites from a producer that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.

973-3 Thermoset Pultruded Structural Shapes.

Thermoset pultruded structural shapes must meet the requirements in the materials section of the ASCE, Pre-Standard for Load & Resistance Factor Design (LRFD) of Pultruded Fiber Reinforced Polymer (FRP) Structures.

Manufactured components shall be inspected according to ASTM D3917 for dimensional tolerances and ASTM D4385 for visual defects.

Pultruded profiles located on bridge and overhead sign structures shall meet a flame spread index of Class B in accordance with ASTM E84 and meet the requirements of UL94 with a rating of V-1.

973-4 Vacuum Infusion Processed (VIP) Structural Shapes.

973-4.1 Materials:

973-4.1.1 Fibers: Use commercial grade glass fibers that conform to ASTM D578. Glass fibers may be in any form such as rovings, woven fabrics, braided fabrics, stitched fabrics, continuous fiber mats, continuous strand mats, continuous filament mats (CFM), and chopped strand mats (CSM) of any size or weight.

Each structural element shall contain a minimum of 40% (by weight) of glass fibers oriented in a minimum of two directions in accordance with the manufacturer's requirements.

Tensile strength of glass fiber strands, yarns and rovings shall not be less than 290 ksi in accordance with ASTM D7290, determined by a tension test in accordance with ASTM D2343.

973-4.1.2 Resin: Use a commercial grade thermoset resin for fabricating shapes.

973-4.1.3 Additives: Additives such as fillers, promoters, accelerators, inhibitors, UV agents, and pigments, used in the processing or curing shall be compatible with the fiber and resin.

973-4.2 Physical and Mechanical Properties: The physical properties of VIP FRP products shall conform to the requirements of Table 973-1. The characteristic mechanical properties of VIP FRP composite structural members, determined in accordance with ASTM D7290, shall equal or exceed the minimum requirements in Table 973-2 for shapes and Table 973-3 for plates.

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Table 973-1 Required Physical Properties - VIP FRP		
Physical Property	Requirement	Test Method
Barcol Hardness	> 40	ASTM D2583
Glass Transition Temperature	> 180 F	ASTM D4065
Coefficient of Thermal Expansion	< 7.5 x 10^{-6} in/in/ F (longitudinal)	ASTM D696
Moisture Equilibrium Content	< 2%	ASTM D570, Section 7.4

Table 973-2 Required Mechanical Properties - VIP FRP Shapes		
Property	Minimum Requirement	Test Method
Longitudinal Tensile Strength	30,000 psi	ASTM D3039
Transverse Tensile Strength	7,000 psi	
Longitudinal Tensile Modulus	3 x 10^6 psi	
Transverse Tensile Modulus	0.8 x 10^6 psi	
Longitudinal Compressive Strength	30,000 psi	ASTM D6641
Longitudinal Compressive Modulus	3 x 10^6 psi	
Transverse Compressive Modulus	1 x 10^6 psi	
In-Plane Shear Strength	8,000 psi	ASTM D5379
In-Plane Shear Modulus	0.4 x 10^6 psi	ASTM D5379
Interlaminar Shear Strength	3,500 psi	ASTM D2344

Table 973-3 Required Mechanical Properties -VIP FRP Plates		
Property	Minimum Requirement	Test Method
Longitudinal Tensile Strength	20,000 psi	ASTM D3039
Transverse Tensile Strength	7,000 psi	
Longitudinal Tensile Modulus	1.8 x 10^6 psi	
Transverse Tensile Modulus	0.7 x 10^6 psi	
Longitudinal Compressive Strength	24,000 psi	ASTM D6641
Transverse Compressive Strength	15,500 psi	
Longitudinal Compressive Modulus	1.8 x 10^6 psi	
Transverse Compressive Modulus	1 x 10^6 psi	
Longitudinal Flexural Strength	30,000 psi	ASTM D790
Transverse Flexural Strength	13,000 psi	
Longitudinal Flexural Modulus	1.6 x 10^6 psi	
Transverse Flexural Modulus	0.9 x 10^6 psi	
In-Plane Shear Strength	6,000 psi	ASTM D5379
In-Plane Shear Modulus	0.4 x 10^6 psi	
Interlaminar Shear Strength	3,500 psi	ASTM D2344

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973-4.3 Fire, Smoke and Toxicity: VIP profiles located on bridge and overhead sign structures shall meet a flame spread index of Class B in accordance with ASTM E84 and meet the requirements of UL94 with a rating of V-1.

973-4.4 Impact Tolerance: Where impact resistance is stipulated, impact resistance shall be determined in accordance with ASTM D7136.

973-5 Thermoplastic Structural Shapes.

973-5.1 General: For the purpose of this specification, use the following definitions:

a. Thermoplastic Structural Shapes (TSS) includes a thermoplastic matrix reinforced with chopped fiberglass filaments.

b. Reinforced Thermoplastic Structural Shapes (RTSS) includes a thermoplastic matrix reinforced with chopped fiberglass filaments and continuous FRP reinforcing bars meeting the requirements of this Section. Steel reinforcing bars are not permitted.

973-5.2 Materials: Use polyethylene made from recycled post consumer or post industrial thermoplastics. Mix the polyethylene with appropriate colorants, UV inhibitors, hindered amine light stabilizers, antioxidants, and chopped fiberglass reinforcement so that the resulting product meets the requirements specified in Table 973-4 for RTSS and Table 973-5 for TSS. Use a minimum of 15% (by weight) chopped fiberglass reinforcement for both TSS and RTSS. The thermoplastic matrix must not corrode, rot, warp, splinter or crack. Meet the requirements of 932-3 for FRP reinforcing bar materials.

For RTSS members, the use of separate materials for skin and core is at the discretion of each manufacturer; however, both materials must meet the requirements in Table 973-4. The material surrounding the rebar within 1 inch from the rebar surface shall not contain voids greater than 3/4 inch diameter and extend no further than 2 inches along the length of the member. The cross section of the product shall not contain voids exceeding 1-1/4 inches in diameter and the sum of all voids greater than 3/8 inches in diameter shall not exceed 5% of the cross sectional area.

Extrude final product as one continuous piece with no joints or splices to the dimensions and tolerances in accordance with Table 973-6.

Reject any sections containing cracks or splits.

Table 973-4
RTSS Matrix

Property	Test Method	Requirement
Density	ASTM D792	48–63 pcf
Water Absorption	ASTMD570	2 hrs: <1.0% weight increase 24 hrs: <3.0% weight increase
Brittleness	ASTM D746	Brittleness temperature < minus 40°C
Impact Resistance	ASTM D256, Method A (Izod)	>0.55 ft-lbs/in
Hardness	ASTM D2240	44-75 (Shore D)
Ultraviolet	ASTM D4329 UVA	500 hours <10% change in Shore D Durometer Hardness

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Table 973-4 RTSS Matrix		
Property	Test Method	Requirement
Abrasion	ASTM D4060	Weight Loss: <0.02 oz Cycles = 10,000 Wheel = CS17 Load = 2.2 lb
Chemical Resistance	ASTM D543	Sea Water: <1.5% weight increase Gasoline: <9.5% weight increase No. 2 Diesel: <6.0% weight increase
Tensile Properties	ASTM D638	2,200 psi at break min.
Compressive Modulus	ASTM D695	40 ksi min.
Static Coefficient of Friction	ASTM D1894	0.25, wet max.
Screw Withdrawal	ASTM D6117	400 lb (screw) min.

Table 973-5 TSS Matrix		
Property	Test Method	Requirement
Density	ASTM D792	50-65 pcf
Impact Resistance	ASTM D256 Method A (Izod)	>0.55 ft-lbs/in
Hardness	ASTM D2240	44-75 (Shore D)
Ultraviolet	ASTM D4329 (UVA)	500 hours <10% change in Shore D Durometer Hardness
Chemical Resistance	ASTM D756 or ASTM D543	Sea Water: <1.5% weight increase Gasoline: <7.5% weight increase No. 2 Diesel: <6.0% weight increase
Tensile Properties	ASTM D638	3,000 psi at break min.
Static Coeffecient of Friction	ASTM D2394	0.25, wet or dry min.
Nail Withdrawal or Screw Withdrawal	ASTM D6117	250 lb (nail) min. 400 lb (screw) min.
Secant Modulus at 1% Strain	ASTM D6109	150,000 psi min.
Flexural Strength	ASTM D6109	2,500 psi min.
Compressive Strength	ASTM D6108	2,200 psi min.
Compressive Strength Perpendicular to grain	ASTM D6108	700 psi min.

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Table 973-6 Tolerances	
Dimension	Tolerance
Length	0/+6 inch
Width – RTSS Width – TSS	±1/2 inch ±1/4 inch
Height – RTSS Width – TSS	±1/2 inch ±1/4 inch
Clear cover from outer surface to rebar elements (RTSS)	≥3/4 inch (wales) ±1/2 inch (other)
Straightness (while lying on a flat surface)	<1-1/2 inches per 10 feet

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SECTION 974
SURFACE APPLICATIONS

974-1 Description.

This section specifies the material requirements for detectable warnings, patterned pavement and green-colored pavement markings.

974-2 Detectable Warnings.

Provide detectable warnings in accordance with the Americans with Disabilities Act Standards for Transportation Facilities, Section 705. Provide detectable warnings consisting of materials intended for exterior use subject to routine pedestrian traffic and occasional vehicular traffic. Provide detectable warnings with size and pattern comprised of truncated domes aligned in parallel rows. Detectable warnings with a diagonal pattern are not permitted. Detectable warnings consisting of truncated domes fabricated in the field are not permitted.

974-2.1 Approved Product List Submittal Requirements: Manufacturers seeking evaluation of products for inclusion on the APL shall submit an application in accordance with Section 6 and include the documentation identified in the Table 974-1. Documentation and reports must demonstrate that the product meets the requirements of this Section, Section 527, and the Standard Plans, Index 522-002.

Table 974-1

Documentation	Requirements
Product Photo	Displays the significant features of the product.
Technical Data Sheet	Uniquely identifies the product and includes product specifications, storage instructions, and recommended installation materials and equipment as applicable.
Product Label	For each component of the product system.
Safety Data Sheet (SDS)	SDS meeting OSHA requirements for product and manufacturer recommended installation materials as applicable. Non-Hazardous, per RCRA Subtitle C Table 1 of 40 CFR 261.24 “Toxicity Characteristic” and not exude fumes which are hazardous, toxic, or detrimental to persons or property.
AASHTO Product Evaluation & Audit Solutions Test Report or Independent Laboratory Test Report	Testing must be conducted using the Project Work Plan for AASHTO Product Evaluation & Audit Solutions Laboratory Testing of Detectable Warning Systems, using the cold exposure category [i.e., 4 repetitions of the following exposure series: Abrasion (4 cycles) followed by freeze-thaw (15 cycles)].
Independent Laboratory Test Report	Test CAP Y in accordance with ASTM E1349.
Installation Instructions	Surface preparation and installation procedures for different substrates. The minimum curing time prior to installing the product for surface-applied materials.

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Table 974-1	
Documentation	Requirements
Product Sample	Submit upon request from the Department. If the product is a system, a sample of each component must be submitted.

974-2.2 Performance Requirements: Provide detectable warnings that meet the performance requirements of Table 974-2. Manufacturers shall provide before exposure testing and proof that the product has been submitted for exposure testing. All testing shall be complete by July 1, 2023.

Table 974-2		
Property	Documentation	Test Value
Domes and Spacing Dimensional Testing[1]	Provide Test Report[2] or Independent Laboratory Test Report	Meets the requirements of the Americans with Disabilities Act Standards for Transportation Facilities, Section 705.
Slip Resistance[1]	Provide Test Report[2] or Independent Laboratory Test Report	Dry Coefficient of Friction – 0.8 min. Wet Coefficient of Friction – 0.65 min. (include recessed areas between truncated domes).
Visual and Microscopic Evaluation[1]	Provide Test Report[2] or Independent Laboratory Test Report	No lifting, debonding, flaking, missing domes, partial domes, or significant cracking.
Bond Strength on Uncured (≤ 72 hours) Concrete Panel [AASHTO T 388]	Independent Laboratory Test Report	For surface applied detectable warning systems installed on uncured concrete: 150 psi min. with an elapsed concrete panel cure time of less than 72 hours.
Color/Contrast [1,3] [ASTM G155 / D4355]	Independent Laboratory Test Report	Color: CAP Y Safety Yellow: 25 – 45 Brick Red: 5 – 15 Black: 0 – 5

[1] Report values before and after exposure testing.
[2] Test report from AASHTO Product Evaluation & Audit Solutions
[3] 1,000 hours, UV exposure only.

974-3 Patterned Pavement.

Provide patterned pavement products that produce an adherent, weather resistant, friction resistant, and wear resistant surface that meets the requirements of this Section, and Section 523.

Material color and friction elements shall be integral and homogenous.

Patterned pavement installations requiring removal of pavement are not permitted.

974-3.1 Approved Product List Submittal Requirements: Manufacturers seeking evaluation of products for inclusion on the APL shall submit an application in accordance with Section 6 and include the documentation identified in Table 974-3. Documentation and reports must demonstrate that the product meets the requirements of this Section and Section 523.

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Table 974-3	
Documentation	Requirements
Product Photo	Displays the significant features of the product.
Technical Data Sheet	Uniquely identifies the product and includes product specifications, storage instructions, and recommended installation materials and equipment as applicable. Include the following information as applicable: 1. Use on concrete surfaces. 2. Use on asphalt surfaces. 3. Patterns, textures, and templates. 4. Resin, sealers, coatings, coloring, and friction materials. 5. Friction material source and rate of application.
Product Label	For each component of the product system.
Safety Data Sheet (SDS)	SDS meeting OSHA requirements for each material used in the product system. Non-Hazardous, per RCRA Subtitle C Table 1 of 40 CFR 261.24 "Toxicity Characteristic" and not exude fumes which are hazardous, toxic, or detrimental to persons or property.
Installation Instructions	Surface preparation and installation procedures for different substrates.
Product Sample	Submit upon request from the Department. A sample of each component must be submitted.

974-3.2 Performance Requirements: Provide patterned pavement products that meet the performance requirements of Table 974-4.

974-3.2.1 Department Testing: Submit product samples and panels for Department analysis upon request from the Department and in accordance with this Specification. Products are subject to verification testing in accordance with this Section and infrared identification curve (2.5 to 15 µm) for the vehicle component.

974-3.2.2 Friction Resistance: In-service pavement markings shall maintain a DFT40 value of 40 or greater, or FN 40R value of 35 or greater for a three-year period as tested per FM 5-622-Part B.

Table 974-4		
Property	Documentation	Test Method and Value
Wear	Field Service Test Photos	Visual, Wearing shall not expose more than 15% of the underlying surface area as measured within the traveled way for 3 years.
Initial Friction Resistance [FM 5-622 Part A]	Department Testing Reports	Dynamic Friction Tester (DFT40) ≥ 50

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974-4 Green-Colored Pavement Markings.

Provide high-quality materials, producing an adherent, weather-resistant, friction-resistant, wear-resistant surface, and shall be uniformly distributed throughout the cross-sectional area. Color shall be integral and consistent throughout the installation.

974-4.1 Approved Product List Requirements: Manufacturers seeking evaluation of products for inclusion on the APL shall submit an application in accordance with Section 6 and include the documentation identified in Table 974-5. Documentation and reports must demonstrate that the product meets the requirements of this Section. Manufacturers must identify the materials for all components of the green-colored pavement marking materials system including friction materials.

Table 974-5

Documentation	Requirements
Product Photo	Displays the significant features of the product.
Technical Data Sheet	Uniquely identifies the product and includes product specifications, storage instructions, and shelf life.
Installation Instructions	Uniquely identifies the product and includes the following information as applicable: 1. Surface preparation and installation procedures for different substrates such as concrete and asphalt surfaces. 2. The minimum substrate curing time prior to installing the product. 3. Installation materials and equipment. 4. Resin, sealers, coatings, coloring, and friction materials. 5. Friction material source and rate of application. 6. Number of coats and the thickness of each coat.
Product Label	For each component of the product system. Labels must contain the following information as applicable: 1. Uniquely identifies the product name. 2. Address of the manufacturer. 3. Show the color, date of manufacture, and lot number. 4. Warning of any special handling or precautions of the material, as recommended by the manufacturer. 5. The two reactive component material shall be clearly marked with the volume of materials in units of gallons and the product name. 6. The thermoplastic material shall be clearly marked with the thickness of the preformed material in units of inches.
Product Packaging	The thermoplastic material shall be packaged in suitable biodegradable or thermo-degradable containers which will not adhere to the product during shipment and storage.

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Table 974-5	
Documentation	Requirements
Safety Data Sheet (SDS)	SDS meeting OSHA requirements for each product component and manufacturer recommended installation materials as applicable. Non-Hazardous, per RCRA Subtitle C Table 1 of 40 CFR 261.24 “Toxicity Characteristic” and not exude fumes which are hazardous, toxic, or detrimental to persons or property.
Independent Laboratory Test Report	Glass elements shall contain no more than 200 ppm by weight of lead or arsenic when tested in accordance with the Environmental Protection Agency (EPA) Testing Methods 3052, 6010B, and 6010C.
Independent Laboratory Test Report	Report color and friction before polishing in accordance with FM 5-622 Part A
Product Sample for Department Testing	Submit upon request from the Department. If the product is a system, a sample of each component must be submitted.
Product Panels for Department Testing	Submit upon request from the Department. Prepare panels in accordance with FM 5-622-Part A

974-4.2 Performance Requirements: Provide colored pavement products that meet the performance requirements of Table 974-6 and Table 974-7 this Section.

974-4.2.1 Department Testing: Submit product samples and panels for Department analysis upon request from the Department and in accordance with this Specification. Products are subject to verification testing in accordance with this Section and infrared identification test.

Table 974-6		
Property	Documentation	Test Method and Value
Color	Department Testing Reports	The daytime chromaticity (x, y), both before and after polishing and accelerated weathering, must fall within the box in Table 974-7.
Daytime Luminescence Factor (Y)	Department Testing Reports	Must be greater than or equal to 15, both before and after polishing and accelerated weathering. [FM 5-622 Part A]
Wear	Department Field Service Test Photos	Visual, Wearing shall not expose more than 15% of the underlying surface area as measured within the traveled way for 3 years.
Initial Friction Resistance	Department Testing Reports	Dynamic Friction Tester (DFT40) ≥ 50 in accordance with [FM 5-622 Part A]
In-service Friction Resistance]	Department Testing Report	Dynamic Friction Test (DFT40) value of 40 or greater in accordance with [FM 5-622 Part B

974-4.2.2 Green Color Requirements:

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Table 974-7 Daytime Chromaticity Coordinates for Green-Colored Pavement Marking Materials (Corner Points)				
	1	2	3	4
x	0.230	0.266	0.367	0.444
y	0.754	0.460	0.480	0.583

974-4.2.3 Pavement Distress: Pavement distress occurring after installation of colored pavement marking materials may result in removal from the APL, and require the manufacturer to mill, resurface, replace, and install with a product on the APL at no additional cost to the Department.

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SECTION 975
STRUCTURAL COATING MATERIALS

975-1 General Requirements.

975-1.1 General: Upon curing, all coatings and/or coating systems must produce an adherent coating that is visually uniform. The composition of the coating is left to the discretion of the manufacturer but the finished product shall meet all requirements of this Section. All coats of multi-coat systems shall be supplied by the same manufacturer. Multi-component coatings shall be prepackaged in the required ratios.

975-1.2 Environmental Requirements: Coating materials and their waste shall be characterized as non-hazardous as defined by Resource Conservation and Recovery Act (RCRA) Subarticle C rules, Table 1 of 40 CFR 261.24 Toxicity Characteristic.

Volatile Organic Compounds (VOC) shall be less than 3.5 pounds per gallon when tested in accordance with ASTM D3960.

975-1.3 Approved Product List (APL): All polymeric coating materials except the materials in 975-4 shall be listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their products shall submit the product data sheets, performance test reports from AASHTO Product Evaluation & Audit Solutions, or an independent laboratory showing that the product meets the requirements of this Section, a Product SDS or performance test reports showing percent weight compositional analysis including Chemical Abstract Number, ACGIH time weighted average and ceiling exposure limits for all components, lower and upper explosive limits, flash point, boiling point, amount of volatile organic compounds by weight, and specific gravity for each component of the coating system, and a APL application in accordance with Section 6.

975-1.4 Packaging and Labeling: Materials shall be shipped in containers legibly marked with application instructions, lot number, batch number, date of manufacture, shelf life, and Department APL number. Each lot or batch manufactured must have a unique number.

975-1.5 Coating Identification: When applicable, the Department will conduct Fourier Transform Infrared Spectroscopy (FTIR) analysis on coating system components for material identification.

975-2 Structural Steel Coating Systems.

975-2.1 General: Structural steel coatings shall meet the application requirements of Section 560. Prepare and coat sixteen flat and four composite test panels in accordance with AASHTO R-31 (in color White, Grey, or Green) for each coating system proposed for approval and submit to the State Materials Office (SMO). Samples will be subject to verification testing by the Department, as identified in 975-2.2. In addition, submit a 1-quart wet sample of each component of each coating system, one container of compatible caulk to the SMO.

975-2.2 Performance Requirements: Each coating system will be subject to the testing identified in 975-2.2.1 and 975-2.2.2. All coatings, regardless of color, shall meet the requirements in Table 975-1.

975-2.2.1 Random Laboratory Verification Testing: Prepare and coat twelve flat test panels for random laboratory verification testing.

975-2.2.2 Outdoor Exposure Testing: Prepare and coat eight test panels (four flat and four composite) for exposure at the Department's outdoor test site. Panels will be tested in accordance with ASTM G7.

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Table 975-1 Structural Steel Coating System Performance Requirements		
Laboratory Testing		
Property	Test Method	Acceptance Criteria
Slip Coefficient	AASHTO R 31 Test No. 1	Min. Class B (primer only)
Salt Fog Resistance	AASHTO R 31 Test No. 2 ASTM D610	Blister Value = 10 Average Rust Creep at the Scribe ≤ 3/32” Rust grade ≥ 9S, 9G, 9P after 8,760 hours
Salt Fog Resistance Unscribed		Blister Value = 10 Rust grade ≥ 9S, 9G, 9P after 8,760 hours
Cyclic Weathering Resistance	AASHTO R 31 Test No. 3	Blister Value = 10 Average Rust Creep at the Scribe ≤ 6/32”, Color Retention $\Delta E^*_{ab} \leq 8.0$, Gloss loss≤ 33% after 15 cycles – 336 hours each cycle
Abrasion Resistance	AASHTO R 31 Test No. 4	Wear Index ≤ 2.7 mg/cycle
Adhesion	ASTM D4060 1,000 Cycles, CS-17 Wheel, 1 kg. Weight	Avg. system tensile strength ≥ 800 psi
2-Year Outdoor Testing		
Property	Test Method	Acceptance Criteria
Rusting	ASTM D610 ASTM D1654 a (scribed) ASTM D1654 (un-scribed)	Rust Grade ≥ 9S, 9G, 9P Rating of Failure at Scribe ≥ 9 After 2-Years
Blistering	ASTM D714	Blister Value = 10 After 2-Years
Adhesion	ASTM D4541; annex A4	Avg. Tensile Strength ≥ 800 psi (un-scribed area) After 2-Years
Color Retention	ASTM D2244	Avg. $\Delta E^*_{ab} \leq 8.0$ After 2-Years
Gloss	ASTM D523	Avg. ≤ 33% loss of gloss After 2-Years

975-2.3 Structural Steel Coating Systems for New Structures: Systems must meet the general composition requirements of Table 975-2 and this section.

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Table 975-2 Structural Steel Coating System General Composition Requirements			
Primer	Intermediate	Finish	Clear (Optional)
Inorganic Zinc-Rich Ethyl Silicate	None	Inorganic Ethyl Silicate	Manufacturers Recommendation
Inorganic Zinc-Rich Ethyl Silicate	Cycloaliphatic Amine Epoxy Or Polyamide Epoxy	Polyurethane	
		Polysiloxane	
		Acrylic	
		Fluoropolymer	
Inorganic Zinc-Rich Ethyl Silicate	Polyurethane (Epoxy Stripe)	Fluoropolymer	

975-2.3.1 High Performance Coating Systems (Color Pigmented):

975-2.3.1.1 Prime Coat: Provide inorganic zinc-rich primers consisting of zinc dust, functional additives, and an inorganic binder, with appropriate solvents. The composition of the primer shall consist of an inorganic self-curing vehicle, that contains solvent-reducible silicates, titanates, and polymeric versions of the silicates. Zinc dust pigment shall contain a minimum of 77% zinc dust by weight and a maximum lead level of 0.01% in accordance with ASTM D520. The manufacturer shall identify the amount of zinc dust on the product label. The performance requirements for gloss and color retention are not applicable.

975-2.3.1.2 Intermediate Coat: Intermediate coatings must meet Table 975-2. Epoxies must be a cycloaliphatic amine or polyamide.

975-2.3.1.3 Finish Coat: The finish coat shall provide the color and gloss required for the completed coating system. A finish coat may be comprised of a single pigmented coat or a pigmented coat with a clear coat that meets Table 975-2.

975-2.3.1.4 Clear Coat: The clear coat may contain a dissipating colorant. The dissipating colorant shall be visible for a minimum of 12 hours after application and shall completely dissipate within 96 hours after application.

975-2.3.2 Interior Box Girder Coating: The interior coat shall be one coat of white epoxy paint meeting 975-2.3.1.2 and listed on the Department's APL. Faying surfaces and areas to be stud welded are to be masked off and coated with a zinc-rich primer from the APL. The performance requirements for gloss and color retention are not applicable.

975-2.4 Structural Steel Coating Systems for Existing Structures: Systems must meet the general composition requirements of Table 975-3 and this section.

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<table>
<tr><th colspan="4">Table 975-3
Structural Steel Coating System General Composition Requirements</th></tr>
<tr><th>Primer</th><th>Intermediate</th><th>Finish</th><th>Clear (Optional)</th></tr>
<tr><td>Organic Zinc-Rich Epoxy
Or
Inorganic Zinc-Rich Ethyl Silicate</td><td>None</td><td>Inorganic Ethyl Silicate</td><td rowspan="5">Manufacturers Recommendation</td></tr>
<tr><td rowspan="4">Organic Zinc-Rich Epoxy
Or
Inorganic Zinc-Rich Ethyl Silicate</td><td rowspan="4">Cycloaliphatic Amine Epoxy
Or
Polyamide Epoxy</td><td>Polyurethane</td></tr>
<tr><td>Polysiloxane</td></tr>
<tr><td>Acrylic</td></tr>
<tr><td>Fluoropolymer</td></tr>
</table>

975-2.4.1 Prime Coat: Provide inorganic or organic zinc-rich primers consisting of zinc dust, functional additives, and an organic binder with appropriate solvents. The composition of the primer shall consist of an organic vehicle that may chemically cure or may dry by solvent evaporation. Zinc dust pigment shall contain a minimum of 77% zinc dust by weight and a maximum lead level of 0.01% accordance with ASTM D520.

Organic zinc-rich primers shall be used as galvanizing repair compounds for areas greater than 100 square inches.

975-2.4.2 Intermediate Coat: Intermediate coatings must meet Table 975-3 E. Epoxies must be a cycloaliphatic amine or polyamide.

975-2.4.3 Finish Coat: Finish coating shall provide the color and gloss required for the completed coating system. A finish coat may be comprised of a single pigmented coating or a pigmented coating with a clear coat.

975-2.4.4. Clear Coat: The clear coat may contain a dissipating colorant. The dissipating colorant shall be visible for a minimum of 12 hours after application and shall completely dissipate within 96 hours after application.

975-3 Galvanized Steel Coating System.

Coatings applied over galvanized steel shall meet the requirements of Table 975-2 with the exception that test panels shall be galvanized in accordance with ASTM A123 prior to application of subsequent coatings.

Coatings applied over galvanized steel strain poles, mast arms, and monotube assemblies shall meet the requirements of Section 649 and 975-4.

975-4 Paint for Galvanized Steel Strain Poles, Mast Arms, Monotube Assemblies, Conventional Light Pole Assemblies, and Aluminum Poles, Pedestals, and Posts.

Paint systems shall meet the color requirements as specified in the Contract Documents. All paint systems shall possess physical properties and handling characteristics that are compatible with the application requirements of Section 649 for galvanized steel and Section 646 and 715 for aluminum. Materials shall be specifically intended for use over galvanized steel or aluminum, as appropriate. Paint systems shall exhibit no loss of adhesion or total color difference (ΔE^*_{ab}) greater than 8.0 units for five years after final acceptance as specified in 5-11. Cumulative surface area of delamination in excess of 100 square inches will constitute an adhesion failure. Delamination shall be defined as any area of exposed metal surface subsequent

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to hand tool cleaning in accordance with SSPC-SP2. A ΔE^*_{ab} value exceeding 8.0 units per the International Commission on Illumination L*a*b* 1976 (CIELAB) space and color difference formula, measured in accordance with ASTM D2244, will constitute a color retention failure.

The Department will measure and enter in the Department's database the CIELAB color chromaticity coordinates for the color of the top coat of sample coupons provided as required by 649-4.3 using a BYK-Gardner Handicolor colorimeter using D65 illuminant and 2-degree geometry settings. The Department-measured CIELAB chromaticity coordinates shall define the initial color and will be used for resolution of color retention failures and the resolution of color retention disputes.

975-5 Elastomeric Coatings.

975-5.1 General: Use an elastomeric coating system to provide a waterproof barrier over post-tensioning anchorages or other areas designated in the Plans. The components of the coating system shall be supplied by a single manufacturer and sold as a waterproof coating system. The surface preparation and application of the coating system shall be performed in strict accordance with the manufacturer's specifications. Upon request, submit a one quart wet sample of each component of each coating system to the SMO.

975-5.2 Physical Properties: The use of an epoxy prime coat is dependent upon the requirements of the manufacturer's waterproofing system. The polyurethane chemistry may be either waterborne aromatic (moisture-curing) or aromatic (moisture-sensitive). The elastomeric coating shall meet the requirements in Table 975-4.

Table 975-4
Elastomeric Coatings Performance Requirements

Property	Test Method	Acceptance Criteria
Hardness, Shore A	ASTM D2240	Between 60 and 90
Tensile Strength	ASTM D412	≥750 psi
Elongation	ASTM D412	≥400%
Tear Strength	ASTM C957	>70 psi
Abrasion Resistance H-18 wheels 1,000 gm/wheel	ASTM C957	≤350 mg loss / 1,000 revs.
Crack Bridging 1,000 Cycles	ASTM C957	System Passes
Elongation Recovery	ASTM C957	≥94%

975-5.3 System Modifications for Use on Exposed External Anchorages: Provide the elastomeric coating system with a 100% acrylic aliphatic polyurethane top coating where required as shown on Standard Plans Index 462-002, or when applied to other exposed external surfaces. Manufacturers of the elastomeric coating system shall include the acrylic top coating as part of the elastomeric coating system for approval.

975-6 Class 5 Applied Finish Coatings.

975-6.1 General: All coatings shall possess physical properties and handling characteristics compatible with the application requirements of Section 400. Unless otherwise specified, the color of the finish coat shall meet FED-STD-595, Table VIII, Shade No. 36622, or No. 36642 for uncoated weathering steel bridges.

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975-6.2 Coating Requirements: Prepare four, 4 inch by 8 inch (except as required below) fiber cement test panels with a mass of 7 to 9 pounds per square foot of surface area to perform the laboratory tests. Apply the finish coating to each test panel at a rate of 50 square feet per gallon, plus or minus 10 square feet per gallon. Seal the corners of all test panels with a high build epoxy or equivalent to prevent moisture ingress at corners and cut edges. Submit the samples to an independent laboratory for testing. Coating performance shall meet the requirements in Table 975-5. Upon request, submit a one quart wet sample of each component of each coating system to the SMO.

Table 975-5 Class 5 Applied Finish Coatings Performance Requirements		
Laboratory Testing		
Property	Test Method	Acceptance Criteria
Resistance to Wind Driven Rain	ASTM D6904	No visible water leaks, and if the rear face of the block is damp, the average gain in weight of the three 8”x16”x2” blocks must be less than 0.2 lb.
Freeze thaw resistance	AASHTO R 31	No disbondment
Water Vapor Transmission	ASTM D1653; Method B, Condition C	WVT≥10 perms
Abrasion Resistance	ASTM D968, 3,000 liters of sand	No loss of coating thickness ASTM D6132
Salt Spray (fog) resistance	ASTM B117, 2,000 hours	No disbondment
Fluorescent UV-Condensation Exposure	ASTM D4587, 2000 hours, 4 hours UV, 4 hours condensation	No blistering (ASTM D714), cracking (visual), or delamination (visual). chalking (ASTM D4214Method D) rating no less than 8.
Fungal Resistance	ASTM D3273	Rating of 10, ASTM D3274

975-7 Anti-Graffiti Coating Materials.

975-7.1 General Requirements: Anti-graffiti coatings intended for use under this specification shall be of a composition capable of preventing the adhesion of and facilitating the removal of acrylic, polyurethane, and alkyd spray paint. All anti-graffiti coatings shall possess the physical and handling characteristics that are compatible with the requirements of Section 563. The manufacturer shall designate non-sacrificial products as water cleanable in accordance with this Section.

Anti-graffiti coatings shall contain less than 5.0 pounds per gallon volatile organic compounds (VOC) as defined by 40 CFR Part 59, Subpart D, evaluated as per ASTM D3960.

The manufacturer shall supply the following additional information:

1. Technical data sheet that includes installation instructions and graffiti removal instructions by pressure washing with water.
2. Sacrificial Coating Removal instructions, as applicable.

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3. Certification that non-sacrificial anti-graffiti coating shall not blister, crack, check, chalk, delaminate, or exhibit a color change of more than 8 dE94 (or dE76) CIE LAB units for a period of one year after installation.

975-7.2 Performance Requirements: For laboratory testing, use flat test panels prepared in accordance with AASHTO R 31.

Outdoor exposure testing will be performed by the Department, if applicable. Submit four, 4 inch by 8 inch fiber cement test panels to the SMO. Panels will be exposed at the Department's outdoor test site in accordance with ASTM G7. Coating performance shall meet the requirements in Table 975-6.

Upon request, submit a one quart wet sample of each component of each coating system to the SMO.

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Table 975-6 Anti-Graffiti Coatings Performance Requirements		
Outdoor Exposure Testing – Non-Sacrificial		
Property	Test Method	Acceptance Criteria
Graffiti Resistance (water cleanable)	FM 5-580: 6 months exposure at FDOT test site (2500 psi using pressure washer)	Complete removal of solvent based acrylic, and alkyd based spray paint. No delamination or visual defects.

Laboratory Testing - Sacrificial		
Property	Test Method	Acceptance Criteria
Cyclic Weather Testing	AASHTO R 31: no salt fog, 95°F, 0%- 90% Relative Humidity, 500 hours, alternating RH every 100 hours	No melting or disbondment
Outdoor Exposure Testing - Sacrificial		
Property	Test Method	Acceptance Criteria
Sacrificial Coating removability	FM 5-580: 6 months exposure at FDOT test site (2500 psi using pressure washer)	Complete removal of solvent based acrylic, and alkyd based spray paint from substrate

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SECTION 981
TURF MATERIALS

981-1 General.

The types of seed and sod will be specified in the Contract Documents. All seed and sod shall meet the requirements of the Florida Department of Agriculture and Consumer Services and all applicable state laws, and shall be approved by the Engineer before installation.

All seed, sod and mulch shall be free of noxious weeds and exotic pest plants, plant parts or seed listed in the current Category I "List of Invasive Species" from the Florida Exotic Pest Plant Council (FLEPPC, https://www.fleppc.org). Any plant officially listed as being noxious or undesirable by any Federal Agency, any agency of the State of Florida or any local jurisdiction in which the project is being constructed shall not be used. Any such noxious or invasive plant or plant part found to be delivered in seed, sod or mulch will be removed by the Contractor at his expense and in accordance with the law.

All materials shall meet plant quarantine and certification entry requirements of Florida Department of Agriculture & Consumer Services, Division of Plant Industry Rules.

981-2 Seed.

The seed shall have been harvested from the previous year's crop. All seed bags shall have a label attached stating the date of harvest, LOT number, percent purity, percent germination, noxious weed certification and date of test.

Each of the species or varieties of seed shall be furnished and delivered in separate labeled bags. During handling and storing, the seed shall be cared for in such a manner that it will be protected from damage by heat, moisture, rodents and other causes.

All permanent and temporary turf seed shall have been tested within a period of six months of the date of planting.

All permanent and temporary turf seed shall have a minimum percent of purity and germination as follows:

1. All Bahia seed shall have a minimum pure live seed content of 95% with a minimum germination of 80%.
2. Bermuda seed shall be of common variety with a minimum pure live seed content of 95% with a minimum germination of 85%.
3. Annual Type Ryegrass seed shall have a minimum pure live seed content of 95% with a minimum germination of 90%.

981-3 Sod.

981-3.1 Types: Unless a particular type of sod is called for in the Contract Documents, sod may be either centipede, bahia, or bermuda at the Contractor's option. It shall be well matted with roots. Where sodding will adjoin, or be in sufficiently close proximity to, private lawns, other types of sod may be used if desired by the affected property owners and approved by the Engineer.

981-3.2 Dimensions: The sod shall be taken up in commercial-size rectangles, or rolls, preferably 12 inches by 24 inches or larger, except where 6 inch strip sodding is called for, or as rolled sod at least 12 inches in width and length consistent with the equipment and methods used

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to handle the rolls and place the sod. Sod shall be a minimum of 1-1/4 inches thick including a 3/4 inch thick layer of roots and topsoil. Reducing the width of rolled sod is not permitted after the sod has been taken up from the initial growing location. Any netting contained within the sod must be certified by the manufacturer to biodegrade within one year.

981-3.3 Condition: The sod shall be sufficiently thick to secure a dense stand of live turf. The sod shall be live, fresh and uninjured, at the time of planting. It shall have a soil mat of sufficient thickness adhering firmly to the roots to withstand all necessary handling. It shall be planted within 48 hours after being cut and kept moist from the time it is cut until it is planted. No sod which has been cut for more than 48 hours may be used unless specifically authorized by the Engineer. A letter of certification from the turf Contractor as to when the sod was cut, and what type, shall be provided to the Engineer upon delivery of the sod to the job site.

The source of the sod may be inspected and approved by the Engineer prior to being cut for use in the work.

981-4 Mulch.

The mulch material shall be compost meeting the requirements of Section 987, hardwood barks, shavings or chips; or inorganic mulch materials as approved by the Engineer; or hydraulically applied wood fiber mulch or bonded fiber matrix (BFM) for the establishment of turf material.

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SECTION 982
FERTILIZER

982-1 Fertilizers.

Fertilizers shall comply with the State fertilizer laws.

The numerical designations for fertilizer indicate the minimum percentages (respectively) of total nitrogen, available phosphoric acid, and water-soluble potash, contained in the fertilizer. At least 50% of the nitrogen shall be from a slow-release source.

982-2 Certification.

The Engineer shall collect a copy of the fertilizer label and retain according to the FDOT retention policy. The label shall include guaranteed values for total nitrogen, available phosphoric acid, water-soluble potash, and sulfur.

982-3 Fertilizer Rates.

Soil laboratory fertilization recommendations are based on the amount (lbs) of nutrients (N, P_2O_5, K_2O) to apply per given area (usually 1,000 square feet.). From this recommendation it is necessary to select an appropriate fertilizer grade and then determine how much of this fertilizer to apply to the area.

If a complete fertilizer (containing all three primary nutrients) is not available in the ratio of N-P-K necessary to match the ratio required in the fertilizer recommendation, mixed-grade or single-nutrient fertilizers should be used to satisfy each nutrient requirement.

To calculate fertilizer rates:

1. Measure the area to be fertilized in square feet.
2. Select fertilizers to be used based on the soil testing laboratory recommendations by matching the ratio of nutrients recommended to the fertilizer grades available.
3. Determine the amount of fertilizer to apply to a given area (1,000 square feet.) by dividing the recommended amount of nutrient by the percentage of the nutrient (on a decimal basis) in the fertilizer. Apply no more than 0.25 lbs P_2O_5/1000 square feet per application prior to planting.
4. Adjust the amount of fertilizer to the project area.

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SECTION 983
WATER FOR GRASSING

The water used in the grassing operations may be obtained from any approved source. The water shall be free of any substance which might be harmful to plant growth. Effluent water shall meet all Federal, State and local requirements.

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SECTION 985
GEOSYNTHETIC MATERIALS

985-1 Description.

Geosynthetic materials are used for nonstructural and structural applications and shall be either geotextiles (woven or non-woven) or geogrids (woven or extruded) that are used for drainage, erosion control, reinforcement, separation or stabilization.

985-2 General Requirements.

985-2.1 Product Acceptance: All geosynthetic materials shall be one of the products listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of products for inclusion on the APL shall submit an application in accordance with Section 6 and include the following documentation. A separate application must be submitted for each geotextile type to be evaluated, showing that the product meets the applicable requirements.

Documentation	Requirements
Installation Instructions	Include surface preparations, installation, overlap or sewing instructions, and repair procedures.
AASHTO Product Evaluation & Audit Solutions: Audit Report, for Structural Geosynthetic Materials Only	Manufacturer's facility included on list of compliant producers
AASHTO Product Evaluation & Audit Solutions: Test Results	Product meets requirements of this Section
Product Label Photo	Displays the Product Name
Product Photo	Displays the significant features of the product as required in this section. Displays location of Manufacturer name and model number.
Technical Data Sheet	Uniquely identifies the product and includes product specifications, reporting requirements, and storage instructions

Products will be listed on the APL according to the geosynthetic application type.

985-2.2 Material Application: In addition to the general requirements, meet the following physical requirements:

Drainage 985-3
Erosion Control 985-4
Structural 985-5

985-2.3 Materials: The geosynthetic material shall be a woven, non-woven or extruded material consisting of long-chain polymeric filaments or yarns such as polypropylene, polyethylene, polyester, polyamides or polyvinylidene chloride formed into a stable network such that the filaments or yarns retain their relative position to each other. The base plastic shall contain stabilizers and/or inhibitors to make the filaments resistant to deterioration due to ultra-violet light, heat exposure and potential chemically damaging environment. The edges of the material shall be selvaged or otherwise finished to prevent the outer yarn from pulling away from the material and shall be free of any treatment which may significantly alter its physical properties.

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985-2.4 Physical Requirements: Each geosynthetic material shall be tested by an independent third party in accordance with the methods shown. All testing and reported values, except Apparent Opening Size (AOS), are to be minimum average roll values in the weakest principal direction, unless indicated otherwise in this Section. Values for AOS are maximum average roll values.

985-2.5 Packaging and Labeling: Geosynthetics shall be packaged in a protective covering sufficient to protect the material from temperatures greater than 140 F, sunlight, dirt, and other debris during shipment and storage. The manufacturer's name, product name, style number, roll dimensions and LOT numbers must be clearly labeled on all packaging.

985-2.6 Overlaps and Seams: Overlaps shall be in accordance with the manufacturer's recommendations, unless specified otherwise in the Contract Documents for a particular application. To reduce overlaps, the geosynthetic material may be sewn together in accordance with the manufacturer's recommendations. Sew the seams with thread meeting the chemical requirements and minimum seam strength requirements for the application.

985-3 Drainage.

985-3.1 Application: Select geotextile materials based on the following applications:

Table 985-1
Drainage Applications

Geotextile Type	Description	Standard Plans Index
D-1	Revetment (Special)	
	Rock, Rubble without bedding stone	
	Ditch Pavement (Rubble Riprap) without bedding stone	524-001
D-2	Revetment (Standard)	
	Articulating Block	
	Gabions	524-001
	Rock, Rubble, and Broken Concrete with bedding stone	
	Ditch Pavement (Rubble Riprap) with bedding stone	524-001
	Joint Cover for Mechanically Stabilized Retaining Wall with Coarse Aggregate Backfill	
	Joint Cover for Mechanically Stabilized Retaining Wall Supporting Spread Footing Foundations	
D-3	Underdrain: Types II, III, and V	440-001
	French Drain	443-001
	Sheet Piling Filter	
	Filter Fabric Jacket (Culvert)	430-001
	Box Culvert Joints	400-289 and 400-291
	Concrete Pavement Subdrainage	446-001
	Joint Cover for Mechanically Stabilized Retaining Wall with Sand or Limerock Backfill	
D-4	Slope Pavement	
	Ditch Pavement (Sand-Cement Riprap or Concrete)	524-001

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Table 985-1 Drainage Applications		
Geotextile Type	Description	Standard Plans Index
	Coarse Aggregate Wrap	
D-5	Separation Geotextile	
	Cast-In-Place Retaining Wall	

985-3.2 Physical Requirements: Materials for drainage applications must be tested in accordance with and meet the following physical requirements:

Table 985-2 Geotextile Selection	
In-situ Soil Type or Drainage Application	Class for Type D1, D2, D3 Materials
< 15% passing a No. 200 Sieve*	a
15% to 50% passing a No. 200 Sieve*	b
> 50% passing a No. 200 Sieve*	c
> 50% passing a No. 200 Sieve* with Plastic Index >7	d
MSE Joint Cover for Sand or Limerock Backfill	e
MSE Joint Cover for Coarse Aggregate Backfill	f
*as per AASHTO T88.	

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Table 985-3 Drainage Geotextiles Test Methods and Requirements for Types D-1, D-2 and D-3			
Property/Test Method	D-1	D-2	D-3
Limitation	Woven Monofilament Geotextiles only	Woven Geotextiles only. No Slit Film Geotextiles	No Slit Film Geotextiles
Minimum Permittivity (Sec - 1) per ASTM D4491	D-1a = 0.7 D-1b = 0.2 D-1c = 0.1 D-1d = 0.1 D-1e = 0.25 D-1f = 1.5	D-2a = 0.7 D-2b = 0.2 D-2c = 0.1 D-2d = 0.1 D-2e = 0.25 D-2f = 1.5	D-3a = 0.5 D-3b = 0.2 D-3c = 0.1 D-3d = 0.1 D-3e = 0.7
Maximum AOS (mm, US Sieve No.) per ASTM D4751	D-1a = 0.425 (40) D-1b = 0.250 (60) D-1c = 0.212 (70) D-1d = 0.300 (50) D-1e = 0.212 (70) D-1f = 0.600 (30)	D-2a = 0.425 (40) D-2b = 0.250 (60) D-2c = 0.212 (70) D-2d = 0.300 (50) D-2e = 0.212 (70) D-2f = 0.600 (30)	D-3a = 0.425 (40) D-3b = 0.250 (60) D-3c = 0.212 (70) D-3d = 0.300 (50) D-3e = 0.212 (70)
Minimum Grab Tensile Strength (lbs) per ASTM D4632	315	Woven Monofilament = 248 Other Woven Geotextiles = 315	Elongation <50% = 248 Elongation ≥50% = 158
Mass per Unit Area (oz/sy) per ASTM D5261	Provide Test Result	Provide Test Result	Provide Test Result
Minimum Puncture Strength (lbs) per ASTM D6241	618	Woven Monofilament = 495 Other Woven Geotextiles = 618	Elongation <50% = 495 Elongation ≥50% = 309
Minimum Trapezoidal Tear (lbs) per ASTM D4533	113	Woven Monofilament = 57 Other Woven Geotextiles: = 113	Woven Monofilament = 57 Other Geotextiles: Elongation <50% = 90 Elongation ≥50% = 57
Minimum UV Resistance per ASTM D4355 (% Retained Strength)	50% @500 hours	50% @500 hours	50% @500 hours

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Table 985-4 Test Methods and Requirements for Drainage Geotextiles Types D-4 and D-5		
Property/Test Method	D-4	D-5
Minimum Permittivity (Sec^{-1}) per ASTM D4491	0.5	0.5
Maximum AOS (mm, US Sieve No.) per ASTM D4751	0.425 (40)	0.212 (70)
Minimum Grab Tensile Strength (lbs) per ASTM D4632	180	90
Mass per Unit Area (oz/sy) per ASTM D5261	Provide Test Result	Provide Test Result
Minimum Puncture Strength (lbs) per ASTM D6241	223	223
Minimum Trapezoidal Tear (lbs) per ASTM D4533	70	40
Minimum UV Resistance per ASTM D4355 (% Retained Strength)	50% @500 hours	50%@500 hours

985-4 Erosion Control.

985-4.1 Application: Materials may contain natural fibers added to acceptable plastic erosion mats for the sole purpose of facilitating turf growth. However, materials used for erosion control applications must be tested without any natural fiber components in accordance with and meet the physical requirements Table 985-6.

Table 985-5 Erosion Control Applications	
Type	Description
E-1	Staked Silt Fence
E-2	Wind Screen
E-3	Plastic Erosion Mat (Turf Reinforcement Mat) (Type 1)
E-4	Plastic Erosion Mat (Turf Reinforcement Mat) (Type 2)
E-5	Plastic Erosion Mat (Turf Reinforcement Mat) (Type 3)

985-4.2 Physical Requirements: Each geosynthetic material shall meet the following requirements:

Table 985-6 Test Methods and Requirements for Erosion Control Materials					
Property/Test Method	E-1	E-2	E-3	E-4	E-5
Permittivity (Sec^{-1}) per ASTM D4491	0.05	0.05	NA	NA	NA
Grab Tensile Strength (lbs) per ASTM D4632	90	90	NA	NA	NA
Minimum UV Resistance per ASTM D4355 (% Retained Strength)	80% @500 hours	80% @150 hours	80% @500 hours		
Tensile Strength **(lbs/ft) per ASTM D6818 or D5035	NA	NA	135x70	275x135	550x275

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Table 985-6 Test Methods and Requirements for Erosion Control Materials					
Property/Test Method	E-1	E-2	E-3	E-4	E-5
Filtration Efficiency (%) per ASTM D5141	75% and min. flow rate of 0.3 gal/sf/min	NA	NA	NA	NA
Design Shear***	NA	NA	≧2.1 psf	≧3.6 psf	≧5.0 psf
**Tensile Strength is expressed in units of measure of lbs/ft, in machine direction and cross direction as MD x CD. ***Design Shear limits for Erosion mats must be determined by 30 minutes sustained flow in an unvegetated state as determined by tests performed by Utah State University, Texas Transportation Institute or an independent testing laboratory approved by the State Drainage Engineer.					

985-5 Structural.

985-5.1 Applications: Materials for reinforcement, separation and stabilization applications must be tested in accordance with and meet the physical requirements below. The ultimate tensile strength of all R-1 materials must be at least 4800 pounds per foot in both the machine and cross machine directions.

Table 985-7 Reinforcement, Separation and Stabilization Applications	
Type	Description
R-1	Geosynthetic Reinforced Soil (GRS-IBS)
R-2	Reinforcement of Foundations over Soft Soils
R-3	Reinforced Soil Slopes
R-4	Reinforced Embankment
R-5	Construction Expedient

985-5.2 Physical Requirements: Each geosynthetic material shall be tested in accordance with the following requirements:

Table 985-8 Test Methods and Reporting Requirements for Structural Geosynthetics			
Property/Test Method	Structural Application Type	Test Methods for Woven Geotextiles	Test Methods for Woven or Extruded Geogrids
Permittivity (sec^{-1})	R - 1, 2, 3, 4, 5	ASTM D4491	NA
UV Stability (Min Retained Strength @500 hr)	R - 3	ASTM D4355	ASTM D4355
Puncture Strength (lbs)	R - 5	ASTM D6241	NA
Grab Strength (lbs)	R - 5	ASTM D4632	NA
Opening Size	R - 1, 2, 3, 4, 5	AOS (US Sieve No.) ASTM D4751	Aperture Size (in x in)
Tensile Strength (lbs/ft)		ASTM D4595	ASTM D6637
Machine Direction Ultimate, (T_{ult})			
2% Strain	R - 1, 3		
5% Strain	R - 2, 3, 4, 5		

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Table 985-8 Test Methods and Reporting Requirements for Structural Geosynthetics			
Property/Test Method	Structural Application Type	Test Methods for Woven Geotextiles	Test Methods for Woven or Extruded Geogrids
10% Strain	R - 1, 2, 3, 4, 5		
Cross Direction Ultimate			
2% Strain	R - 1, 3,		
5% Strain	R - 2, 3, 4, 5		
10% Strain	R - 1, 2, 3, 4, 5		
Strain @ Ultimate Tensile Strength	R - 1, 2, 3, 4, 5		
Tear Strength (lbs)		ASTM D4533	NA
Machine Direction	R - 5		
Cross Direction	R - 5		
Soil-Geosynthetic Friction	R - 1, 2, 3	ASTM D5321	ASTM D5321/6706
Pullout Resistance	R - 3	ASTM D6706	ASTM D6706
Creep Resistance-T_{creep} (lbs/ft)	R - 2, 3	ASTM D5262	ASTM D5262
Creep Reduction Factor (T_{ult}/T_{creep})	R - 2, 3	NA	NA
Installation Damage (RF_{ID})		AASHTO R69	AASHTO R69
Sand	R - 2, 3, 4		
Limestone	R - 2, 3, 4		
Durability (RF_D)		AASHTO R69	AASHTO R69
Chemical	R - 2, 3, 4		
Biological	R - 2, 3, 4		
Joint Strength (RF_j)			
Mechanical	R - 2, 3	GRI: GT7	GRI: GG4(a) & GG4(b)
Sewn	R - 2, 3	ASTM D4884	NA

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SECTION 987
SOIL LAYER MATERIALS

987-1 Description.

All material shall be suitable for plant growth. The organic matter content of the soil layer after mixing shall be a minimum of 2.5%, a maximum of 10%, in accordance with FM 1-T267 and have a pH value of 5.5 or greater and less than or equal to7.0 as determined in accordance with FM 5-550. The organic matter content shall be created using any of the following materials.

987-2 Materials.

Soil layer materials may be obtained from either, or a combination of, the following sources:

1. Excavation within the limits of construction on the project. Such material may be stockpiled or windrowed on the project in areas approved by the Engineer.
2. Designated borrow pits for the project.
3. From other sources of organic soil materials provided by the Contractor.

987-2.1 Organic Soil: This may consist of muck, mucky peat and peat and shall have an organic matter content of 30% or more if the mineral fraction is more than 50% clay, or more than 20% organic matter if the mineral fraction has no clay.

987-2.2 Blanket Material: Meet the material classification shown in the Plans and Standard Plans, Index 120-001.

987-2.3 Compost: Meet the requirements of Florida Department of Environmental Protection Rule 62.709.550 Type Y (yard waste), Type YM (yard waste and manure), Type A (municipal solid waste compost) or Rule 62.640.850 Type AA (composted biosolids) and have unrestricted distribution.

987-2.3.1 Compost for use as a Soil Amendment: If the electrical conductivity (EC) value of the compost exceeds 4.0dS (mmhos/cm) based on the saturated paste extract method, the compost shall be leached with water prior to application.

987-2.3.2 Compost for use as a Mulch: The compost shall contain no foreign matter, such as glass, plastic or metal shards. The compost shall be slightly coarse to coarse in nature (over half of the solids shall be from particles 1/2 inches in size and no greater than 6 inches). Preference shall be given to compost or mulch made from uncontaminated woody waste materials.

987-2.4 Landscape Soil: Landscape soil must be sandy loam or loamy sand with properties of AASHTO classification A-2-4 or A-4. The soil must have an organic matter content of 5 to 10% using the loss on ignition (LOI) test in accordance with FM 1-T267 from a soil testing laboratory approved in accordance with 105-7. Soil must be free of litter and deleterious substance such as cans, debris, particles greater than 0.50 inches, and rinsate containing lime or toxic materials.

Soil must be free of noxious plants or propagules of plants listed in Florida Rule 5B-57.007, and invasive exotic plants listed under Category I Florida Exotic Plant Pest Council.

Where shown in the Plans or when approved by the Engineer, existing soil may be amended with compost or biosolids to meet the requirements of this Section. Use compost in accordance with FDEP Rule 62.709.550 and 62.709.600. Use biosolids in accordance with Florida Rule 62.640.850.

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SECTION 990
TEMPORARY TRAFFIC CONTROL DEVICE MATERIALS

990-1 General.

This Section specifies the material requirements for temporary traffic control devices.

990-2 Retroreflective Sheeting for Temporary Traffic Control Devices.

990-2.1 Bands for Temporary Tubular Markers, Vertical Panels, Barricades, and other Devices: Bands for temporary tubular markers, vertical panels, barricades, and other devices shall meet the requirements of ASTM D4956 for Type III or higher retroreflective sheeting materials identified in Section 994.

990-2.2 Collars for Traffic Cones: Collars for traffic cones shall meet the requirements of ASTM D4956 Type III or higher retroreflective prismatic sheeting materials identified in Section 994 including supplementary requirements for reboundable sheeting. The outdoor weathering shall be for 6 months for all sheeting types.

990-2.3 Drums: Drums shall meet the requirements of ASTM D4956 for Type III or higher retroreflective sheeting materials identified in Section 994 including supplementary requirements for reboundable sheeting.

990-2.4 Sign Panels: Meet the requirements of 990-8.

990-3 Portable Devices (Arrow Boards, Changeable Message Signs, Regulatory Signs, Radar Speed Display Units and Truck Mounted Changeable Message Signs), Automated Flagger Assistance Devices).

990-3.1 General: All portable devices shall meet the physical display and operational requirements of the Manual on Uniform Traffic Control Devices (MUTCD) and be listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their product must submit the following:

1. Certification showing that the product meets the requirements of this Section.

2. Drawings of the device along with technical information necessary for proper application, field assembly, and installation.

Portable devices shall meet the following requirements:

3. Ensure that all assembly hardware less than 5/8 inch in diameter, including nuts, bolts, external screws and locking washers are Type 304 or 316 passivated stainless steel. Stainless steel bolts, screws and studs shall meet ASTM F593. Nuts shall meet ASTM F594. All assembly hardware greater than or equal to 5/8 inch in diameter shall be galvanized. Bolts, studs, and threaded rod shall meet ASTM A307. Structural bolts shall meet ASTM F3125, Grade A325.

4. The controllers and associated on-board circuitry shall meet the requirements of the Federal Communications Commission (FCC) Title 47, Subpart B, Section 15 regulations concerning the emission of electronic noise by Class A digital devices. All electronic assemblies shall meet the requirements of NEMA TS-4-2016 Section 2.

5. The controller and associated on-board circuitry shall not be affected by mobile radio, or any other radio transmissions.

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6. An operator's manual shall be furnished with each unit.

7. All portable devices shall be permanently marked with, manufacturer's name or trademark, model/part number, and date of manufacture or serial number.

8. Portable devices and trailers shall be delineated on a permanent basis by affixing retroreflective sheeting in a continuous line on the face of the trailer as seen by oncoming road users.

990-3.1.1 Electrical Systems:

990-3.1.1.1 Solar Powered Unit: The solar powered unit shall meet the following:

1. The unit shall provide automatic recharging of power supply batteries to normal operating levels with meters showing charge.

2. Solar array recovery time for arrow boards and regulatory signs shall be accomplished in a maximum of three hours.

3. Arrow boards and changeable message signs shall be designed to provide 180 days of continuous operation with minimum onsite maintenance.

990-3.1.1.2 Battery Life Test: Meet the following:

1. The photovoltaic unit shall be designed to provide 21 days of continuous operation without sunlight with a minimum of onsite maintenance for arrow boards and changeable message signs, or 10 days of continuous operation without sunlight with a minimum of onsite maintenance for regulatory signs and radar speed display units, or 2 days of continuous operation without sunlight with a minimum of onsite maintenance for Automated Flagger Assistance Devices signs.

2. The battery shall be equipped with a battery controller to prevent overcharging and over-discharging. An external battery level indicator shall be provided.

3. The battery, controller, and power panel shall be designed to be protected from the elements and vandalism.

4. Automatic recharging of power supply batteries shall be provided with charge indicator meter.

5. An AC/DC battery charger unit shall be provided.

990-3.1.2 Display Panel and Housing:

1. The display housing assembly shall be weather-tight.

2. Except for Automated Flagger Assistance Devices, the display assembly shall be equipped with an automatic dimming operational mode capable of a minimum of 50% dimming and a separate manual dimmer switch

3. The display panel background and frame for the display assembly shall be painted flat black and shall meet Federal Specification TT-E-489.

4. The display panel for arrow boards and changeable message signs, when raised in the upright position, shall have a minimum height of 7 feet from the bottom of the panel to the ground, in accordance with the MUTCD. The display panel for radar speed display units, when raised in the upright position, will have a minimum height of 5 feet from the bottom of the panel to the ground.

5. The regulatory speed sign panel for regulatory signs and radar speed display units, when raised in the upright position, shall have a minimum height of 7 feet from the bottom of the regulatory sign panel to the ground.

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6. The unit shall have an accessible mechanism to easily raise and lower the display assembly. A locking device shall also be provided to ensure the display panel will remain in the raised or lowered position.

7. The display panel for changeable message signs shall have a safety system to protect against the panel falling from the trailer to the roadway should the panel separate from the lift system.

990-3.1.3 Controller: The Controller shall meet the following:

1. Controller and control panel shall be housed in a weather, dust, and vandal resistant lockable cabinet.

2. Controller and associated on-board circuitry shall meet the requirements of the FCC Title 47, Subpart B, Section 15 regulations concerning the emission of electronic noise by Class A digital devices.

3. For changeable message signs and arrow boards ensure that the sign control software provides an on-site graphical representation that visibly depicts the message displayed on the sign face.

4. For changeable message signs, if remote communication is included, ensure that the sign controller is addressable through the Ethernet communications network using software that complies with the National Transportation Communications for ITS Protocol (NTCIP) 1101 base standard, including all amendments as published at the time of contract letting, the NTCIP Simple Transportation Management Framework, and conforms to Compliance Level 1. Ensure that the software implements all mandatory objects in the supplemental requirement SR-700-4.1.1-01, FDOT Dynamic Message Sign NTCIP Requirements, as published on the FDOT State Traffic Engineering and Operations Office web site at the time of contract letting. Ensure that the sign complies with the NTCIP 1102v01.15, 2101 v01.19, 2103v02.07, 2201v01.15, 2202 v01.05, and 2301v02.19 standards. Ensure that the sign complies with NTCIP 1103v02.17, section 3. Ensure that additional objects implemented by the software do not interfere with the standard operation of mandatory objects.

990-3.1.4 Support Chassis: The support chassis shall meet the following:

1. The support chassis shall be self-contained and self-supporting without the use of additional equipment or tools.

2. Both trailer and truck-mounted units are allowed for arrow boards and changeable message signs. Trailer mounted units are required for regulatory signs and radar speed display units. Automated Flagger Assistance Devices may be trailer or non-trailer units.

a. Trailer mounted unit:

1. The sign, power supply unit and all support systems shall be mounted on a wheeled trailer.

2. The trailer shall be equipped with Class A lights, using a plug adaptor.

3. The trailer shall be equipped with adjustable outrigger leveling pads, one on each of the four frame corners.

4. The trailer shall be designed to be set up at the site with its own chassis and outriggers, without being hitched to a vehicle.

5. The trailer shall be equipped with fenders over the tires and shall be made from heavy-duty material sufficient to allow a person to stand and operate or perform maintenance on the unit.

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6. The trailer shall meet all equipment specifications set forth in Chapter 316 of the Florida Statutes, and by such rule, regulation or code that may be adopted by the Department of Highway Safety and Motor Vehicles.

990-3.2 Portable Arrow Board:

990-3.2.1 Arrow Board Matrix:

1. The minimum legibility distance for various traffic conditions are based on the decision-sight distance concept. The minimum legibility distance is the distance at which a driver can comprehend the arrow board message on a sunny day or a clear night. The arrow board size that is needed to meet the legibility distance is listed as follows:

Table 990-1			
Type	Minimum Size	Minimum Number of Elements	Minimum Legibility Distance
B	30 by 60 inches	13	3/4 mile
C	48 by 96 inches	15	1 mile

Type B arrow boards may be used on low to intermediate speed (0 mph to 50 mph) facilities or for maintenance or moving operations on any speed facility. Type C arrow boards shall be used for all other operations on high-speed (50 mph and greater) facilities and may be substituted for Type B arrow boards on any speed facility.

2. Devices shall meet all arrow board displays identified in the MUTCD.

3. The element lens should be 5-3/4 inches in diameter. Smaller element lens diameters are permissible only if they provide an equivalent or greater brightness indication and meet the legibility criteria in 990-3.2.1(a).

4. The color of the light emitted shall be in accordance with the MUTCD.

5. There shall be a 360 degree hood for close-up glare reduction.

6. For solar powered arrow boards the bulbs shall provide a 350 candle power intensity for day use and an automatic reduction or dimming capacity for night use. The dimmed night operation shall provide adequate indication without excessive glare.

7. The flashing rate of the element shall not be less than 25 flashes or more than 40 flashes per minute as required in the MUTCD.

8. The minimum element “on time” shall be 50% for the flashing arrow and 25% for the sequential chevron.

990-3.3 Portable Changeable Message Sign:

990-3.3.1 Message Matrix:

1. Message matrix panel shall be a maximum height of 7 feet by a maximum width of 146 inches.

2. The matrix must be capable of displaying three lines of 8 characters using an 18 inch or 12 inch font. PCMS with a minimum font size of 18 inches shall be used on any speed facility. PCMS with a minimum font size of 12 inches may be used on facilities with speed limits of 45 mph or less.

3. The matrix must display characters that meet or exceed the numeral and letter sizes prescribed in the MUTCD and SHS (Standard Highway Signs) companion document. Fonts and graphics must mimic the characteristics of fonts and graphics defined in NEMA TS4, the MUTCD, and SHS.

4. Similar components shall be interchangeable.

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990-3.3.2 Operation and Performance:

1. The message shall be displayed in upper case except when lower case is project specific and is allowed by the MUTCD.

2. The message matrix panel shall be visible from one-half mile.

3. The 18 inch letter height message shall be legible from 650 feet for nighttime conditions and 800 feet for normal daylight conditions.

4. The 12 inch letter height message shall be legible from 650 feet for nighttime conditions and 650 feet for normal daylight conditions.

5. Under variable light level conditions the sign shall automatically adjust its light source to maintain legibility.

6. The message panel shall have adjustable display rates, so that the entire message can be read at least twice at the posted speed.

7. The control panel shall have the capability to store a minimum 50 pre-programmed messages.

8. The controller in the control panel shall be able to remember messages during non-powered conditions.

9. The controller shall allow the operator to generate additional messages on site via the keyboard.

10. All messages shall be flashed or sequenced. In the sequence mode, the controller shall have the capability to sequence three line messages during one cycle.

990-3.4 Portable Regulatory Signs:

990-3.4.1 Sign Panel Assembly: The sign panel assembly shall consist of a 24 inches by 30 inches “SPEED LIMIT XX” sign panel and a “WHEN FLASHING” sign panel, intended to notify oncoming traffic the speed limit where workers are present. The sign panel assembly shall meet the following minimum physical requirements:

1. The sign panel shall fold down and be pinned in place for towing. Maximum travel height shall be 80 inches.

2. Construct the sign panel and light housing to allow the unit to be operated in the displayed position at speeds of 30 mph. Design the sign panel assembly to withstand transport speeds of 65 mph.

3. Construct the sign panel such that, when in the raised position, the sign panel will have a height of 7 feet from the bottom of the lowest panel to the ground, in accordance with the MUTCD.

4. Provide the unit with a mechanism to raise and lower the sign panel. Provide the unit with a device to lock the sign panel in the raised and lowered position.

990-3.4.2 Flashing Lights: Provide a pair of hooded PAR 46 LED advance warning flashing lamps on each side of the top of the sign panel. These lamps shall be visible day or night at a distance of one mile with a flash rate of approximately 55 flashes per minute.

The lamp lens should be at least 5-3/4 inches in diameter. Smaller diameter lens are permissible if they provide an equivalent or greater brightness indication and meet the legibility criteria above.

The color of the light emitted shall be in accordance with the MUTCD. For solar powered units, the bulbs shall provide a 350 candlepower intensity for day use and an automatic reduction or dimming capacity for night use. The dimmed night operation shall provide adequate indication without excessive glare.

990-3.5 Portable Radar Speed Display Unit:

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990-3.5.1 Display Unit Panel and Housing: Meet the requirements of 990-3.1.2 and the following physical requirements as a minimum:

1. Provide capability to mount a 24 inches by 30 inches regulatory sign with interchangeable numbers showing the posted speed limit above the message display.
2. Provide legend "YOUR SPEED" either above or below the message display.

990-3.5.2 Message Display: The message display shall meet the following physical requirements as a minimum:

1. Provide a bright LED, two-digit speed display on a flat black background with bright yellow LEDs.
2. Each digit shall contain either a seven-segment layout or matrix-style design. Each digit shall measure a minimum 18 inches in height.
3. Speed display shall be visible from a distance of at least one-half mile and legible from a distance of at least 650 feet under both day and night conditions.
4. Display shall adjust for day and night operation automatically with a photocell.

990-3.5.3 Radar: The radar unit shall not be affected by normal radio transmissions and meet the following physical requirements as a minimum:

1. Approach-Only sensor.
2. Equipped with a low power K-Band transmitter.
3. Part 90 FCC acceptance, 3 amps, 10.8 V_{DC} to 16.6 V_{DC}. Fuse and reverse polarity protected.
4. Range of 1,000 feet for mid-size vehicle, capable of accurately sensing speeds of 10 mph to 99 mph with over speed function that operates when a vehicle approaches over the posted speed limit.

990-3.6 Truck Mounted Changeable Message Sign:

990-3.6.1 General: Truck mounted changeable message signs shall meet the physical display and operational requirements of the MUTCD and be listed on the APL.

1. Sign shall be secured on the vehicle for normal operation.
2. A fault light shall be located on rear of the sign and operate whenever the sign is displaying a message. The light shall flash at the same rate as the message being displayed.
3. An operator's manual shall be furnished with each sign.
4. The manufacturer name, model or part number, and date of manufacture or serial number shall be permanently affixed to the sign housing.

990-3.6.2 Display Panel and Housing:

1. The housing maximum size shall not exceed a width of 96 inches.
2. The housing shall be designed to withstand exposure to the elements and include a locking device to secure the housing from unauthorized entry.
3. Provisions (by convection or fan) shall be made for heat dissipation within the unit.
4. The message matrix panel background and frame for the dynamic message assembly shall be painted flat black, Federal Specification TT-E-489.
5. The face of the display shall be easily opened from the front. Faces that open up shall be locked to stay open far enough to allow for servicing of all message panel components.

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6. The face of the sign shall be covered by an impact resistant polycarbonate face that aids against glare and includes an ultraviolet inhibitor to protect from fading and yellowing.

7. The display panel support structure, when raised in the upright position, shall be designed to allow for a minimum height of 7 feet from the bottom of the panel to the ground.

8. The unit shall have a manual and automatic control mechanism to raise and lower the display assembly. A locking device shall also be provided to ensure the display panel will remain in the raised or lowered position.

990-3.6.3 Message Matrix:

1. The matrix shall utilize light emitting diodes (LED).

2. LEDs used shall be amber (590 nm dominate wavelength) and shall meet the visibility requirements of this specification. LEDs shall have a viewing angle no less than 30 degrees. LED intensity shall not fall below 80 percent within three years.

3. All display modules shall be identical and interchangeable.

4. The matrix shall be capable of displaying a minimum of two lines of eight characters each, using a 10 inch font that meets the height to width ratio and character spacing requirements in the MUTCD, Section 2L.04 (paragraphs 05, 06, and 08) and Section 6F.60, paragraph 15.

5. The matrix shall provide variable letter, graphic and symbol sizes from 10 to 36 inches. The matrix must display characters that meet or exceed the numeral and letter sizes prescribed in the MUTCD and SHS companion document. Fonts and graphics must mimic the characteristics of fonts and graphics defined in NEMA TS4, the MUTCD, and SHS.

990-3.6.4 Electrical System:

1. The power supply shall be a 12 V_{DC} system designed to operate the sign with a dedicated battery that is charged by the vehicle electrical system, but isolated so it does not drain the vehicle battery.

2. All internal sign components shall be treated with a protective, weather-resistant polyurethane or silicone conformal coating to protect against the adverse effects of humidity and moisture.

990-3.6.5 Sign Controller:

1. The sign controller shall be housed inside the sign and shall be equipped with a security lockout feature to prevent unauthorized use.

2. An external weather-resistant, hand-held control keypad shall be used to display the message on the sign.

3. The sign controller shall have the capability to provide a predetermined or blank default message upon loss of controller function.

990-3.6.6 Operation and Performance:

1. The message shall be displayed in upper case.

2. The message matrix panel shall be visible from one-half mile. With a 10 inch character displayed, the sign shall be legible from a distance of 400 feet in both day and night conditions. Under variable light level conditions, the sign shall automatically adjust its light source to meet the 400 foot visibility requirement.

3. The sign shall have the capability to store a minimum of 40 common messages and graphics of which a minimum of 30 shall be user-programmable messages.

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4. All messages shall be capable of being flashed or sequenced. In the sequence mode, the message shall consist of no more than two phases, with each phase consisting of no more than three lines of text. Both message dwell time and message flash rate shall be individually programmable.

990-3.7 Automated Flagger Assistance Devices (AFAD):

990-3.7.1 General: AFAD's shall meet the physical display and operational requirements in the MUTCD and be listed on the APL. Manufacturers seeking evaluation of their product for the APL must include detailed vendor drawings showing typical application of the device in accordance with Standard Plans, Index 102-603. All electronic assemblies shall meet the requirements of NEMA TS-5-2017 Section 4.

990-3.7.2 Stop/Slow Automated Flagger Assistance Devices: Provide a remotely operated Stop/Slow AFAD including a Stop/Slow sign that alternately displays the stop face and the slow face of a Stop/Slow paddle.

When a gate arm is used, ensure that the gate arm descends to a down position across the approach lane of traffic when the stop face is displayed and then ascends to an upright position when the slow face is displayed.

Ensure the gate arm is fully retroreflectorized on both sides, with vertical alternating red and white stripes at 16 inch intervals measured horizontally in accordance with the MUTCD. When the arm is in the down position blocking the approach lane:

1. The minimum vertical aspect of the arm and sheeting shall be 2 inches; and,

2. The end of the arm shall reach at least to the center of the lane being controlled.

990-3.7.3 Red/Yellow Lens Automated Flagger Assistance Devices: Provide a remotely operated Red/Yellow Lens AFAD that alternately displays a steadily illuminated circular red lens and a flashing circular yellow lens to control traffic.

Ensure that the Red/Yellow Lens AFAD includes a gate arm that descends to a down position across the approach lane of traffic when the steady circular red lens is illuminated and then ascends to an upright position when the flashing circular yellow lens is illuminated.

Ensure that the gate arm is fully retroreflectorized on both sides, with vertical alternating red and white stripes at 16 inch intervals measured horizontally in accordance with the MUTCD. When the arm is in the down position blocking the approach lane:

1. The minimum vertical aspect of the arm and sheeting shall be 2 inches; and,

2. The end of the arm shall reach at least to the center of the lane being controlled.

Do not provide a change interval between the display of the steady circular red indication and the display of the flashing circular yellow indication. Provide a steady illuminated circular yellow indication, with at least a 5 second duration, between the transition from flashing circular yellow indication and the display of the steady circular red indication. The Engineer may approve a different duration, provided it falls within the range recommended by the MUTCD.

990-4 Removable Tape.

990-4.1 General: Removable tape shall be one of the products listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their product shall submit an

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application in accordance with Section 6. Evaluation of Removable Tape will utilize data from an independent laboratory or data from AASHTO Product Evaluation & Audit Solutions.

990-4.2 Composition: Removable tape shall be one of the products listed on the APL. The pavement stripes and markings shall consist of high quality plastic materials, pigments, and glass spheres or other retroreflective materials uniformly distributed throughout their cross-sectional area, with a reflective layer of spheres or other retroreflective material embedded in the top surface. No foil type materials shall be allowed.

990-4.3 Retroreflectivity: The white and yellow pavement markings shall attain an initial retroreflectance of not less than 300 mcd/m^2/lx and 250 mcd/m^2/lx, respectively. Black pavement markings shall have a retroreflectance of less than 20 mcd/m^2/lx. The retroreflectance of the white and yellow pavement markings at the end of the six-month period shall not be less than 150 mcd/m^2/lx.

990-4.4 Thickness: The APL will list the specified thickness of each approved product.

990-4.5 Durability and Wear Resistance: When properly applied, the material shall provide neat, durable stripes and markings. The materials shall provide a cushioned resilient substrate that reduces sphere crushing and loss. The film shall be weather resistant and, through normal wear, shall show no significant tearing, rollback or other signs of poor adhesion. Durability is the measured percent of pavement marking material completely removed from the pavement. The pavement marking material line loss must not exceed 5.0% of surface area.

990-4.6 Conformability and Resealing: The stripes and markings shall be capable of conforming to pavement contours, breaks and faults under traffic at pavement temperatures recommended by the manufacturer. The film shall be capable of use for patching worn areas of the same types of film in accordance with the manufacturer's recommendations.

990-4.7 Tensile Strength: The stripes and markings shall have a minimum tensile strength of 40 psi when tested according to ASTM D638. A rectangular test specimen 6 inches by 1 inch by 0.05 inches minimum thickness shall be tested at a temperature range of 40°F to 80ºF using a jaw speed of 0.25 inches per minute.

990-4.8 Elongation: The stripes and markings shall have a minimum elongation of 25% when tested in accordance with ASTM D638.

990-4.9 Plastic Pull test: The stripes and markings shall support a dead weight of 4 pounds for not less than five minutes at a temperature range of 70°F to 80ºF. Rectangular test specimen size shall be 6 inches by 1 inch by 0.05 inches minimum thickness.

990-4.10 Adhesive: Precoat removable tape with a pressure sensitive adhesive capable of being affixed to asphalt concrete and portland cement concrete pavement surfaces without the use of heat, solvents, and other additional adhesives or activators. Ensure that the adhesive does not require a protective liner when the removable tape is in rolled form for shipment. Ensure that the adhesive is capable of temporarily bonding to the roadway pavement at temperatures of 50ºF and the above without pick-up distortion by vehicular traffic.

990-4.11 Color: Meet the requirements of 971-1.6.

990-4.12 Removability: Ensure that the manufacturer shows documented reports that the removable tape is capable of being removed intact or in substantially large strips after being in place for a minimum of 90 days and under an average daily traffic count per lane of at least 5,000 vehicles per day at temperatures above 40ºF, without the use of heat, solvents, grinding or blasting.

990-5 Temporary Raised Pavement Markers (RPMs).

Temporary RPMs shall meet the requirements of Section 970.

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990-6 Temporary Glare Screen.

990-6.1 Design and Installation: Manufactured glare screen systems may be modular or individual units listed on the APL and shall meet the following requirements:

1. Glare screen units shall be manufactured in lengths such that when installed the joint between any one modular unit will not span barrier sections. Color shall be medium gray green, similar to AMS-STD-595A-34227.

2. Blades, rails and/or posts shall be manufactured from polyethylene, fiberglass, plastic, polyester or polystyrene, and be ultraviolet stabilized and inert to all normal atmospheric conditions and temperature ranges found in Florida.

3. For paddle type designs, the blade width shall not be more than 9 inches. Blades or screen for individual or modular systems shall be 24 inches to 30 inches high and capable of being locked down at an angle and spacing to provide a cut-off angle not less than 20 degrees.

4. For glare screen mounted on temporary concrete barrier, a strip (minimum 3-inch width and minimum 72 square inches) of reflective sheeting as specified in 994-2 must be placed on each side of a panel, centered in each barrier section (at a spacing not to exceed 15 feet) and positioned in such a manner as to permit total right angle observation by parallel traffic.

5. Prior to approval an impact test shall be performed by the manufacturer to verify the safety performance of the proposed system. The minimum impact strength of the posts, blades, rail and the barrier attachment design shall be sufficient to prevent the unit from separating from the barrier when impacted by a 3-inch outside diameter steel pipe traveling at 30 mph and impacting mid-height on the glare screen assembly.

6. All hardware shall be galvanized in accordance with ASTM A123 or stainless steel in accordance with AISI 302/305.

7. The anchorage of the glare screen to the barrier must be capable of safely resisting an equivalent tensile load of 600 pounds per foot of glare screen with a requirement to use a minimum of three fasteners per barrier section.

Alternative designs for temporary glare screen may be submitted as a Cost Savings Initiative Proposal in accordance with 4-3.9.

990-7 Temporary Traffic Control Signals.

990-7.1 General: Temporary traffic control signals shall meet the physical display and operational requirements of conventional traffic signal described in the MUTCD for portable traffic signals and be listed on the APL. The standard includes but is not limited to the following:

1. Use signal heads having three 12 inch vehicular signal indications (Red, Yellow and Green). Ensure there are two signal heads for each direction of traffic.

2. The traffic signal heads on this device will be approved by the Department.

3. Department approved lighting sources will be installed in each section in accordance with the manufacturer's permanent directional markings, that is, an "Up Arrow", the word "UP" or "TOP," for correct indexing and orientation within a signal housing.

4. The masts supporting the traffic signal heads will be manufactured with the lowest point of the vehicular signal head as follows:

a. Eight feet above finished grade at the point of their installation for "pedestal" type application or

b. Seventeen to 19 feet above pavement grade at the center of roadway for "overhead" type application.

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5. The yellow clearance interval will be programmed 3 seconds or more. Under no condition can the yellow clearance interval be manually controlled. It must be timed internally by the controller as per Department specifications.

6. The green interval must display a minimum of 5 seconds before being advanced to the yellow clearance interval.

7. The controller will allow for a variable all red clearance interval from 0 seconds to 999 seconds.

8. Portable traffic control signals will be either manually controlled or traffic actuated. Indicator lights for monitoring the signal operation of each approach will be supplied and visible from within the work zone area.

9. When the portable traffic control signals are radio actuated the following will apply:

a. The transmitter will be FCC Type accepted and not exceed 1 watt output per FCC, Part 90.17. The manufacturer must comply with all “Specific limitations” noted in FCC Part 90.17.

b. The Controller will force the traffic signal to display red toward the traffic approach in case of radio failure or interference.

10. The trailer and supports will be painted construction/maintenance orange enamel in accordance with the MUTCD color.

11. Ensure the certification number is engraved or labeled permanently on equipment.

12. Ensure the device has an external, visible, water resistant label with the following information: “Certification of this device by the Florida Department of Transportation allows for its use in Construction Zones Only”.

13. All electronic assemblies shall meet the requirements of NEMA TS-5-2017 Section 4.

990-8 Work Zone Signs.

990-8.1 Post Mounted Sign Supports:

990-8.1.1 General: Provide steel u-channel posts that conform to ASTM A499 Grade 60. For each u-channel post, punch or drill 3/8 inch diameter holes on 1 inch centers through the center of the post, starting approximately 1 inch from the top and extending the full length of the post. Ensure that the weight per foot of a particular manufacturer’s post size does not vary more than plus or minus 3.5% of its specified weight per foot. Taper the bottom end of the post for easier installation. Machine straighten the u-channel to a tolerance of 0.4% of the length.

990-8.2 Portable Sign Stands: Provide portable sign stands that meet the requirements of MASH TL-3.

990-8.2.1 Product Application: Manufacturers seeking inclusion on the APL must submit the following:

1. Product Drawing, which at a minimum includes:
   a. Model Number
   b. Sign panel size
   c. Allowable sign panel substrate material
   d. Height to bottom of sign panel
   e. Any field assembly details and technical information necessary for proper application and installation

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2. Crash testing reports.
3. All relevant FHWA Eligibility Letters.

990-8.3 Sign Panels: Use signs that meet the material and process requirements of ASTM D4956 and Section 994. Use Type VI sheeting for vinyl signs. Mesh signs must meet the color, daytime luminance, and non-reflective requirements of Section 994, Type VI. Use Type IV sheeting for fluorescent orange work zone signs. Incident management signs shall be Type VI fluorescent pink. Use Type IV and Type XI sheeting for all other work zone signs.

990-9 Temporary Raised Rumble Strips.

990-9.1 General: Temporary raised rumble strips shall meet the physical display and operational requirements in the MUTCD for temporary raised rumble strips and be listed on the APL. The temporary raised rumble strip may be either a removable striping type or a portable type described below:

990-9.1.1 Removable Striping Type:

Table 990-2	
Characteristic	Requirement
Composition:	Removable Polymer Striping Tape with pre-applied adhesive
Color:	White, Black or Orange
Cross-section:	0.25 in. to 0.50 in. (height) x 4 in. (wide)

990-9.1.2 Portable Type:

Table 990-3	
Characteristic	Requirement
Composition:	Molded Engineered Polymer, Steel or Aluminum
Weight	Internally ballasted to a minimum of 100 lbs. to maintain position in use without the use of adhesives or mechanical fasteners
Color:	White, Black or Orange
Shape	Beveled on the leading edge
Cross-section:	0.625 in. to 0.875 in. (height) x 12 in. to 14 in. (wide)

990-10 Temporary Barrier.

Producers of temporary concrete barrier seeking inclusion on the Department's Production Facility Listing shall meet the requirements of Section 105.

Manufacturers seeking evaluation of proprietary temporary barrier systems for inclusion on the APL must meet MASH TL-3 criteria and submit the following:

1. Product drawings, signed and sealed by a Professional Engineer registered in the State of Florida, which at a minimum must include:
   a. Freestanding and anchored details, as appropriate
   b. Section views and tables showing required setback distance (deflection space) for all installation configuration options
   c. Alignment and Length of Need requirements
   d. Transition and overlap details
   e. End treatment details
2. Installation manuals

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3. Crash testing reports
4. All relevant FHWA Eligibility Letters

990-11 Temporary Crash Cushion (Redirective or Gating).

Manufacturers seeking evaluation of crash cushions for inclusion on the APL must meet MASH TL-2 or TL-3 criteria and submit the following:

1. Product drawings, signed and sealed by a Professional Engineer registered in the State of Florida, which at a minimum must include:
    a. Anchorage details for both the crash cushion and abutting temporary barrier
    b. Tables showing the relevant system information and lengths for all options
    c. Length of need location
    d. Transition details
    e. List of all components
2. Installation manuals
3. Crash testing reports
4. All relevant FHWA Eligibility Letters

990-12 Truck Mounted Attenuators and Trailer Mounted Attenuators:

Equip truck mounted and trailer mounted attenuator units with lights and reflectors in compliance with applicable Florida motor vehicle laws, including turn signals, dual tail lights, and brake lights. Ensure that lights are visible in both the raised and lowered positions if the unit is capable of being raised.

Install either alternating black with yellow or white with orange sheeting on the rear of trailer mounted attenuators and truck mounted attenuators in both the operating and raised position. Use Type III (work zone) or Type IV sheeting consisting of 4 or 6 inch wide stripes installed to form chevrons that point upward. All sheeting except black must be retroreflective.

Manufacturers seeking evaluation of truck mounted attenuators or trailer mounted attenuators for inclusion on the APL must meet the MASH TL-2 or TL-3 criteria and submit the following:

1. Minimum and maximum support vehicle weights
2. User manuals
3. Crash testing reports
4. All relevant FHWA Eligibility Letters

990-13 Channelizing Devices.

990-13.1 General: Provide channelizing devices in accordance with the MUTCD and the dimensions shown in the Standard Plans.

990-13.2 Product Application: Manufacturers seeking inclusion of channelizing devices on the APL shall submit the following:

1. For Cones, Drums, and Temporary Tubular Markers:
    a. Photographs
    b. Drawings of sufficient detail to distinguish between similar devices
    c. Manufacturer self-certification of MASH compliant
2. For Barricades and Vertical Panels:
    a. Installations Instructions

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b. Photographs

c. Drawings (may be included in Installation Instructions) of sufficient detail to distinguish between similar devices

d. Any field assembly details and technical information necessary for proper application and installation

e. Crash testing reports demonstrating the device meets MASH TL-3

f. All relevant FHWA Eligibility Letters

990-14 Pedestrian Longitudinal Channelizing Devices.

990-14.1 General: Provide pedestrian Longitudinal Channelizing Devices (LCDs) in accordance with the MUTCD and the Standard Plans.

990-14.2 Product Application: Manufacturers seeking inclusion of pedestrian LCDs on the APL must submit the following:

1. Installations Instructions
2. Photographs
3. Drawings (may be included in Installations Instructions) of sufficient detail to distinguish between similar devices
4. Any field assembly details and technical information necessary for proper application and installation
5. Crash testing reports demonstrating the device meets MASH TL-3
6. All relevant FHWA Eligibility Letters

990-15 Flagger Equipment.

990-15.1 STOP/SLOW Paddles: Provide STOP/SLOW paddles with rigid handles in accordance with the MUTCD and the Standard Plans.

990-15.1.1 Product Application: Manufacturers seeking inclusion of STOP/SLOW Paddles on the APL must submit the following:

a. Photographs or drawings of sufficient detail to distinguish between similar devices

b. Manufacturer self-certification of MASH compliance

990-16 Portable Temporary Lane Separator.

990-16.1 General: Provide portable temporary lane separator in accordance with the Standard Plans and must come in connectable sections of 36 inches to 48 inches in length.

990-16.2 Product Application: Manufacturers seeking inclusion of portable temporary lane separator on the APL shall submit the following:

1. Installations Instructions
2. Photographs
3. Drawings (may be included in Installation Instructions) of sufficient detail to distinguish between similar devices
4. Any field assembly details and technical information necessary for proper application and installation
5. Crash testing reports demonstrating the device meets MASH TL-3
6. All relevant FHWA Eligibility Letters

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990-17 Type III Barricade.

990-17.1 General: Provide type III barricades in accordance with the requirements of the MUTCD and the dimensions shown in the Standard Plans.

990-17.2 Product Application: Manufacturers seeking inclusion of type III barricades on the APL shall submit the following:

1. Installations Instructions
2. Photographs
3. Drawings (may be included in Installation Instructions) of sufficient detail to distinguish between similar devices
4. Any field assembly details and technical information necessary for proper application and installation
5. Crash testing reports demonstrating the device meets MASH TL-3
6. All relevant FHWA Eligibility Letters

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SECTION 991
CHANNELIZING DEVICE MATERIALS

991-1 Tubular Markers.

991-1.1 General: This subarticle describes the material requirements for tubular markers installed in accordance with Section 704. All Tubular Marker products shall be listed on the Department's Approved Products List (APL).

991-1.2 Dimensions: The post shall have a minimum diameter of 3 inches. The base of the tubular marker shall have a maximum diameter, width, or length of 8 inches. The height of the tubular marker above the pavement surface shall be 36 inches.

991-1.3 Color: Tubular Marker color must be uniform and integral throughout entire height of the post. The base may be black in color.

991-1.3.1 White: The yellowness index shall not exceed 12, tested in accordance with ASTM E313. The daytime 45 degrees, 0 degrees luminance factor, Cap Y, shall be a minimum of 70, tested in accordance with ASTM E1349.

991-1.3.2 Yellow: The daytime 45 degrees, 0 degrees luminance factor, Cap Y, shall be a minimum of 60, tested in accordance with ASTM E1349.

991-1.4 Retroreflective Sheeting: The color of the retroreflective sheeting shall match the color of the tubular marker. The retroreflective sheeting shall be abrasion resistant Type IV or Type V and meet the requirements of Section 994. The retroreflective sheeting shall meet supplementary requirements for reboundable sheeting as stated in section S.2 of ASTM D4956. The sheeting shall wrap around the entire circumference of the tube and have a minimum vertical dimension of 10 inches. The top of sheeting shall be 1-1/2 inches plus or minus 1/2 inch below the top of post.

991-1.5 Product Testing: Manufacturers seeking evaluation of Tubular Markers not listed on the APL must include test reports from AASHTO Product Evaluation & Audit Solutions documenting the product meets the requirements of this Section. Impact testing must be performed on concrete in accordance with AASHTO Product Evaluation & Audit Solutions: Evaluation of Temporary Traffic Control Devices, Flexible Delineators for the category of High Speed Applications and for hot weather test temperature only.

Impact tests shall be performed only on tubular markers measuring 36 inches above the pavement surface.

Acceptable products are those meeting the following requirements after receiving an average of 45 bumper impacts per sample and an average of 150 tire impacts per sample:

1. All posts shall self-restore to within 15 degrees list or lean from vertical.
2. All posts shall have a minimum of 50% of its cross-section, at any point along the post height, free of tears or cracks.

991-1.6 Approved Product List Submission Requirements: Manufacturers seeking evaluation of Tubular Marker products for inclusion on the APL shall submit an application in accordance with Section 6 and include the following documentation.

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Table 991-1	
Documentation	Requirement
Installation Instructions	Include mounting surface preparations, and touch-up and repair procedures. Separate installation instructions are required for different substrates. Identify adhesive types and mechanical anchor types for attachment of base to substrate.
AASHTO Product Evaluation & Audit Solutions: Audit Report	See Section 991-1.5
Product Label Photo	Displays the Product Name. Displays additional label requirements, if needed.
Product Photo	Displays the significant features of the product. Displays location of Manufacturer name and model number.
Technical Data Sheet, marker	Uniquely identifies the product and includes product specifications, storage instructions, and recommended installation materials and equipment as applicable.
Product Sample	Upon request from the Department, submit a sample of the tubular marker mounting material or hardware. If the product is a system comprised of multiple parts, a sample of each part must be submitted.

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SECTION 992
HIGHWAY LIGHTING MATERIALS

992-1 General.

992-1.1 Pole Design Criteria: The light poles and bracket arms shall be in accordance with the requirements of the AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, the FDOT Structures Manual and with the specific requirements contained in this Section.

992-1.2 Luminaires, Driver, etc.: All luminaires shall be one of the products listed in the Department's Approved Product List (APL). Manufacturers seeking evaluation of their product shall submit an application and sample luminaire in accordance with Section 6.

The light source for luminaires shall be either light emitting diodes (LED), magnetic induction or plasma induction.

The luminaire housing shall be constructed of precision cast aluminum with a corrosive resistant polyester powder coat finish. The standard color shall be gray. The housing shall have an electrical terminal block to attach the luminaire cable and a hinged door which provides direct access to internal parts. Hinged doors are not required for high mast luminaires and underdeck luminaires. All hardware on the exterior of the housing shall be stainless steel. The refractor and lens shall consist of glass or an optical grade polymer. The manufacturer shall place a permanent tag in the luminaire housing imprinted with: the manufacturer name, luminaire voltage, lamp wattage, and provide a blank area for the Contractor to inscribe the installation date.

Luminaires shall meet the following requirements: UL 1598 listed and labeled for installation in wet locations by an OSHA recognized "Nationally Recognized Testing Laboratory" (NRTL), be capable of maintaining 94.1% intensity at 10,000 hours with an ambient temperature of 25°C (IES LM-80) and have IESNA light distribution curves (IES LM-79) by an EPA recognized laboratory.

The driver shall be rated for 100,000 hours and have a power factor greater than or equal to 90% at full load with a total harmonic distortion less than or equal to 20% at full load. The fixture shall accommodate a circuit voltage of 480V.

Luminaires shall be provided with a minimum 10kV/10kA internal surge suppression module meeting UL 1449/ANSI C62.41.2 Category C.

The manufacturer shall submit a five-year non-prorated full warranty on all components of the luminaire to the Department. The warranty shall begin on the project acceptance date and include all components of luminaire.

992-1.3 Conductors: All conductors shall be color-coded stranded copper meeting the requirements of NEMA WC 70. All conductors shall be tested and listed by a NRTL.

Service and circuit conductors shall be single-conductor cable Type THWN-2 and shall not be smaller than No. 6 AWG.

Bonding ground conductor shall have a green jacket and shall not be smaller than No. 6 AWG.

992-1.4 Conduit: Conduit shall meet the requirements of Section 630.

992-1.5 Electrical Ground Rod: The electrical ground rods shall be 5/8 inch copper clad steel. Electrical ground rods shall be sectional type where length exceeds 10 feet.

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992-1.6 Fittings and Bends: Fittings, bends and miscellaneous hardware shall be in accordance with the National Electrical Code (NEC) and shall be compatible with the adjacent conduit and materials.

992-1.7 Conductor Splices: Unless otherwise shown in the Standard Plans or authorized by the Engineer, splices shall be made with compression sleeves or split bolt connectors. The connector shall be sealed in silicone gel that easily peels away leaving a clean connection. The gel shall be contained in a UV, impact, and abrasion resistant closure that when snapped around the split bolt will provide a waterproof connection without the use of tools or taping.

992-1.8 Pull Boxes: Pull boxes shall meet the requirements of Section 635.

992-1.9 Distribution Service Point Equipment: All electrical equipment shall be provided with 75°C terminal lug connectors.

992-1.9.1 Service Main: Two pole 480 V, 35,000 min. AIC, solid neutral, NEMA 4X stainless steel, enclosed circuit breaker rated for service entrance.

992-1.9.2 Control Panel Enclosure: NEMA 4X stainless steel enclosure ground mounted in accordance with Standard Plans, Index 639-002. Dimensions shall be as necessary for equipment inside.

992-1.9.3 Control Panel Main Disconnect: Two Pole, 480V, 35,000 AIC with solid neutral in NEMA 1 enclosure. Number and rating of branch circuit breakers shall be as indicated in Plans.

992-1.9.4 Lighting Contactor: Two pole, 480V electrical contactor in NEMA 1 enclosure w/HOA on cover, 120V coil and fused control power transformer.

992-1.9.5 Electrical Panel: Single Phase (two pole), 480V, with solid neutral in NEMA 1 enclosure.

992-1.9.6 Surge Protection Device: Type 1, UL or NRTL listed to 1449, Third Edition. Surge current rating on per phase basis shall equal or exceed 50kA. I-nominal rating shall be 10kA or 20kA. 480V true single phase system modes of protection shall include L-G and N-G having UL 1449-3 Voltage Protection Ratings of 2000V or lower. 240/480V split phase systems deriving 480V across two energized conductor's modes of protection shall include L-G and N-G having UL 1449-3 Voltage Protection Ratings of 1200V or lower.

992-2 Conventional Lighting.

992-2.1 Poles: Poles for conventional lighting shall be aluminum unless otherwise shown in the Plans.

992-2.1.1 Aluminum Poles: Aluminum poles shall be round, one piece, continuous-tapered high-strength aluminum, and of an approved alloy meeting the requirements of the Standard Plans. The poles shall be of such length as to provide the approximate luminaire mounting height shown in the Plans. Poles installed on bridges, walls and median concrete barriers shall be equipped with internal vibration damping devices.

992-2.1.2 Concrete Poles: Concrete poles may be used only when specified in the Plans. When specified, concrete poles shall meet the requirements of Section 641 and Standard Plans, Index 641-010 for a Type P-III pole.

992-2.2 Bases: Aluminum poles shall be installed on transformer bases with the exception of lights installed on bridge pilasters or on top of median concrete barriers. Transformer base poles shall have a grounding lug in the transformer base. The base shall be arranged for anchoring to a transformer base with four 1 inch anchor bolts (minimum size).

992-2.3 Bracket Arms: Bracket arms shall be aluminum, truss-type construction, consisting of upper and lower members with vertical struts, and shall have the luminaire end

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formed to accommodate a 2 inch pipe slipfitter. The bracket arms shall meet the design requirements of 992-1.1. Bracket arms shall be attached to aluminum poles, with machine bolts and pole adapters, unless approved otherwise.

992-2.4 Luminaires: Provide luminaires in accordance with the following requirements.

992-2.4.1 Luminaires for Conventional Lighting: Luminaires shall meet the following additional requirements:

a. A maximum correlated color temperature (CCT) of 4000°K meeting ANSI C78.377A (3985°K, plus or minus 275°K).

b. The optical portion of the housing shall be sealed to provide an IP 66 rating.

The luminaire mounting assembly shall be a slipfitter type designed to accommodate a nominal 2 inch pipe size (2-3/8 inch O.D.) arm or a pole top mounting assembly designed to accommodate a 2-3/8 inch pole top tenon.

For APL qualification, the manufacturer must have a fixture with an IESNA light distribution curve (IES LM-79) by an EPA recognized laboratory, meeting a minimum pole spacing of 240 feet using the AGi32 lighting optimization tool with the following settings:

Table 992-1

Setting	Requirement
Roadway Standard	IES RP-8-18
R-Table	R3 (Q0=0.07)
Roadway Layout	Two Rows Opposite, With Median, 2R OPP w/M
Roadway Width	40 feet
Median Width	22 feet
Number of Lanes in Direction of Travel	3
Driver's Side of Roadway	Right
Calculation Area	Bottom
Mounting Height	As per manufacturer's recommendation
Setback	12 feet
Tilt	0°
Optimization Criteria	Avg. Illuminance = 1.5 fc Avg./Min. Ratio = 4 Max./Min. Ratio= 10 Lv Max./L Avg. Ratio= 0.3
Arm Length	Pole top fixtures – as provided by the IES file Arm mounted fixtures – 12 feet

992-2.4.2 Luminaires for Wildlife-Sensitive Conventional Lighting: Luminaires must meet the following additional requirements:

a. The light source for the luminaires must be true red, orange, or amber light-emitting diodes (LEDs) with no more than 1.75% of the spectral power distribution below 560 nm. Submit testing report.

b. The optics must have an IP 66 rating. Submit testing report.

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c. The luminaire mounting assembly must be a slipfitter type designed to accommodate a nominal 2 inch pipe size (2-3/8 inch O.D.) arm or a pole top mounting assembly designed to accommodate a 2-3/8 inch pole top tenon.

d. Luminaires must have a IESNA light distribution curve (IES LM-79) designated by an EPA-recognized laboratory. Submit testing report.

e. Luminaires must meet a minimum pole spacing of 50 feet using the AGi32 lighting optimization tool in accordance with the settings shown in 992-2.4. Submit IES file.

992-2.5 Luminaire Cable: Pole and bracket cable shall be multi-conductor Type XHHW-2 XLP TC with three No. 10 AWG wires. The ground wire must have green-colored insulation.

992-2.6 In Line Fuse Holders: In line fuse holders shall provide a breakaway connection and be UL recognized per Guide IZLT2 and rated for 600V. The wire connections in the fuse holders shall be a copper or equivalent type setscrew. Fused connections shall utilize an ATQ or FNQ 10 amp time delay fuse rated for 500V. Fuses shall be UL listed to Standard 248-14. The rating for the fuse holders shall be water resistant or submersible rated.

992-2.7 Surge Protection Devices for Circuit Protection at Poles: The metal oxide varistor (MOV) based SPD shall be potted in a manner to be waterproof. UL listing is not required. SPD's per mode surge current rating shall be 20kA for 480V to ground and 20kA for neutral to ground. Maximum continuous operation voltage (MCOV) shall be not less than 550Vrms and not greater than 600Vrms. All wires and internal spacings shall be insulated for 600Vrms.

992-2.8 Pole Cable Distribution System:

992-2.8.1 General: These requirements are applicable for all systems rated up to and including 600V. The installed system shall be in compliance with Standard Plans, Index 715-001.

Systems installed as alternates to the Standard Plans shall be one of the products listed on the APL. Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6.

Alternate Systems shall meet the following requirements:

A modular color coded cable system consisting of rubber cords with integrally molded watertight submersible connectors, inline fuses, submersible surge arrestor and breakaway connectors shall be installed. The cables shall extend from an underground pull box near the base of the pole to the luminaires at the top of the pole. A cable system shall be required at each pole.

The cable system shall consist of the following described components:

1. Distribution Block: The red molded body shall contain a three wire female outlet integrally molded to a 24 inch length of 10/3 SOOW cable with an end molded to the body and the other end shall be spliced in the field to the distribution cable that feeds through the underground pull box near the base of the pole. The block shall be watertight and submersible when the integrally fused plug on the power cable is engaged and fully seated. Dimensions shall be approximately 2 inches by 3 inches by 3 inches. The size is important because of limited space.

2. Surge Arrestor Cable: Provide a 12 inch length of 10/2 SOOW cable with a red male plug to match the red female connector cable extending from the fused plug on the power cable. The other end of the surge arrestor cable shall be integrally molded to a

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MOV waterproof surge arrestor. The red male plug shall make a submersible connection when mated to the red female connector on the power cable. A separate 12 inch length of No. 10 THWN green ground wire shall be provided from the surge arrestor to attach to the ground system in the pull box.

3. Power Cable: This cable feeds the luminaire cable and the surge arrestor cable from the load side of its integrally fused red male plug end. The red fused plug shall contain 10A 500V fuses (13/32 inch by 1-1/2 inch) or equal. The fuse holder manufacturer's suggested slug (blank or dummy fuse) must be installed on the neutral side for line to neutral service. Both lines shall be fused for line to line service. The section that feeds the luminaire cable shall be a 10 foot section of 10/3 SOOW cable with an orange female connector molded to the end extending up into the base of the pole. This female connector shall pass easily through a standard size 1-1/4 inch PVC elbow and make a submersible connection when mated with the orange male plug on the luminaire cable. The section that feeds the surge arrestor cable shall be 12 inches in length of 10/2 SOOW cable with a red female connector on the end. The red female connector shall make a submersible connection when mated to the red male plug on the surge arrestor cable.

4. Luminaire Cable: This cable is Type XHHW-2 XLP-TC with three No. 10 AWG an orange male molded plug molded to match the orange female end of the power cable. The connector shall require 25 pounds of force to mate or disengage from the female end. When engaged the connection shall be watertight and submersible. The cable strain relief shall extend approximately 2 inches from the connector.

The distribution block and each connector shall be made of thermosetting synthetic polymer which is non-flame supporting and which remains flexible over a temperature range of minus40°F to plus 190°F. Hardness of the molded rubber shall be 65 durometer.

992-2.8.2 Testing and Performance Criteria: The system shall pass the following performance criteria in accordance with NEC 110 2.

1. Dielectric Test: No breakdown shall occur with a test potential of 1,960V applied between the primary conductors (tied together) and the protective ground for a period of one-minute.

2. Leakage Current Test: Leakage current shall be measured on the mated connectors between the primary conductors and the protective ground conductor. When tested at the rated operating voltage, the leakage current shall not exceed 0.5 mA. The mated connectors shall then be wrapped in aluminum foil and the leakage current measured between the primary conductors and the foil wrap. When tested at the rated operation voltage the leakage current shall not exceed 0.5 mA.

3. Flame Retardant Test: Flammability tests shall be conducted on the cable, the molded body of the connectors, and the molded protective caps. These materials shall be subjected to five flame application, on for 15 seconds and off for 15 seconds. The materials shall self-extinguish within one minute upon removal of the flame and not burn through.

4. Internal Temperature Test: The internal temperature rise of the contact area of the mated connectors shall not exceed a temperature rise of 54°F referenced to 73°F ambient temperature when operated at the maximum current rating.

5. External Temperature Test: The external temperature rise of the mated connectors and the cable shall not be greater than 54°F referenced to 73°F ambient temperature when operated at the maximum current rating.

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6. Fault Test: The mated connectors shall be fault tested by applying a test current of 1,000A, 60 Hz for a minimum of 3 cycles (50 ms). The mated connectors shall then satisfactorily pass the dielectric test.

7. Drop Test: The connectors shall not break, crack or suffer other damage when subjected to eight consecutive drop tests from 3 feet above the concrete floor with the connectors having been rotated 45 degrees between each drop.

8. Crushing Test: No breakage of deformation shall result when the mated and unmated connectors are subjected to a crushing force of 500 pounds for one minute. Following the crush test, the dielectric test shall be satisfactorily passed.

9. Impact Test: No breakage or deformation shall result when the connectors are subjected to an impact caused by dropping a cylindrical 10 pound weight having a flat face 2 inches in diameter from a height of 18 inches.

10. Flex Test: No detachment or loosening shall result when each connector is subjected to a 5,000 cycle flex test at the cable/bond area back and forth in a plane through an angle of 180 degrees. Following the flex test the dielectric test shall be satisfactorily passed.

11. No Load Endurance Test: No excessive wear shall result when the male and female connectors and protective cap and female connector were subjected to 2,000 cycles of complete insertion and withdrawal.

12. Rain Test: The mated and capped connectors shall be subjected to a continuous water spray (simulating worst case outdoor rain down pour) for at least one hour at a rate of at least 18 inches per hour at an operating pressure of 5 psi. The dielectric and leakage current tests shall be satisfactorily passed. The connectors shall be unmated and caps removed. Inspection shall indicate that water had been successfully prevented from reaching the contact areas of the connectors.

13. Watertight (Immersion) Test: The mated and capped connectors shall be immersed in water for one hour in which the highest point of the test samples in as least 3 feet below the water level. Immediately following the immersion, a satisfactory dielectric and leakage current tests shall be performed. The connectors shall be unmated and caps removed. Inspection shall indicate that water had been successfully prevented from reaching the contact areas of the connectors.

14. Exposure to Deteriorating Liquids: The cable and connectors shall be dried at 212°F for one hour. The samples shall then be immersed in ASTM Reference Oil No. l and ASTM Reference Fuel C liquids for one hour. The samples shall show no evidence of bubbling, cracking or corrosion. Within one hour after being removed from the fluids, the test samples shall satisfactorily pass the flammability test.

992-3 High Mast Lighting.

992-3.1 Poles: Poles for high mast lighting shall be galvanized steel unless otherwise shown in the Plans. Steel high mast poles shall be continuous-tapered, round or minimum of 12 sided poles and meet the requirements of the Standard Plans.

Each pole shall include a galvanized steel winch plate of sufficient size to mount the winch, portable drive unit mounting tube, circuit breaker panel and surge arrestor.

992-3.2 Luminaires: The luminaires shall meet the following requirements.

a. A maximum correlated color temperature (CCT) of 4000°K meeting ANSI C78.377A (3985°K, plus or minus 275°K).

b. The optical portion of the housing shall be sealed to provide an IP 66 rating.

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The luminaire mounting assembly shall be a slip fitter type designed to accommodate a nominal 2 inch pipe size (2-3/8 inch O.D.) connection. For qualification, the manufacturer must have a fixture with a Type V IESNA light distribution curve (IES LM-79) by an EPA recognized laboratory, capable of providing photometrics similar to a 1000 W HPS fixture when mounted on 80 to 120 foot poles.

992-3.3 Surge Protective Devices for Surge Protection at Poles: Surge protective devices (SPD) shall be Type 1 or Type 2. UL or NRTL listed to UL 1449 Third Edition. Surge current rating on a per phase basis shall be equal or exceed 50kA. I-nominal rating shall be 10kA or 20kA. Modes of protection shall include L-G and N-G having UL 1449-3 Voltage Protection Ratings (VPR's) of 2000V or lower.

992-3.4 Lowering System: The lowering system may be either a top latch or bottom latch system. The lowering system shall consist of the following.

992-3.4.1 Head frame and Covers: The head frame unit shall rigidly mate the top of the pole to the head frame platform. The platform with its associated sheaves shall be covered to prevent water from entering the top of the pole. The head frame structure shall be stainless steel and attach to the pole by stainless steel bolts or by means of a galvanized steel slipfitter. The head frame shall utilize two stainless steel cable sheaves for each lowering cable. The cable sheaves shall be a minimum of 5 inches in diameter and grooved to the exact cable diameter, for 180 cable bearing surface. The power cord shall travel on sheaves or a combination of rollers providing a radius for the cord of 6 inches or larger. Each end of the sheaves or rollers shall have a keeper to prevent the cable from jumping out of the roller track or sheave cover that will act as a keeper. Bearings shall have permanent lubrication. For top latch systems the head frame shall include latch mechanisms which support the luminaire ring in the latched position and prevent the luminaire ring from rotation. For bottom latch systems the head frame shall include centering guides which center the luminaire ring and prevent the ring from rotation.

992-3.4.2 Luminaire Ring: The luminaire ring assembly shall consist of the luminaire ring, hoisting cable terminator tubes, and weather proof junction box. The luminaire ring and the junction box shall be fabricated of stainless steel. The ring shall be supplied with bolt on 2 inch stainless steel pipe tenons for the required number of luminaires. Two of the stainless steel tenons shall have a 1 inch half coupling welded to the tenon for the possible installation of Federal Aviation Administration (FAA) approved obstruction lights. The inner portion of the ring shall be equipped with a PVC shock absorbing tubes or shall utilize roller contact spring-loaded centering arms which center the luminaire ring and protect the pole and luminaire ring during raising or lowering operations. A 600 volt terminal block, completely prewired shall be included in the junction box. The luminaire ring shall be prewired with distribution wiring suitable for proper application and operation of the luminaires. A male flanged receptacle shall be mounted on the luminaire ring to allow testing of the luminaire while in the lowered position. The receptacle shall face away from the pole for easy access.

992-3.4.3 Lowering Cables: For bottom latch lowering systems, a minimum of two cables shall be used to lower the luminaire ring. Lowering cables for bottom latch systems shall be stainless steel aircraft cables of 1/4 inch or greater diameter. Where the wire cables bend over sheaves or the winch drum, the maximum working stress in the outer fibers of wire cable shall not exceed 20% of the cable manufacture's rated ultimate stress. The hoisting cable shall manually latch at the base of the pole and shall remove the load from the winch system. Each latch point shall be capable of supporting the entire weight of the luminaire ring assembly

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including luminaires. All moving parts of the latch mechanism shall be within reach from the ground level.

For top latch lowering systems, three stainless steel aircraft cables of 3/16 inches or greater diameter shall be provided. The transition yoke, hardware connecting the lowering cables to the transition yoke and hardware connecting the winch cable to the transition yoke shall be stainless steel. Where the wire cables bend over sheaves or the winch drum, the maximum working stress in the outer fibers of wire cable shall not exceed 20% of the cable manufacturer's rated ultimate stress. All latching systems shall remove the load from the winch system. Each latch point shall be capable of supporting the entire weight of the luminaire ring assembly including luminaires.

992-3.4.4 Modular Power Cable System: The modular cable system shall consist of cables with weathertight connectors. All portions of the cable system shall be rated up to and including 600 V. The plugs and connectors shall be UL or NRTL listed to UL 498 twist-lock type devices with a NEMA L16-30R configuration for 480V line to neutral systems or for 480V line to line systems. The X designated prong shall be the hot leg for 480V line to neutral systems. The X and Z designated prongs shall be the hot legs for 480V line to line systems. The Z designated prong shall always be treated as a neutral leg. The plugs and connectors shall be equipped with watertight safety shrouds meeting UL 4X enclosure rating. Plugs and connectors when used on cord sets shall be equipped with IP 55 rated waterproof boots.

The power cable shall be a minimum of 10/3 SOOW cable that is wired from distribution cable in the pull box near the base of the pole to the line side of the circuit breaker panel.

The circuit breaker cable shall be an 8 foot length of 10/3 SOOW (minimum) cable that is connected to the load side of the circuit breaker panel and a female receptacle on the other end. This female receptacle shall mate with the male plug on the pole cable, the male flanged receptacle on the luminaire ring and the male plug on the portable step-down transformer.

The pole cable shall be the length of the mounting height of the pole plus 6 feet. The cable shall be a minimum of 10/3 SOOW with a male plug on one end that mates with the female receptacle on the circuit breaker cable. The other end fits under the lugs in the junction box on the luminaire ring. The power cable shall be attached to the luminaire ring with a stainless steel strain relief Kellem's grip capable of withstanding the pull of the weight of the cable. All power cables should be attached to the stainless steel weathertight wiring chamber with weathertight cable connectors

992-3.4.5 Winch Drum: The drum shall be constructed of stainless steel and be designed to provide a level wind of wire cable. The winch shall be a reversible worm gear self locking type with an integral friction drag brake to prevent free spooling. Raising speed of the luminaire ring shall be a minimum of 12 feet per minute. Stainless steel 7 x 19 aircraft cables of 1/4 inch or greater diameter shall be supplied on the winch. The winch drums shall be designed to provide smooth winding of the winch cables on the drum and to prevent cable slippage on the drum.

992-3.4.6 External Portable Winch Motor (One per Project): The winch shall be designed for hand operation or for operation by means of a 1/2 inch heavy duty reversing electric drill motor or a portable reversible AC motor with a magnetic brake. Both portable power units shall be mounted to the winch by a stainless steel mounting bracket and shall be

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remote controlled to enable the operator to stand 25 feet from the pole. One portable drill motor or portable motor power unit shall be provided for each project.

992-3.4.7 Portable Step-Down Transformer (One per Project): A portable 1.5 kVA dry type transformer shall be provided for each project. The transformer shall step-down the high mast distribution voltage to 120/240V. The transformer shall be mounted in a NEMA 3R enclosure and have a male plug or receptacle which mates to circuit power cable. The transformer shall also have a 120V grounded receptacle for use by electric drill motor or portable motor power unit.

992-4 Sign Lighting.

992-4.1 Luminaires: The luminaires shall meet the following requirements.

a. A maximum correlated color temperature (CCT) of 5000°K meeting ANSI C78.377A (5028°K, plus or minus 283°K).

b. The optical portion of the housing shall be sealed to provide an IP 66 rating.

The luminaire mounting assembly for a sign luminaire shall be a slipfitter type designed to accommodate a 1-1/2 inch, Schedule 40 steel pipe arm connection.

992-5 Underdeck Lighting.

992-5.1 Luminaires: The luminaires shall meet the following requirements.

a. A maximum correlated color temperature (CCT) of 4000°K meeting ANSI C78.377A (3985°K, plus or minus 275°K).

b. The optical portion of the housing shall be sealed to provide an IP 55 rating.

Underdeck fixtures shall be wall mounted fixtures.

992-5.2 Conductors: Underdeck structure lighting conductors shall be Type RHW or THW and shall not be smaller than No. 10 AWG.

992-6 Protection of Light Poles.

Each metal pole shall be appropriately and adequately protected by “tire wrapping” with heavy paper, or by some other effective means, so that no chipping, gouging, or other significant surface damage will be incurred during transit or installation. The poles, when installed, shall be clean and uniformly free from dark streaks and discoloration.

992-7 Luminaire Retrofit Kits for Conventional Lighting.

Luminaire retrofit kits shall meet the following requirements:

a. The light source for luminaire retrofit kits shall be light emitting diodes (LEDs) meeting ANSI C78.377A with a maximum correlated color temperature of 4000ºK (3985ºK ± 275ºK).

b. The luminaire retrofit kit shall be UL 1598C listed by an OSHA “Nationally Recognized Testing Laboratory” (NRTL).

c. The optics shall have an IP 66 rating. Submit testing report.

d. LEDs shall be capable of maintaining 94.1% intensity at 10,000 hours with an ambient temperature of 25°C (IES LM-80). Submit testing report.

e. Luminaire retrofit kits shall have a IESNA light distribution curve (IES LM-79) designated by an EPA-recognized laboratory. Submit testing report.

f. Luminaire retrofit kits shall meet a minimum pole spacing of 240 feet using the AGi32 lighting optimization tool in accordance with the settings shown in Sub-article 992-2.4. Submit IES file.

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g. Luminaire retrofit kits shall have a driver rated for 100,000 hours with a power factor greater than or equal to 90% at full load and a total harmonic distortion less than or equal to 20% at full load. Submit driver information that documents these requirements, including the operational temperature of the driver at 25ºC.

h. Luminaire retrofit kits shall accommodate a circuit voltage of 480V.

i. Luminaire retrofit kits shall be provided with a minimum 10kV/10kA internal surge protection device (SPD) meeting UL 1449 and ANSI C62.41.2 Category C High. Submit SPD information that documents these requirements.

j. The manufacturer shall submit a five-year non-prorated full warranty on all components of the luminaire retrofit kit to the Department. The warranty shall begin on the project acceptance date and include all components of the luminaire retrofit kit.

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SECTION 993
DELINEATORS

993-1 Description.

This section specifies the material requirements for flexible post delineators and barrier delineators.

993-2 Approved Product List.

All flexible post and barrier delineators shall be one of the products listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of products for inclusion on the APL shall submit an application in accordance with Section 6 and include the following documentation. A separate application must be submitted for each product to be evaluated, showing that the product meets the applicable requirements.

Table 993-1
Submittal Compliance Requirements

Documentation	Requirements
Installation Instructions	Surface preparation and installation procedures
Label	Displays the name of the manufacturer, Name of product, APL number,
AASHTO Product Evaluation & Audit Solutions Test Report	For flexible post delineators: AASHTO Product Evaluation & Audit Solutions Evaluation of Temporary Traffic Control Devices- Flexible Delineators, for the proposed mounting category
Product Photo	Displays the significant features of the product and product packaging.
Technical Data Sheet	a. Uniquely identifies the product, b. Product specifications, c. Installation materials and equipment. d. Surface preparation

993-3 Flexible Post Delineators.

993-3.1 Dimensions: The post shall have a minimum width of 3 inches facing traffic and of such length to generally provide a height of 48 inches above the pavement surface.

993-3.2 Color: The post shall be opaque white. The yellowness index shall not exceed 12 when tested in accordance with ASTM E313. The daytime 45 degrees, 0 degrees luminance factor, Cap Y, shall be a minimum of 70, tested in accordance with ASTM E1349.

993-3.3 Retroreflective Sheeting: The reflective sheeting shall be Types IV, V, or XI and meet the requirements of Section 994. The reflective sheeting shall have a minimum width of 3 inches and have a minimum area of 30 square inches.

993-3.4 Impact Performance: Six of the eight posts shall be capable of returning to a vertical position plus or minus 10 degrees with no delaminating. No post shall split, crack, break, or separate from base. Posts shall be tested and evaluated according to the AASHTO Product Evaluation & Audit Solutions Evaluation of Temporary Traffic Control Devices: Flexible Delineators, for the following categories:

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993-3.4.1 Pavement/Surface Mounted: Use the Metropolitan Delineator Applications category for Hot Weather with a minimum of 10 impacts (default testing procedure uses a maximum of 200 impacts).

993-3.4.2 Ground Mounted: Use the Ground Mount Side of Roadway Applications category for Hot Weather (default testing procedure uses a maximum of 10 impacts).

993-4 Barrier Delineators.

993-4.1 General: Barrier delineators shall consist of retroreflective sheeting permanently adhered to 0.090-inch minimum thick body. The body shall have a flexible hinge which allows the reflector to fold down and spring back to an upright position after impact. Barrier delineators for guardrail shall be designed for mounting to the web of steel posts or designed for mounting to the top of wood posts. Barrier delineators for concrete barrier, traffic railings, and vehicular longitudinal channelizing devices (LCDs) shall be designed for mounting to the top of barrier.

993-4.2 Retroreflective Sheeting: The sheeting for barrier delineators shall be Type IV or XI meeting the requirements of Section 994. The sheeting shall be yellow or white, depending on the locations of use for each. The dimensions of the retroreflective sheeting shall be a minimum of 3 inches wide by 4 inches high. The sheeting shall be installed by the delineator manufacturer. Delineators for use on median barriers must have yellow sheeting on both sides.

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SECTION 994
RETROREFLECTIVE AND NONREFLECTIVE SHEETING AND SIGN PANEL FABRICATION

994-1 Description.

994-1.1 General: This Section specifies the requirements for retroreflective and nonreflective sheeting and sign panel materials and fabrication. This includes the sign sheeting materials such as transparent and opaque process inks for retroreflective sheeting materials, vinyl and transparent overlays.

994-2 Retroreflective and Nonreflective Sheeting Systems.

994-2.1 Materials: Retroreflective sheeting material shall be classified in accordance with and meet the requirements of ASTM D4956. Overlay materials include colored and colorless transparent overlays (to provide UV protection) and vinyl. Inks include transparent and opaque silkscreen inks as well as inkjet inks used in digital print systems.

994-2.2 Approved Product List (APL): All sheeting, process inks and overlay materials shall be listed as a system on the Department's Approved Product List (APL). Sign sheeting systems shall consist of base sheeting with ink and/or overlay materials. Products with an ASTM classification of Type XI or greater will not be accepted for qualification on the APL for fluorescent orange. Manufacturers seeking evaluation of their products need to submit product data sheets, performance test reports from an independent laboratory showing the sign sheeting system meets the requirements of this Section, and APL application in accordance with Section 6. Information on the APL application shall include the individual materials comprising the sign sheeting system and identify colors, ASTM base sheeting classification, adhesive backing class, availability of transparent and/or opaque backing and availability of liner types.

994-2.3 Performance Requirements:

994-2.3.1 General: Sheeting, process inks and overlay materials shall be tested in accordance with, and meet all the performance requirements of ASTM D4956, including Supplemental Requirement S2, Reboundable Sheeting Requirements, except as amended in this Section.

For performance requirements that are color dependent, each color included in the APL application shall be tested and meet the requirements identified in ASTM D4956 or this Section as applicable. All sign sheeting systems consisting of inks and/or overlays will be tested as a system consisting of white base sheeting and each color of ink and/or overlay.

Panels for testing sheeting shall be prepared in accordance with 994-3 for testing. The in-service life for the sign sheeting system shall equal the life of the reflective base sheeting of the system.

994-2.3.2 Retroreflective Intensity: The retroreflectivity of sheeting and sheeting systems shall meet the minimum initial requirements as stated for all observation and entrance angles as identified in ASTM D4956. The 0.2 and 0.5 degree observation angles with an entrance angle of minus 4 degrees per ASTM D4956 shall be used for in-service requirements.

Rotational sensitivity shall be tested in accordance with AASHTO M268. Rotationally sensitive sheeting will be noted on the APL.

994-2.3.3 Clear Overlay Films: Clear overlay film shall be compatible with the sign sheeting system and not delaminate or discolor for the in-service life of the system.

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994-2.3.4 Outdoor Weathering: Outdoor weathering exposure of sign sheeting systems shall be performed in accordance with ASTM D4956, and meet the requirements for each system, color, and classification. All testing shall be conducted at an exposure location meeting the Tropical Summer Rain Climate Type (Miami, Florida or equivalent). Outdoor weathering is not required for Type VI fluorescent pink.

994-2.3.5 Packaging and Labeling: Packaging and labeling shall meet the requirements of ASTM D4956.

994-2.3.6 Samples: Field samples shall be obtained in accordance with the Department's Sampling, Testing and Reporting Guide Schedule and on a random basis at the discretion of the Engineer.

994-3 Sign Panels.

994-3.1 Materials: For aluminum sheets and plates for sign panels, meet the requirements of ASTM B 209, Aluminum Association Alloy 6061-T6, 5154-H38 or 5052-H38 and those shown in the Plans.

994-3.2 Preparation of Sign Blanks:

994-3.2.1 De-greasing and Etching for Aluminum Sign Blanks:

994-3.2.1.1 General: Prior to the application of retroreflective sheeting, use any of the methods shown below to de-grease and etch the aluminum sign blanks.

994-3.2.1.2 Hand Method: Under this method, de-grease and etch the blanks in one operation, using steel wool (medium grade) with any of the following combinations of materials:

1. An abrasive cleanser of a commercial grade kitchen scouring powder.
2. Acid and a suitable detergent solution.
3. An alkaline solution.

Thoroughly rinse the blanks with clean water following all hand de-greasing operations.

994-3.2.1.3 Power-Washer Method: Under this method, de-grease the blanks with an inhibited alkaline cleanser, by spraying for 90 seconds with the solution between 135 and 249ºF, the exact temperature to be as recommended by the manufacturer of the cleanser. After the spraying, rinse the blanks with clean water. Then etch the blanks by immersing them in a 6 to 8% solution of phosphoric acid at a temperature of 100 to 180ºF for 60 seconds. After immersion, rinse the blanks in clean water.

994-3.2.1.4 Immersion Method: Under this method, de-grease the blanks by immersing them in a solution of inhibited alkaline cleanser at a temperature between 160 and 180ºF for three to five minutes, and then rinsing with clean water. Then etch blanks by immersing them in a 6 to 8% solution of phosphoric acid at a temperature of 100ºF for three minutes. After immersion, rinse the blanks in clean water.

994-3.2.1.5 Vapor De-greasing Method: Under this method, de-grease the blanks by totally immersing them in a saturated vapor of trichloroethylene. Remove trademark printing with lacquer thinner or a controlled alkaline cleaning system.

994-3.2.1.6 Alkaline De-greasing Method: De-grease the blanks by totally immersing them in a tank containing an alkaline solution, controlled and titrated in accordance with the solution manufacturer's directions. Adapt immersion time to the amount of soil present and the thickness of the metal. After immersion, thoroughly rinse the blanks with running water.

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994-3.2.1.7 Etching Method when De-greasing is Separate Operation: If using either of the de-greasing methods described in this section, accomplish etching by one of the following alternate methods:

1. Acid Etch: Etch well in a 6 to 8% phosphoric acid solution at 100ºF, or in a proprietary acid etching solution. Rinse thoroughly with running cold water, which may be followed by a hot water rinse.

2. Alkaline Etch: Etch aluminum surfaces in an alkaline etching material that is controlled by titration. Meet the time, temperature, and concentration requirements specified by the solution manufacturer. After completing etching is complete, rinse the panel thoroughly.

994-3.2.1.8 Chromate Coating: Before applying retroreflective sheeting to the aluminum, treat the aluminum sign surfaces with chromate conversion coating. Coating may consist of an organic or inorganic chromate material. Coatings shall be applied according to the manufacturer's instructions and shall conform to ASTM B449, Class 2.

994-3.3 Drying: Dry the panels using a forced-air drier. Use a device or clean canvas gloves, to handle the material between all cleaning and etching operations and the application of retroreflective sheeting. Do not allow the metal to come in contact with greases, oils or other contaminants prior to the application of retroreflective sheeting.

994-3.4 Fabrication of Sign Blanks: Fabricate all metal parts to ensure a proper fit of all sign components. Complete all fabrication, with the exception of cutting and punching of holes, prior to metal de-greasing and applying the retroreflective sheeting. Cut metal panels to size and shape and keep free of buckles, warp, dents, burrs, and defects resulting from fabrication. Use aluminum sheets with increments of 4 feet in width; except, for sign widths that are not multiples of 4 feet. A maximum of two panels may be cut to less than 4 feet, and no panel may be cut to less than one foot. Mount aluminum sheets vertically and provide backing strips at vertical joints to keep the abutting sheets in proper alignment.

Ship all multi-panel signs to the project intact, completely assembled and ready to be installed. Fabricate signs taller than 10 feet as two separate signs with a horizontal splice, ready to be spliced and installed.

994-3.5 Fabrication of Retroreflective Sign Faces:

994-3.5.1 General: Fabricate signs with sign sheeting systems listed on the APL meeting the requirements in Section 700, the Standard Plans and the Plans.

994-3.5.2 Application of Sheeting: Apply retroreflective sheeting to the base panels with mechanical equipment in a manner specified for the manufacture of traffic control signs by the sheeting manufacturer. For sheeting that has been identified as rotationally sensitive, apply white sheeting for cut-out legends, symbols, borders and route marker attachments within the parent sign face at the optimum rotation angle according to the identification markings. Apply all background sheeting at a uniform rotational angle. The retroreflective sheeting for each sign will be from the same roll or LOT number. Apply consecutively alternate successive width sections of either sheeting or panels to ensure that corresponding edges of sheeting lie adjacent on the finished sign. If the sign cannot be constructed from retroreflective sheeting from the same roll or LOT number, the fabricator may color match from a different LOT; the color between the rolls cannot exceed three ΔE's using test method ASTM D 2244. The Engineer shall not accept nonconformance that may result in non-uniform shading and an undesirable contrast between adjacent widths of applied sheeting or non-optimum retroreflectivity in the finished sign and installation.

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Sheeting is to be trimmed at 45-degree angle from the edge of each panel. Finish signs by sealing sheeting splices and sign edges according to sign manufacturer recommendations.

994-3.5.3 Direct and Reverse Screen Processing: Screen message and borders on retroreflective sheeting in accordance with the recommendations of the ink or overlay manufacturer. Process messages either before or after applying the sheeting to the base panels.

The transparent and opaque process inks furnished for direct and reverse screen processing shall be of a type and quality formulated for retroreflective sheeting materials as listed on the APL and applied in accordance with the manufacturer's instruction. Screen processing in accordance with the techniques and procedures recommended by the manufacturer shall produce a uniform legend of continuous stroke width of either transparent or opaque ink, with sharply defined edges and without blemishes on the sign background that will affect the intended sign use.

994-3.5.4 Digital Printing Process: Digital print systems shall include a digital printer, with appropriate software and drivers, flexible white or colored prismatic retroreflective sheeting with colorless overlay in accordance with the recommendation of the sheeting manufacturer. The use of a certified digital sign fabricator will be required. Digital sign fabricators shall be certified by the reflective sheeting manufacturer or a third-party certifier approved by the reflective sheeting manufacturer. Inks or ribbons shall be of a type and quality formulated to produce colors that meet the chromaticity requirements given in ASTM D4956 for retroreflective sheeting material when printed and finished as recommended by the sheeting manufacturer.

994-3.5.5 Finished Sign Face: Provide finished signs with properly aligned clean cut and sharp messages and borders. Fabricated signs shall be free of wrinkles, bubbles, foreign matter, scratches, free of patches, or other visually identifiable defects. Ensure that finished background panels are essentially a plane surface.

994-3.5.6 Packaging and Labeling: For permanent roadway signs, label the back of all finished panels at the bottom edge with "FDOT", the date of fabrication, sign sheeting system manufacturer, Type, and the fabricator's initials. For Type VI non-reflective vinyl work zone signs, label the back of all finished panels at the bottom edge with "Daytime Use Only". Make the labels unobtrusive, but legible enough to be easily read by an observer on the ground when the sign is in its final position. Apply the label in a manner that is at least as durable as the sign face.

Properly package signs to protect them during storage, shipment and handling to prevent damage to the sign face and panel.

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SECTION 995
TRAFFIC CONTROL SIGNAL AND DEVICE MATERIALS

995-1 Description.

995-1.1 General: This Section governs the requirements for all permanent traffic control signals and devices. All equipment shall be permanently marked with manufacturer name or trademark, part number, and date of manufacture or serial number.

995-1.2 Product Acceptance: All specified products shall be items listed on the Department's Approved Product List (APL), unless otherwise noted below. Manufacturers seeking evaluation of products for inclusion on the APL shall submit an application in accordance with Section 6 and include the following documentation. A separate application must be submitted for each product to be evaluated, showing that the product meets the applicable requirements.

Table 995-1

Documentation	Requirements
Assembly and Installation Instructions	Include any surface preparations, assembly/installation instructions, operation manual, troubleshooting guides, and repair procedures.
Independent Laboratory Test Results	Product meets requirements of this Section.
Product Label Photo	Labeling shows the manufacturer's name, trademark, and product model number/name. Label shows the date of manufacture and/or the manufacturer's batch number. Additional label requirements, as listed within this Section.
Product Photo	Displays the significant features of the product as required in this section.
Compliance Matrix	Include completed compliance matrix at https://www.fdot.gov/traffic/traf-sys/product-specifications.shtm
Manufacturer's Product Specifications	Include product specifications showing electrical requirements, voltages, etc.
Product Drawings or Cut Sheet	Show mounting points, mechanical details, block diagrams, schematics, etc.
Parts List	List major parts and field serviceable components.

995-1.3 Abbreviations: The following abbreviations are used in this Section:

Acrylonitrile Butadiene Styrene (ABS)
Alternating Current (AC)
Direct Current (DC)
Electronic Industries Alliance (EIA)
Global Positioning System (GPS)
Hypertext Transfer Protocol (HTTP)
Institute of Transportation Engineers (ITE)
Internet Protocol (IP)

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Local Area Network (LAN)
Network Time Protocol (NTP)
Telecommunications Industry Association (TIA)
Uniform Code Flash (UCF)
Uniform Resource Locator (URL)
Ultraviolet (UV)

995-2 Vehicle Detection Systems.

995-2.1 General: All parts shall be constructed of corrosion-resistant materials, such as UV stabilized or UV resistant plastic, stainless steel, anodized aluminum, brass, or gold-plated metal. All fasteners exposed to the elements shall be Type 304 or 316 passivated stainless steel.

If the assembly includes a cabinet, meet the requirements of Section 676.

Detectors shall meet the environmental requirements of NEMA TS 2-2021.

995-2.2 Inductive Loop Detector Units: Rack mount inductive loop detector units shall meet the requirements of NEMA NEMA TS 2-2021 and CALTRANS TEES 2020. Shelf mount detector units shall meet the requirements of NEMA TS 1-1989.

995-2.3 Video Vehicle Detection System (VVDS):

995-2.3.1 Configuration and Management: The VVDS shall be provided with software that allows local and remote configuration and monitoring. The system shall be capable of displaying detection zones and detection activations overlaid on live video inputs. The VVDS shall meet the following criteria:

1. Allows a user to edit previously defined configuration parameters, including size, placement, and sensitivity of detection zones.

2. Retains its programming in nonvolatile memory. The detection system configuration data shall be capable of being saved to a computer and restored from a saved file. All communication addresses shall be user programmable.

3. Offers an open Application Programming Interface (API) and software development kit available to the Department at no cost for integration with third party software and systems.

995-2.3.2 Detection Camera: Camera shall be recommended by the video detection system manufacturer. Cameras that are integrated and included in a VVDS shall be compliant with the Code of Federal Regulations Section 200.216 Prohibition on certain telecommunications and video surveillance services or equipment https://www.ecfr.gov/current/title-2/subtitle-A/chapter-II/part-200/subpart-C/section-200.216.

995-2.3.3 Machine Vision Processor: The VVDS shall include a machine vision processor that allows video analysis, presence detection, data collection, and interfaces for inputs and outputs as well as storage and reporting of collected vehicle detection data.

995-2.3.4 Communications: The VVDS shall include a minimum of one serial or Ethernet communications interface and shall meet the following criteria.

1. Serial interface and connectors shall conform to TIA-232 standards. Ensure that the serial ports support data rates up to 115200 bps; error detection utilizing parity bits (i.e., none, even, and odd); and stop bits (1 or 2).

2. Wired Ethernet interfaces shall provide a 10/100 Base TX connection. Verify that all unshielded twisted pair/shielded twisted pair network cables and connectors comply with TIA-568.

3. Wireless communications shall be secure and wireless devices shall be Federal Communications Commission (FCC) certified. The FCC identification number shall be

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displayed on an external label and all detection system devices shall operate within their FCC frequency allocation.

4. Cellular communications devices shall be compatible with the cellular carrier used by the agency responsible for system operation and maintenance.

5. The system shall be configured and monitored via one or more communications interface.

995-2.3.5 Video Inputs and Outputs: Analog video inputs and outputs shall utilize BNC connectors.

995-2.3.6 Solid State Detection Outputs: Outputs shall meet the requirements of NEMA TS 2-2021, 6.5.2.26.

995-2.3.7 Electrical Requirements: The system shall operate using a nominal input voltage of 120 V of alternating current (V_{AC}) and with an input voltage ranging from 89 to 135 V_{AC}. If a system device requires operating voltages other than 120 V_{AC}, a voltage converter shall be supplied.

995-2.4 Microwave Vehicle Detection System (MVDS): Sidefire MVDS sensors shall have a minimum 200-foot range and the capability to detect a minimum of 8 lanes of traffic.

995-2.4.1 Configuration and Management: The MVDS shall be provided with software that allows local and remote configuration and monitoring. The system software shall be capable of displaying detection zones and detection activations in a graphical format. The MVDS shall meet the following criteria:

1. Allows a user to edit previously defined configuration parameters, including size, placement, and sensitivity of detection zones.

2. Retains its programming in nonvolatile memory. Ensure that the detection system configuration data can be saved to a computer and restored from a saved file. Ensure that all communication addresses are user programmable.

3. Detection system software offers an open API and software development kit available to the Department at no cost for integration with third party software and systems.

995-2.4.2 Communications: Major components of the detection system (such as the sensor and any separate hardware used for contact closures) shall include a minimum of one serial or Ethernet communications interface and shall meet the following criteria:

1. The serial interface and connector conforms to TIA-232 standards and the serial ports support data rates up to 115200 bps; error detection utilizing parity bits (i.e., none, even, and odd); and stop bits (1 or 2).

2. Wired Ethernet interfaces provide a 10/100 Base TX connection. Verify that all unshielded twisted pair/shielded twisted pair network cables and connectors comply with TIA-568.

3. Wireless communications are secure and that wireless devices are FCC certified. The FCC identification number is displayed on an external label and all detection system devices operate within their FCC frequency allocation.

4. Cellular communications devices are compatible with the cellular carrier used by the agency responsible for system operation and maintenance.

5. The system can be configured and monitored via one or more communications interface.

6. Cameras that are integrated and included in a MVDS shall be compliant with the Code of Federal Regulations Section 200.216 Prohibition on certain telecommunications

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and video surveillance services or equipment https://www.ecfr.gov/current/title-2/subtitle-A/chapter-II/part-200/subpart-C/section-200.216.

995-2.4.3 Solid State Detection Outputs: Outputs shall meet the requirements of NEMA TS2-2021, 6.5.2.26.

995-2.4.4 Electrical Requirements: The microwave detector shall operate with a nominal input voltage of 12 V_{DC} and with an input voltage ranging from 89 to 135 V_{AC}. If any system device requires operating voltages other than 120 V_{AC}, a voltage converter shall be supplied.

The detector shall be FCC certified and has been granted authorization to operate within a frequency range established and approved by the FCC. The FCC identification number shall be displayed on an external label.

995-2.5 Wireless Magnetometer Detection System (WMDS):

995-2.5.1 Configuration and Management: The detection system shall be provided with software that allows local and remote configuration and monitoring and shall meet the following criteria.

1. Allows a user to edit previously defined configuration parameters.
2. Retains its programming in nonvolatile memory and the detection system configuration data can be saved to a computer and restored from a saved file. All communication addresses shall be user programmable.
3. The detection system software offers an open API and software development kit available to the Department at no cost for integration with third party software and systems.

995-2.5.2 Communications: Components of the detection system (such as sensors, access points, and contact closure cards) shall include a minimum of one serial or Ethernet communications interface and shall meet the following criteria.

1. The serial interface and connector conforms to TIA-232 standards and the serial ports support data rates up to 115200 bps; error detection utilizing parity bits (i.e., none, even, and odd); and stop bits (1 or 2).
2. Wired Ethernet interfaces provide a 10/100 Base TX connection and all unshielded twisted pair/shielded twisted pair network cables and connectors comply with TIA-568.
3. Wireless communications are secure and that wireless devices are FCC certified. The FCC identification number is displayed on an external label and all detection system devices operate within their FCC frequency allocation.
4. Cellular communications devices are compatible with the cellular carrier used by the agency responsible for system operation and maintenance.
5. The system can be configured and monitored via one or more communications interface.

995-2.5.3 Solid State Detection Outputs: Outputs shall meet the requirements of NEMA TS2-2021, 6.5.2.26.

995-2.5.4 Electrical Requirements: The WDMS shall operate with an input voltage ranging from 89 to 135 V_{AC}. If any system device requires operating voltages other than 120 V_{AC}, a voltage converter shall be supplied.

995-2.6 Automatic Vehicle Identification (AVI):

995-2.6.1 Configuration and Management: The detection system shall be provided with software that allows local and remote configuration and monitoring.

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995-2.6.2 Communications: Components of the detection system (such as sensors, controllers, and processing hardware) shall include a minimum of one serial or Ethernet communications interface and shall meet the following criteria.

1. The serial interface and connector conforms to TIA-232 standards and the serial ports support data rates up to 115200 bps; error detection utilizing parity bits (i.e., none, even, and odd); and stop bits (1 or 2).

2. Wired Ethernet interfaces provide a 10/100 Base TX connection and all unshielded twisted pair/shielded twisted pair network cables and connectors comply with TIA-568.

3. Wireless communications are secure and that wireless devices are FCC certified. The FCC identification number is displayed on an external label and all detection system devices operate within their FCC frequency allocation.

4. Cellular communications devices are compatible with the cellular carrier used by the agency responsible for system operation and maintenance.

5. The system can be configured and monitored via one or more communications interface.

995-2.6.3 Probe Data Detector Requirements:

1. Transponder Readers shall be compatible with multiple tag protocols, including Allegro and the protocol defined in ISO18000-6B.

2. Bluetooth Readers shall be capable of operating using either solar power or AC power.

3. License Plate Readers shall not require the use of visible strobes or other visible supplemental lighting.

995-2.6.4 Electrical Requirements: The AVI shall operate with an input voltage ranging from 89 to 135 V_{AC}. If any system device requires operating voltages other than 120 V_{AC}, a voltage converter shall be supplied. For solar powered devices, the detection system must operate for 5 days without solar assistance.

995-2.7 Wrong Way Vehicle Detection Systems (WWVDS):

995-2.7.1 Configuration and Management: The WWVDS shall be provided with software that allows local and remote configuration and monitoring. That the system shall have the capability to display detection zones and detection activations. The WWVDS shall meet the following criteria:

1. WWVDS controllers shall support either an on-board real-time clock/calendar with on-board battery backup, or the controller's internal time clock can be configured to synchronize to a time server using the network time protocol (NTP) in order to maintain the current local date/time information. For NTP, the synchronization frequency must be user configurable and permit polling intervals from once per minute to once per week in one-minute increments. For NTP, the controller must allow the user to define the NTP server by IP address.

2. Allows a user to edit previously defined configuration parameters, including size, placement, and sensitivity of detection zones.

3. Retains its programming in nonvolatile memory. The detection system configuration data shall be capable of being saved to a computer and restored from a saved file. All communication addresses shall be user programmable.

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4. Offers an open Application Programming Interface (API) or software development kit available to the Department at no cost for integration with third party software and systems.

995-2.7.2 Communications: Major components of the WWVDS (such as the sensor and any separate hardware used for contact closures) shall include a minimum of one serial or Ethernet communications interface and shall meet the following criteria:

1. The serial interface and connector conforms to TIA-232 standards and the serial ports support data rates up to 115200 bps; error detection utilizing parity bits (i.e., none, even, and odd); and stop bits (1 or 2).

2. Wired Ethernet interface provides, at a minimum, a 10/100 Base TX connection. Verify that all unshielded twisted pair/shielded twisted pair network cables and connectors comply with TIA-568.

3. Wireless communications are secure and that wireless devices are FCC certified. The FCC identification number is displayed on an external label and all WWVDS devices operate within their FCC frequency allocation.

4. Cellular communications devices are compatible with the cellular carrier used by the agency responsible for system operation and maintenance.

5. The system can be configured and monitored via one or more communications interface.

6. The WWVDS is compatible with the Department's SunGuide® software. The SunGuide software requirements are listed in supplemental requirement SR-995-2.7.2-01, Supplemental Wrong Way Vehicle Detection System SunGuide HTTP Protocol, as published on the Department's State Traffic Engineering and Operations Office website at the following https://www.fdot.gov/traffic/Traf-Sys/Product-Specifications.shtm.

7. For WWVDS installed on ramps, the device shall:

a. Send an alert to the SunGuide® software when the wrong-way vehicle is detected.

b. Send a sequence of images for up to ten seconds to the SunGuide software that covers a configurable time before and after the wrong-way vehicle detection.

c. Activate all highlighted signs associated with the WWVDS.

8. For WWVDS installed on mainline lanes, the device shall send an alert to the SunGuide® software when the wrong-way vehicle is detected.

9. Cameras that are integrated and included in a WWVDS shall be compliant with the Code of Federal Regulations Section 200.216 Prohibition on certain telecommunications and video surveillance services or equipment https://www.ecfr.gov/current/title-2/subtitle-A/chapter-II/part-200/subpart-C/section-200.216.

995-2.7.3 Electrical Specifications: Equipment shall operate on solar power or with an input voltage ranging from 89 to 135 V_{AC}. If the device requires operating voltages of less than 120 V_{AC}, supply the appropriate voltage converter. Solar powered systems shall be designed to operate for minimum of 5 activations per day and provide 10 days of operation without sunlight.

995-2.8 Light Detection and Ranging (LiDAR) Vehicle Detection System:

995-2.8.1 Configuration and Management: LiDAR systems shall be provided with software that allows local and remote configuration and monitoring. The system shall be

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capable of displaying detection zones and detection activations on superimposed on live images of the point cloud data produced by the system. The LiDAR system shall meet the following criteria:

1. Allows a user to edit previously defined configuration parameters, including size and placement of detection zones.

2. Retains its programming in nonvolatile memory. The detection system configuration data shall be capable of being saved to a computer and restored from a saved file. All communication addresses shall be user programmable.

3. Offers an open Application Programming Interface (API) and software development kit available to the Department at no cost for integration with third party software and systems.

995-2.8.2 LiDAR sensors: System sensors shall be recommended by the system manufacturer as part of the engineered LiDAR system solution. Detection range must extend up to at least 200 feet from the sensor. Multiple sensors shall be used to reduce occlusion and generate an accurate point cloud representation of the installation environment and detected objects.

995-2.8.3 Perception Software and Processor: The LiDAR system shall include a processor that combines data from multiple LiDAR sensors into a single point cloud for object detection, classification, presence detection, and data collection. The processor shall be a rugged industrial PC with CPU, memory, storage, a commercially available host operating system, and all software required for system operation. The processor shall include physical interfaces for connection of sensors, system inputs, and outputs.

995-2.8.4 Communications: All major system components shall include an Ethernet communications interface that provides a 10/100 Base TX connection. All unshielded twisted pair/shielded twisted pair network cables and connectors shall comply with TIA-568.

Wireless communications shall be secure and wireless devices shall be Federal Communications Commission (FCC) certified. The FCC identification number shall be displayed on an external label and all detection system devices shall operate within their FCC frequency allocation.

Cellular communications devices shall be compatible with the cellular carrier used by the agency responsible for system operation and maintenance.

995-2.8.5 Solid State Detection Outputs: Outputs shall meet the requirements of NEMA TS 2-2021, 6.5.2.26.

995-2.8.6 Electrical Requirements: The system shall operate using a nominal input voltage of 120 V of alternating current (V_{AC}) and with an input voltage ranging from 89 to 135 V_{AC}. If a system device requires operating voltages other than 120 V_{AC}, a voltage converter shall be supplied.

995-2.9 Vehicle Presence Detection System Performance Requirements: Presence detectors shall provide a minimum detection accuracy of 98% and shall meet the requirements for modes of operation in NEMA TS2-2021, 6.5.2.17.

995-2.9.1 Vehicle Presence Detection Accuracy: To verify conformance with the accuracy requirements in this Section and as a precondition for listing on the APL, sample data collected from the vehicle detection system will be compared against ground truth data collected during the same time by human observation or by another method approved by the FDOT Traffic Engineering Research Laboratory (TERL). Ensure sample data is collected over several time periods under a variety of traffic conditions. Weight each data sample to represent

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the predominant conditions over the course of a 24-hour period. Samples will consist of 15- and 30-minute data sets collected at various times of the day. Representative data periods and their assigned weights are provided in Table 995-2.

Table 995-2
Data Collection Periods

Period	Intended To Represent	Duration	Weight
Early morning (predawn) [EM]	12:30 a.m. – 6:30 a.m.	15 minutes	24
Dawn [DA]	6:30 a.m. – 7:00 a.m.	30 minutes	2
AM Peak [AMP]	7:00 a.m. – 8:00 a.m.	15 minutes	4
Late AM Off-Peak [LAOP]	8:00 a.m. – 12:00 p.m.	15 minutes	16
Noon [NO]	12:00 p.m. – 1:00 p.m.	15 minutes	4
Afternoon Off-Peak [AOP]	1:00 p.m. – 5:00 p.m.	15 minutes	16
PM Peak [PMP]	5:00 p.m. – 6:00 p.m.	15 minutes	4
Dusk [DU]	6:00 p.m. - 6:30 p.m.	30 minutes	2
Night [NI]	6:30 p.m. - 12:30 a.m.	15 minutes	24
Total Sum of Weights			96

For example, the sample gathered for the Late AM Off-Peak period is intended to represent typical traffic conditions between 8:00 a.m. and 12:00 p.m. Since the sample period's duration is 15 minutes and the actual period of time represented is 4 hours, the multiplication factor or weight assigned is 16, the number of 15-minute intervals in a 4 hour period.

995-2.9.2 Calculation of Vehicle Presence Detection Accuracy: Determine individual lane presence detection accuracy per period by subtracting from 100 percent the absolute difference of the total time monitored and the cumulative error time, divided by total time, expressed as a percentage.

Within the equation in 995-2.9.2.1, "EM" represents the early morning period. The variable "i" represents a detector or detection zone and could vary from 1,…, N, where "N" is the total number of detectors observed. Substitute other detector numbers and periods as necessary to determine accuracy for all detectors during each period (i.e., dawn, AM peak, late AM off peak, etc.).

Variables used in the following equations are identified as follows:

PA = Presence detection accuracy
TT = Total time
CET = Cumulative Error Time (duration of all false and missed calls)
N=Total number of detectors observed

995-2.9.2.1 Early Morning Vehicle Presence Detection Accuracy for a Single Detector Expressed as a Percentage:

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$$PA_{EM,\det_i} = 100 - \frac{\left|TT_{EM,\det_i} - CET_{EM,\det_i}\right|}{TT_{EM,\det_i}} x100$$

where:

$PA_{EM,\det_i}$ = Presence detection accuracy of detector *i* during the early morning period.

$TT_{EM,\det_i}$ = Total time that detector *i* was monitored (for instance, the 15-minute minimum duration specified in Table 995-2 for the early morning period).

$CET_{EM,\det_i}$ = Cumulative time that detector *i* was in an error state (indicating a detection with no vehicle present or not indicating a detection when vehicle present) during the monitoring period using human observation or another method approved by the Engineer.

The period accuracy will be the arithmetic mean of all individual detector accuracies.

In the equation in 995-2.9.2.2, "EM" represents the early morning period and "*N*" is the total number of detectors tested. Substitute other periods as necessary to determine the accuracy for each period (i.e., dawn, AM peak, late AM off-peak, etc.).

995-2.9.2.2 Early Morning Vehicle Presence Detection Accuracy for All Detectors Expressed as a Percentage:

$$PA_{EM} = \left(\frac{\sum_{i=1}^{N} PA_{EM,\det_i}}{N} \right)$$

Where:

PA_{EM} = Average accuracy of all detectors during the early morning.

$PA_{EM,\det_i}$ = Accuracy of detector *i* during early morning.

Calculate the roadway segment accuracy over all periods using the equation in 995-2.9.2.3.

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995-2.9.2.3 Total Vehicle Presence Detection Accuracy for All Detectors Expressed as a Percentage:

$$PA_{Total} = \frac{[PA_{EM}x24 + PA_{DA}x2 + PA_{AMP}x4 + PA_{LAOP}x16 + PA_{NO}x4 + PA_{AOP}x16 + PA_{PMP}x4 + PA_{DU}x2 + PA_{NI}x24]}{96}$$

Where:

PA_{Total} =Accuracy for all detectors for all periods

PA_{EM} = Accuracy of all detectors during early morning traffic conditions

PA_{DA} = Accuracy of all detectors during dawn traffic conditions

PA_{AMP} = Accuracy of all detectors during AM peak traffic conditions

PA_{LAOP} = Accuracy of all detectors during late AM off-peak traffic conditions

PA_{NO} = Accuracy of all detectors during noon traffic conditions

PA_{AOP} = Accuracy of all detectors during afternoon off-peak traffic conditions

PA_{PMP} = Accuracy of all detectors during PM peak traffic conditions

PA_{DU} = Accuracy of all detectors during dusk traffic conditions

PA_{NI} = Accuracy of all detectors during night traffic conditions

995-2.10 Traffic Data Detection System Acceptance Requirements:

995-2.10.1 Data Accuracy: The vehicle detection system shall be capable of meeting the minimum total roadway segment accuracy levels of 95% for volume, 90% for occupancy, and 90% for speed for all lanes, up to the maximum number of lanes that the device can monitor as specified by the manufacturer.

To verify conformance with the accuracy requirements in this Section and as a precondition for listing on the APL, sample data collected from the vehicle detection system will be compared against ground truth data collected during the same time by human observation or by another method approved by the TERL. Sample data shall be collected over several time periods under a variety of traffic conditions. Weight each data sample to represent the predominant conditions over the course of a 24-hour period. Samples shall consist of 15- and 30-minute data sets collected at various times of the day. Representative data periods and their assigned weights are provided in Table 995-2.

995-2.10.2 Calculation of Volume Accuracy: Determine individual lane volume accuracy per period by subtracting from 100 percent the absolute difference of the total volume measured by the detector and the ground truth volume measurement, divided by the ground truth volume measurement, expressed as a percentage.

In the equation in 995-2.10.2.1, “EM” represents the early morning period. The subscript “*i”* represents a lane at the detection zone on the roadway segment and could vary from 1,…, N, where “N” is the maximum number of lanes being detected. Substitute other lane numbers and periods as necessary to determine the accuracy for each lane during each period (i.e., dawn, AM peak, late AM off-peak, etc.).

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Variables and subscripts used in the equations below are identified as follows:

VT = Total volume
VD = Vehicle detection data (in this case, count data)
GT = Ground truth measurement
VA = Volume accuracy

995-2.10.2.1 Early Morning Volume Accuracy for a Lane Expressed as a Percentage:

$$VA_{EM,\ln_i} = 100 - \frac{\left|VT_{EM,VD,\ln_i} - VT_{EM,GT,\ln_i}\right|}{VT_{EM,GT,\ln_i}} x100$$

Where:

VA_{EM,ln_i} = Volume accuracy for early morning traffic conditions in the i th lane.

VT_{EM,VD,ln_i} = Total volume for the 15-minute early morning period using the vehicle detector in the i th lane.

VT_{EM,GT,ln_i} = Total volume for the 15-minute early morning period in the i th lane using human observation or another method approved by the Engineer.

The period volume accuracy will be the arithmetic mean of the lane volume accuracy over all lanes.

In the equation in 995-2.10.2.2, "EM" represents the early morning period and "*N*" is the total number of lanes of detection on the roadway segment under test. Substitute other periods as necessary to determine the accuracy for each period (i.e., dawn, AM peak, late AM off-peak, etc.).

995-2.10.2.2 Early Morning Volume Accuracy Expressed as a Percentage:

$$VA_{EM} = \left(\frac{\sum_{i=1}^{N} VA_{EM,\ln_i}}{N} \right)$$

Where:

VA_{EM} = Average volume accuracy for early morning traffic conditions for all lanes.

VA_{EM,ln_i} = Volume accuracy for early morning traffic conditions in the i th lane.

Calculate the total volume accuracy over all periods using the equation in 995-2.10.2.3.

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995-2.10.2.3 Total Volume Accuracy Expressed as a Percentage:

$$VA_{Total} = \frac{\left[VA_{EM}x24 + VA_{DA}x2 + VA_{AMP}x4 + VA_{LAOP}x16 + VA_{NO}x4 + VA_{AOP}x16 + VA_{PMP}x4 + VA_{DU}x2 + VA_{NI}x24\right]}{96}$$

Where:

VA_{Total} = Volume accuracy for all lanes for all periods
VA_{EM} = Volume accuracy for early morning traffic conditions
VA_{DA} = Volume accuracy for dawn traffic conditions
VA_{AMP} = Volume accuracy for AM peak traffic conditions
VA_{LAOP} = Volume accuracy for late AM off-peak traffic conditions
VA_{NO} = Volume accuracy for noon traffic conditions
VA_{AOP} = Volume accuracy for afternoon off-peak traffic conditions
VA_{PMP} = Volume accuracy for PM peak traffic conditions
VA_{DU} = Volume accuracy for dusk traffic conditions
VA_{NI} = Volume accuracy for night traffic conditions

995-2.10.3 Calculation of Speed Accuracy: For computing the accuracy of the detector speed measurement, the average speed readings obtained from the detection system are compared to ground truth values.

The equation in 995-2.10.3.1 represents the ground truth average speed computation procedure for a particular lane during a specific time period. The equation in 995-2.10.3.2 represents the average speed computation procedure for a particular lane during a specific time period using data gathered from the detection system.

In the equations in 995-2.10.3.1 and 995-2.10.3.2, the time period described is the early morning period, represented by “EM”, and the subscript “k” represents a vehicle traveling on the roadway and could vary from 1,…, K, where “K” is the total number of vehicles in lane i during the time period under consideration. The subscript “i” represents a lane in a roadway and could vary from 1,…, N, where “N” is the total number of lanes of detection on the roadway segment. Substitute other lanes and periods as necessary and compute the accuracy for each lane for all time periods.

Variables and subscripts used in the equations below are identified as follows:

SA = Speed accuracy
S = Speed of an individual vehicle
K = Total number of vehicles in lane during time period
veh = Vehicle

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995-2.10.3.1 Early Morning Average Ground Truth Speed:

$$S_{Avg,EM,GT,\ln_i} = \frac{1}{K}\sum_{k=1}^{K} S_{EM,GT,\ln_i,veh_k}$$

Where:

SA_{Avg,EM,GT,ln_i} represents the average ground truth vehicle speed for the *i* th lane during the early morning period.

S_{EM,GT,ln_i,veh_k} represents the ground truth speed for the k^{th} vehicle in the i^{th} lane during the early morning period using human observation or another method approved by the Engineer.

995-2.10.3.2 Early Morning Average Vehicle Detector Speed:

$$S_{Avg,EM,VD,\ln_i} = \frac{1}{K}\sum_{k=1}^{K} S_{EM,VD,\ln_i,veh_k}$$

Where:

S_{Avg,EM,VD,ln_i} represents the average speed recorded by the vehicle detector for the ith lane during the early morning period.

S_{EM,VD,ln_i,veh_k} represents the speed for the k th vehicle in the i th lane during the early morning period using the vehicle detector.

Determine lane speed accuracy per period by subtracting from 100 percent the absolute difference of the average lane speed measured by the detector and the average lane ground truth speed, divided by the average lane ground truth speed, expressed as a percent.

In the equation in 995-2.10.3.3, "EM" represents the early morning period. The subscript "*i*" represents a lane of detection on a roadway and could vary from 1,…,N, where "N" is the total number of lanes of detection on the roadway segment. Substitute other lanes as necessary to determine the accuracy for each period (i.e., dawn, AM peak, late AM off-peak, etc.).

995-2.10.3.3 Early Morning Lane Speed Accuracy Expressed as a Percentage:

$$SA_{Avg,EM,\ln_i} = 100 - \frac{\left|S_{Avg,EM,VD,\ln_i} - S_{Avg,EM,GT,\ln_i}\right|}{S_{Avg,EM,GT,\ln_i}} \times 100$$

Where:

SA_{Avg,EM,ln_i} represents the average speed accuracy during early morning traffic conditions for all vehicles that traveled in lane i of the roadway segment.

The period speed accuracy will be the arithmetic mean of the lane speed accuracy, computed using the equation in 995-2.10.3.3, over all lanes.

In the equation in 995-2.10.3.4, "EM" represents the early morning period. The subscript "i" represents a lane of detection on a roadway and could vary from 1,…, N, where "N" is the maximum number of lanes on the roadway segment. Substitute data as

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necessary to determine the accuracy for each period (i.e., dawn, AM peak, late AM off-peak, etc.).

995-2.10.3.4 Early Morning Speed Accuracy Expressed as a Percentage:

$$SA_{EM} = \left(\frac{\sum_{i=1}^{N} SA_{Avg,EM,\ln_i}}{N} \right)$$

Where:

SA_{EM} represents the average speed accuracy during early morning traffic conditions for all lanes of detection on the roadway segment.

Calculate detector speed accuracy for the roadway segment over all periods using the equation in 995-2.10.3.5.

995-2.10.3.5 Total Roadway Segment Accuracy Expressed as a Percentage:

$$SA_{Total} = \frac{[SA_{EM}x24 + SA_{DA}x2 + SA_{AMP}x4 + SA_{LAOP}x16 + SA_{NO}x4 + SA_{AOP}x16 + SA_{PMP}x4 + SA_{DU}x2 + SA_{NI}x24]}{96}$$

Where:

SA_{Total} = Speed accuracy for all lanes for all periods
SA_{EM} = Speed accuracy for early morning traffic conditions
SA_{DA} = Speed accuracy for dawn traffic conditions
SA_{AMP} = Speed accuracy for AM peak traffic conditions
SA_{LAOP} = Speed accuracy for late AM off-peak traffic conditions
SA_{NO} = Speed accuracy for noon traffic conditions
SA_{AOP} = Speed accuracy for afternoon off-peak traffic conditions
SA_{PMP} = Speed accuracy for PM peak traffic conditions
SA_{DU} = Speed accuracy for dusk traffic conditions
SA_{NI} = Speed accuracy for night traffic conditions

995-2.11 Probe Data Detection System Performance Requirements: Probe data detectors shall establish a unique and consistent identifier for each vehicle detected and the time and location that the vehicle was detected and shall provide the following:

1. A minimum match rate of 5% for probe data detection systems that match upstream and downstream detection of the same vehicle
2. A minimum total roadway segment speed and travel time accuracy level of 90%. Verify system performance over several time periods under a variety of traffic conditions as described in 995-2.9.1.

995-2.11.1 Calculation of Match Rate: Match rate is the percentage of the total vehicle population of a road segment that is detected and matched at consecutive probe data detection sites.

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995-2.11.1.1 Early Morning Match Rate Expressed as a Percentage:

$$MR_{EM} = 100 - \frac{\left|M_{EM,VD} - V_{EM,GT}\right|}{V_{EM,GT}} \times 100$$

Where:

MR_{EM} = Match Rate for early morning.

$M_{EM,VD}$ = Number of matched detections between two probe vehicle detection sites (typically a pair of sites at each end of a roadway segment) during early morning.

$V_{EM,GT}$ = Total volume of vehicles that pass the detection area for the 15-minute early morning period using human observation or another method approved by the Engineer.

995-2.12 Wrong Way Vehicle Detection System Accuracy: To verify conformance with the accuracy requirements in this Section and as a precondition for listing on the APL, sample data collected from the WWVDS will be compared against ground truth data collected during the same time by human observation or by another method approved by the FDOT Traffic Engineering Research Laboratory (TERL).

WWVDS accuracy testing shall be performed under controlled conditions at the TERL facility. The wrong way vehicle detection system must be capable of meeting a true positive detection accuracy of 100% using a sample size of 100 wrong way vehicle runs. Sample data shall be collected over several time periods under a variety of conditions. System operation will be monitored for 72 hours. The wrong way vehicle detection system shall not exceed one false positive per 24-hours during the monitoring period.

995-2.12.1 Calculation of WWVDS) System Accuracy: Determine true positive detection accuracy by dividing the number of valid wrong way vehicle detections by the number of vehicles.

995-2.12.1.1 Wrong Way Vehicle Detection System Accuracy expressed as a Percentage:

$$TPDA = \frac{WWVD}{N}\ x\ 100$$

Where:

TPDA = True Positive Detection Accuracy

WWVD = Number of Wrong Way Detections reported by system

N = Total number of wrong way vehicle runs

995-3 Loop Sealant.

Loop sealant shall be furnished in a premeasured two-part formulation and meet the following requirements:

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Table 995-3 Loop Sealant Properties		
Property	Test Method	Performance Criteria
Self-leveling		
Viscosity	ASTM D562 @77°F	Sealant shall not run out of unlevel slots
Adhering to concrete and asphalt	Install in 3/8 inch by 3-inch saw cut, cure for 2 weeks at 77°F	Visual inspection: sealant shall securely adhere to concrete and asphalt No visible signs of shrinkage after curing when tested for shrinkage using a dimensional measurement
Curing	ASTM C679 at 77°F	Tack-Free at 2 hours from time of application
Resistance to Fluids	ASTM D570	Sealant shall resist weather, oils, gasoline, antifreeze, and brake fluid when tested for absorption for water, No. 3 oil, gasoline, antifreeze, and brake fluid for 24 hours
Penetration	ASTM D2240 Shore A	Sealant shall resist penetration of foreign materials when tested for durometer hardness for 24 hours
Expansion Cracking	ASTM D412	Sealant shall resist cracking caused by expansion and contraction due to temperature changes when tested for tensile strength and elongation
Cracking	ASTM C1246	Sealant shall not become brittle with age or temperature extremes when tested for weight loss, cracking, and chalking
Shelf Life	Manufacturer's Recommendations	Sealant shall have a minimum shelf life of 12 months when stored in accordance with the manufacturer recommendations

995-4 Vehicular Traffic Signal Assemblies.

995-4.1 General: Vehicular traffic signal assemblies must meet the requirements of Section 603 and the ITE Standard for Vehicle Traffic Control Signal Heads.

Fastening hardware such as bolts, screws, nuts, washers, latches, and studs must be SAE Type 316 or 304 stainless steel.

Horizontal signal assemblies must be constructed so the door hinges, when installed, are located on the bottom of the signal assembly. Vertical mounted five-section cluster assemblies must be constructed so that the door hinges, when installed, are located along the outside edges of the complete assembly and each section opens away from the horizontally adjacent section.

995-4.2 Twelve Inch Signal Head Assemblies: Construct the assembly of materials and alloys specified in the ITE Standard for Vehicle Traffic Control Signal Heads.

Construct signal housings to allow adjustment in multiple directions for proper signal alignment. If a serrated connection is used for positioning and alignment of the signal, the top and bottom opening of each signal head section must include a circular 72-tooth serrated connection (2-inch nominal I.D.) capable of providing positive positioning and alignment in 5-

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degree increments. When assembled and tightened, these connections must prevent rotation or misalignment of the signal head as well as misalignment between sections. The serrated area must start at the outside of the 2-inch hole and be at least 1/8 inch wide. The teeth must have a minimum depth of 3/64 inch between peaks and valleys, be free from burrs or other imperfections, and provide positive locking with the grooves of mating sections, framework, and brackets. The serration on the top circular connection of a signal section must have a valley at the 0-degree position and the serration on the bottom circular connection must have a peak at the 0-degree position, both aligned perpendicular to the front of the section. Connections must permit the assembly of a multi-section signal with the front of each section aligned within 1 degree.

Provide at least two latching points with latch pads and manual Type 316 or 304 stainless steel latching devices that are tamper resistant.

If backplates are mechanically attached, each signal section must have four backplate mounting attachment points on the back of the signal, on or no more than three inches from each section corner. Attachment points must be capable of accepting No. 10-16x3/8 inch or No. 10-24x3/8 inch Type 316 or 304 stainless steel screws for attaching backplates.

Tri-stud washers, when utilized to secure signal sections, must have a minimum thickness of 0.090 inch. For five-section cluster assemblies, tri-stud washers used to attach the top signal section to the multi-signal bracket and the multi-signal bracket to the bottom four signal sections must have a minimum thickness of 3/8 inch. When fastened together, washer distortion is not allowed.

Design each signal section to prevent the accumulation of standing water within the assembly. All sections comprising a single multi-section assembly must be securely fastened together to form a rigid and weather-proof unit.

995-4.2.1 Doors: Construct each signal section with at least two hinges for mounting a door. Hinge pins must be captive. Doors must remain captive and secure at all times and be capable of either left or right swing. The door latch must hold the door tightly closed. The door must include slotted pads that allow the door to be opened and closed by engaging or disengaging the latching device. The outside face of the door must include four holes equally spaced around the circumference of the lens opening for the attachment of a visor. The lens opening in the door must have a diameter of 11 to 11-1/2 inches.

995-4.2.2 Visors: The rear of the visor must have four tabs, notches, or holes for securing the visor to the signal housing door. The visor mounting method must permit the visor to be rotated and secured at 90 degrees for horizontal signal head installations. All visors must have a minimum length of 9-1/2 inches, and a minimum downward tilt of 3.5 degrees measured from the center of the lens. Tunnel visors must encircle and shield the lens from 300 degrees, plus or minus 10 degrees. Louvers may only be used in combination with full circle visors. Light must not escape between the visor and the door.

995-4.2.3 Gaskets: Gaskets must be constructed of weather-resistant material and be glued or sealed where they meet to provide one continuous length of gasket capable of providing a weatherproof seal for the signal assembly. Provide seals between the housing and door, between the lens and the door, and between any other mating surfaces where dust and moisture could enter. Gasket material must meet NEMA 250 and be constructed of temperature stabilized material that prevents any residue from collecting on the internal surfaces of the signal head.

995-4.2.4 Terminal Blocks: Provide at least one five-connection terminal block in all three or more section signal head assemblies and at least three five-connection terminal

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blocks in all five section signal head assemblies. Terminal block connections in the signal assembly must not require any tools other than a screwdriver.

Mount terminal blocks to the signal housing with Type 316 or 304 passivated stainless steel hardware. Use only non-corrosive wire attachment screws approved by the Department.

995-4.2.5 Color and Finish: The housing, doors, visors and backplates must be powder coated dull black (Federal Standard 595-37038) with a reflectance value not exceeding 25 percent as measured by ASTM E1347. For plastic heads, the black color must be incorporated into the plastic material before molding.

The finish on interior and exterior surfaces of aluminum signal head assemblies, visors, doors, and housing, must be painted in accordance with Military Standard MIL-PRF-24712A or American Architectural Manufacturers Association (AAMA) -2603-02 and must meet the requirements of ASTM D3359, ASTM D3363, and ASTM D522. Surface erosion, flaking, or oxidation must not occur within the normal life expectancy under typical installation conditions.

995-4.2.6 Plastic Signal Housings and Visors: Construct signal housing assembly, door, and visors of UV stabilized plastic with a minimum thickness of 0.1 inch, plus or minus, 0.01 inch, with the following physical properties:

Table 995-4
Plastic Signal Housings and Visors

Test	Minimum Requirement	Method
Specific Gravity	1.17	ASTM D792
Vicat Softening Temp.	305-325°F (152 – 163°C)	ASTM D1525
Brittleness Temp.	Below -200°F (-129°C)	ASTM D746
Flammability	Self-extinguishing	ASTM D635
Tensile Strength	Yield, 8500 psi (58 MPa)	ASTM D638
Elongation at yield	5.5 - 8.5%	ASTM D638
Shear Strength	Yield, 5500 psi (38 MPa)	ASTM D732
Izod impact strength	15ft-lb/in (800 J/m)	ASTM D256
Fatigue strength	950 psi (6.5MPa) at 2.5 mm cycles	ASTM D671
Fatigue strength	950 psi (6.5MPa) at 2.5 mm cycles	ASTM D671

995-4.2.7 Backplates: Backplates may be constructed of either aluminum or plastic. Minimum thickness for aluminum backplates is 0.060 inch and the minimum thickness for plastic backplates is 0.120 inch. Backplate thickness measurement must not include the retroreflective sheeting thickness. The width of the top, bottom, and sides of backplates must measure between five to six inches. Color of backplates must be black in accordance with 995-4.2.5.

If backplates are mechanically attached, provide a minimum of four corner mounting attachment points per signal section (for example, a three-section signal assembly would have 12 mounting points). Attachment points must not interfere with the operation of traffic signal section doors. Backplate outside corners must be rounded and all edges must be de-burred.

If louvers are provided, louver orientation must be vertical on sides and horizontal on top and bottom of the backplate and must be at least 1/2 inch from the inner and

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outer edge of the backplate panel. Universal backplates must fit all traffic signals listed on the APL.

Mount the backplate securely to the signal assembly with Type 316 or 304 passivated stainless steel installation hardware. Backplates, if mechanically attached, must be marked in accordance with 995-1, on the long sides of the backplate.

Backplates must include retroreflective borders using Type IV yellow retroreflective sheeting listed on the APL. Place a 2-inch border on the entire outer perimeter of the backplate panel, no closer than 1/2 inch from any louvers.

All materials must be designed for exterior use and be UV stable.

995-4.2.7.1 Flexible Backplates: Flexible backplates must allow the entire length of longer portions of the backplate to flex 90 degrees, or until the backplate width is reduced to 2.5 inches or less, when influenced by high wind conditions, and return to zero degrees after the wind conditions subside. Flexible backplates must maintain visibility of the retroreflective border to approaching traffic, with up to 40 mph winds.

995-4.2.8 Light-Emitting Diode Optical Unit: The LED optical unit must conform to the requirements of ITE's Performance Specification, Vehicle Traffic Control Signal Heads - Light Emitting Diode (LED) Circular Signal Supplement, dated June 27, 2005 or Vehicle Traffic Control Signal Heads - Light Emitting Diode (LED) Vehicle Arrow Traffic Signal Supplement, dated July 1, 2007, with the following exceptions.

1. Retrofit LED signal modules must be compatible with all traffic signal housings listed on the APL. The rear of the LED signal module must be marked in accordance with 995-4.1.

2. The lens must be tinted with an appropriate color (red, amber, or green) to reduce sun phantom affect and enhance on/off contrast. The tinting must be uniform across the face of the lens and be free from streaks, wrinkles, chips, bubbles, or other imperfections. If a polymer lens is used, a surface coating must be incorporated to provide abrasion resistance.

3. Red and green modules must meet the requirements of ITE's Performance Specification, Vehicle Traffic Control Signal Heads - Light Emitting Diode (LED) Circular Signal Supplement, dated June 27, 2005, with the exception that yellow modules must be 1.7 times brighter than the ITE specification. Arrow modules must meet the requirements of ITE's Performance Specification, Vehicle Traffic Control Signal Heads - Light Emitting Diode (LED) Vehicle Arrow Traffic Signal Supplement, dated July 1, 2007.

995-4.2.9 Electrical: Electrical conductors for LED signal modules must be a minimum of 36 inches in length. Each lead from the LED module must be terminated with insulated slide-on terminals. The conductors must be color coded to identify the color of the module as follows:

1. White must identify the neutral lead.

2. Red circular signals must be identified with a red lead, yellow circular signals with a yellow lead, and green circular signals with a green lead.

3. Red arrows must be identified with a red and black tracer lead, yellow arrows with a yellow and black tracer lead, and green arrows with a green and black tracer lead.

995-5 Pedestrian Signal Assemblies.

995-5.1 General: Pedestrian signal assemblies must meet the requirements of Section 603, the MUTCD, and the ITE standard for Pedestrian Traffic Control Signal Indications.

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995-5.2 Housing and Visor: The housing must be weatherproof, sectional and may consist of as many sections as optical units. The housing must prevent light from escaping from one unit to another. The top and bottom opening of the housing must include a circular 72-tooth serrated connection (2-inch nominal I.D.) capable of providing positive positioning and alignment in 5 degree increments. When assembled and tightened, these connections must prevent rotation or misalignment. The serrated area must start at the outside of the 2-inch hole and be at least 1/8 inch wide. The teeth must have a minimum depth of 3/64 inch between peaks and valleys, free from burrs or other imperfections, and provide positive locking with the grooves of mating sections, framework, and brackets. The serration on the top circular connection of a signal section must have a valley at the 0-degree position and the serration on the bottom circular connection must have a peak at the 0-degree position, both aligned perpendicular to the front of the section. Housings must include latch pads and manual stainless steel latching devices that are captive, or non-removable. Housings must have at least two latching points.

Reinforce all mounting points and adjacent housing material. The door enclosing the lens must be hinged and held securely to the housing. Provide a gasket meeting the requirements of ASTM D1056, Grade 2B2 between the housing and door and between the lens and door. If the fitting between the housing and door is weather-tight, the gasket may be omitted.

Provide a visor or egg-crate louver that eliminates sun phantom for each signal face. Visor must be three-sided and extend a minimum of 7 inches at the top from the face of the lens. The visor must be constructed of noncorrosive No. 18 gauge sheet metal, not less than 0.05 inch thick, or 0.1 inch thick polycarbonate.

All metal housings and visors must be powder-coat painted black in accordance with Military Standard MIL-PRF-24712A or AAMA-2603-02 with a reflectance value not exceeding 25 percent as measured by ASTM E97. For polycarbonate heads, the black color must be incorporated into the material before the molding process.

The housing must be constructed of a non-corrosive material. Cast metal parts must have a minimum tensile strength of 1 ksi (117 MPa) and sheet metal parts a minimum tensile strength of 27 ksi (186 MPa).

995-5.2.1 Die Castings: Meet the requirements in ASTM B85 for the physical characteristics and chemical content for alloys S12A, S12B, SC84A, SC84B, SG100A and SG100B.

995-5.2.2 Sand Castings: Meet the requirements in ASTM B26 for the physical characteristics and chemical content for alloys S5A and CS72A.

995-5.2.3 Permanent Mold Castings: Meet the requirements in ASTM B108 for the physical characteristics and chemical content for alloys S5A and CS72A.

995-5.2.4 Polycarbonate: Polycarbonate housing assemblies, doors and visors must be molded from ultraviolet stabilized polycarbonate plastic with a minimum thickness of 0.1 inch, plus or minus 0.01 inch, and provide the following physical properties:

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Table 995-5 Polycarbonate Housing Assemblies, Doors, and Visors		
Test	Minimum Requirement	Method
Specific Gravity	1.17	ASTM D792
Vicat Softening Temp.	305-325°F (152 – 163°C)	ASTM D1525
Brittleness Temp.	Below -200°F (-129°C)	ASTM D746
Flammability	Self-extinguishing	ASTM D635
Tensile Strength	Yield, 8500 psi (58 MPa)	ASTM D638
Elongation at yield	5.5 - 8.5%	ASTM D638
Shear Strength	Yield, 5500 psi (38 MPa)	ASTM D732
Izod impact strength	15ft-lb/in (800 J/m)	ASTM D256
Fatigue strength	950 psi (6.5MPa) at 2.5 mm cycles	ASTM D671

995-5.3 Light Emitting Diode (LED) Pedestrian Signal Optical Unit (State Standard): Provide a countdown pedestrian signal module meeting the requirements of the latest ITE LED Pedestrian Signal Specifications.

995-5.4 Electrical: Wiring and terminals must meet the size, insulation, length, and color-coding of the current ITE Pedestrian Traffic Control Signal Indicators LED specification. Wires must not have bare wiring exposed where wires are secured.

The pedestrian signal must include a terminal block containing a minimum of three circuits, each with two noncorrosive screw-type terminals. Each terminal must accommodate three No. 18 AWG conductors and be labeled for ease of identification. The terminal block must not be obstructed and be visible when the housing is open.

995-5.5 Hardware: All brackets used to mount pedestrian signals must be an aluminum alloy cast fitting, pipe, or equivalent material approved by the Department. Aluminum and aluminum alloy bars, rods, wires, profiles, and tubes must meet ASTM B221. Aluminum-alloy sand casting must meet ASTM B26. All mounting hardware must be painted black with a reflectance value not exceeding 25 percent as measured by ASTM E97.

Ensure that all assembly hardware, including nuts, bolts, external screws and locking washers less than 5/8 inch in diameter, are Type 304 or 316 passivated stainless steel. Stainless Steel bolts, screws and studs must meet ASTM F593. Nuts must meet ASTM F594. All assembly hardware greater than or equal to 5/8 inch in diameter must be galvanized. Bolts, studs, and threaded rod must meet ASTM A307. Structural bolts must meet ASTM F3125, Grade A325.

995-6 Midblock Crosswalk Enhancement Assemblies.

995-6.1 General: Midblock crosswalk enhancement assemblies are classified as the following types: In-Roadway Light Assemblies and Rectangular Rapid Flashing Beacon Assemblies (RRFB).

995-6.2 In-Roadway Light Assemblies: In-roadway light assemblies must meet the physical and operational requirements of the latest edition of the MUTCD, Chapter 4N.

In-roadway light assemblies can include a passive detector in addition to a pedestrian pushbutton. In-roadway light assemblies must be normally dark and initiate operation upon pedestrian actuation via a pedestrian pushbutton or a passive detector. The In-roadway light assembly will cease operation at a predetermined time after the pedestrian actuation. If a passive detector is used, the In-roadway light assembly may cease operation after the pedestrian clears

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the crosswalk. The duration of the predetermined period shall be programmable and capable of matching the pedestrian clearance time for pedestrian signals as determined by MUTCD procedures. The timer that controls flashing must automatically reset each time a pedestrian call is received.

In-roadway light assemblies must have a minimum luminance of 101 candelas and a minimum viewing angle of 20 degrees.

995-6.3 Rectangular Rapid Flashing Beacon (RRFB): RRFB must include two rapidly and alternately flashed rectangular yellow indications having LED-array based pulsing light sources. Each rectangular yellow indication must be a minimum of five inches wide by two inches high. RRFB installations shall comply with the use and technical conditions of FHWA MUTCD Interim Approval 21 – Rectangular Rapid-Flashing Beacons at Crosswalks. The two RRFB indications shall be aligned horizontally, with the longer dimension horizontal and with a minimum space between the two indications of approximately 7 inches measured from inside edge of one indication to inside edge of the other indication.

995-6.3.1 Beacon Flashing Requirements: The light intensity of the yellow indications shall meet the minimum specifications of SAE Standard J595 for Class 1 (Directional Flashing Optical Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles) dated January 2005. Ensure RRFB assemblies are capable of automatically dimming to reduce brightness of the LEDs at nighttime.

The flash rate of each individual yellow indication, as applied over the full on-off sequence of a flashing period of the indication, shall not be between 5 and 30 flashes per second. When activated, the two yellow indications in each RRFB shall have a flash rate of 75 flash cycles per minute using the following sequence: left side beacon on for 50 milliseconds (msec), both beacons off for 50 msec, right side beacon on for 50 msec, both beacons off for 50 msec, left side beacon on for 50 msec, both beacons off for 50 msec, right side beacon on for 50 msec, both beacons off for 50 msec, both beacons on for 50 msec, both beacons off for 50 msec, both beacons on for 50 msec, both beacons off for 250 msec. No other flash patterns shall be selectable via hardware or software.

995-6.3.2 RRFB Operation: RRFB can include a passive detector in addition to a pedestrian pushbutton. RRFBs must be normally dark and initiate operation only upon pedestrian actuation via a pedestrian pushbutton, or a passive detector. The RRFB will cease operation at a predetermined time after the pedestrian actuation. If the passive detector is used, the RRFB may cease operation after the pedestrian clears the crosswalk. The duration of the predetermined period shall be programmable and capable of matching the pedestrian clearance time for pedestrian signals as determined by MUTCD procedures. The timer that controls flashing must automatically reset each time a pedestrian call is received.

All RRFBs associated with a single crosswalk (including those with an overhead or advance crossing sign, if used) shall simultaneously commence operation of their alternating rapid flashing indications and shall cease operation simultaneously.

RRFBs must include an instruction sign (FTP-68C-21) mounted adjacent to or integral with each pedestrian pushbutton, in accordance with the Standard Plans, Index No. 654-001.

A confirmation light directed at and visible to pedestrians in the crosswalk must be installed integral to the RRFB to give confirmation that the RRFB is in operation.

995-6.3.3 Midblock Accessible Pedestrian Pushbutton: The assembly must contain a speaker, audio amplifier, and noise monitoring microphone for auto volume control.

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The accessible pedestrian pushbutton detector must meet 995-9.3 for the locator tone feature. The pushbutton must not include a vibrotactile indication or percussive indications. The audible message must be programmable.

995-6.4 Cabinets, Housings, and Hardware: Cabinets used as part of the midblock crosswalk enhancement assembly must be currently listed on the APL or meet the requirements of Section 676.

All housings other than approved cabinets must be powder coat painted dull black per SAE AMS-STD-595A with a reflectance value not exceeding 25 percent as measured by ASTM E1347. Cabinets and housings must prevent unauthorized access.

Pole-mount assemblies shall allow installation on 4-1/2 inch outer diameter posts.

Ensure all assembly hardware, including nuts, bolts, external screws, and locking washers less than 5/8 inch in diameter, are Type 304 or 316 passivated stainless steel. Stainless steel bolts, screws, and studs must meet ASTM F593. Stainless steel nuts must meet ASTM F594. All assembly hardware greater than or equal to 5/8 inch in diameter must be galvanized. Carbon steel bolts, studs, and threaded rod must meet ASTM A307. Structural bolts must meet ASTM F3125, Grade A325.

995-6.5 Electrical Specifications: Equipment must operate on solar power or a nominal voltage of 120 V_{AC}. If the device requires operating voltages of less than 120 V_{AC}, supply the appropriate voltage converter. Solar powered systems must be designed to operate for minimum of 100 activations per day and provide 10 days of operation without sunlight. Each activation must be 30 seconds in duration. Solar powered systems must automatically charge batteries and prevent overcharging and over-discharging. Solar powered systems must include a charge indicator.

995-6.6 Environmental Specifications: All electronic assemblies shall operate as specified during and after being subjected to the transients, temperature, voltage, humidity, vibration, and shock tests described in NEMA TS2-20218.3, 2.2.7, 2.2.8, and 2.2.9. Electronics must meet FCC Title 47, Subpart B, Section 15. The optical portion of the housing shall be sealed to provide an IP 67 rating.

995-7 Mast Arm, Span Wire, and Pole Mounting Assemblies.

995-7.1 General: Fastening hardware such as bolts, nuts, washers, set screws, studs, u-bolts, cable and cable swags, must be provided by the mounting assembly manufacturer, must be SAE Type 316 or 304 stainless steel. Hardware (studs, bolts and u-bolts) must be a minimum of 5/16 inch diameter unless otherwise specified in this Section. SAE Grade 8 bolts and nuts are also acceptable. Metallic mounting assemblies must meet ASTM B117 for corrosion resistance.

Connections that provide an entrance to the interior of a traffic device must be weather-resistant.

All assemblies must be constructed to support the weight of any combination of signal indications with all accessories such as back plates and visors.

Connections between signal, disconnect and disconnect hanging hardware must be of the tri-stud design unless otherwise specified in this Section. Tri-stud washers must be a minimum 0.090 inch thick unless otherwise specified in this Section.

Connections must be designed to mate with a standard traffic signal's 2-inch I.D. opening and must be capable of providing positive positioning and alignment of the traffic device. Connection type may be a 72-tooth serrated edge or other connection type as long as all other specifications are met. For 72-tooth serrated edge connections, the teeth must be clean,

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sharp, and at least 1/8 inch wide and 3/64 inch deep. All connection types must be weather resistant.

All mounting assemblies must be capable of providing adjustment in multiple directions for proper alignment of the attached traffic device and to prevent rotation around the vertical axis or misalignment after installation.

Use studs that are either cast directly into the aluminum during the casting process or tapped and locked with a locking material. In each case, a pull-out force must be provided. Messenger wire clamps must be extruded aluminum six inches long or cast U-bolt type.

Torque specifications must be included for all fastening hardware with the assembly installation instructions.

995-7.2 Product Identification: Mounting assemblies must be permanently marked in accordance with 995-1. Identification must be cast into, or metal-marked on, the assembly in a legible manner. When the assembly is made up of multiple components, each component must be identified with the manufacturer's name or trademark.

995-7.3 Finish: Unless otherwise specified, mounting assemblies and components must be supplied with a natural finish with mill scale removed in accordance with Military Standard MIL-PRF-24712A or AAMA 2603-02 and must meet the requirements of ASTM 3359 and ASTM D3363. Disconnect (interior and exterior) and disconnect hub must be powder-coat painted dull black (Federal Standard 595A-37038) with a reflectance value not exceeding 25 percent as measured by ASTM E97. All finished surfaces must have a smooth finish free from cracks, blow-holes, shrinks, excessive material, and other flaws.

995-7.4 Mast Arm Mounting Assemblies: Mast arm mounting assemblies must include the following components: mast arm saddle, swivel, attachment cables (with cable clamp mechanism) or bands. Unless the assembly uses a free-swinging mounting method, mast arm mounting assemblies must include the support tube, and top and bottom support arms. Mast arm mounting assemblies must be designed to be attached to a mast arm by cables or bands. All connections must be designed to prevent movement when 250 pounds of downward force is applied to the completed vehicular traffic signal assembly.

995-7.4.1 Saddle: Saddles must be aluminum or stainless steel and must have a minimum yield strength of 16 ksi and a minimum ultimate tensile strength of 23 ksi in accordance with ASTM B26, ASTM B108, ASTM B85 or ASTM A240.

995-7.4.2 Swivel: Swivels must be aluminum or stainless steel and must have a minimum yield strength of 16 ksi and a minimum ultimate tensile strength of 23 ksi in accordance with ASTM B26, ASTM B108, ASTM B85 or ASTM A240. The swivel must provide at least two connection devices to secure the support tube to the swivel and be configured to permit the support tube to provide adjustment in multiple directions in a plane parallel to the mast arm. Any castings used to attach the support tube to the swivel must be manufactured from the same alloy as the swivel.

995-7.4.3 Saddle Attachment Cables and Bands: Mast arm saddle attachment cables must be 3/16-inch minimum diameter, Type 316 or 304 stainless steel aircraft type wire strand cable. The swage at the ends of the cable (used to tighten the cable against the saddle) must be Type 316 or 304 stainless steel with a minimum 3/8-inch diameter thread. The swage must permit use of a wrench to prevent rotation while tightening the nut at the end of the swage. If the attachment cable does not have swaged clamp screws at each end (double-ended), the unclamped end of the cable must be sintered, welded, or otherwise secured without adhesives to prevent unraveling of the cable. Banding must use two Type 304 or 201 series stainless steel

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3/4 inch wide bands and Type 316 stainless steel buckles (clamp screws). De-burr the edges of the bands.

995-7.4.4 Cable Clamp Mechanism: Mast arm mount components used to secure the cable to the saddle must be aluminum or stainless steel and must have a minimum yield strength of 23 ksi and a minimum ultimate tensile strength of 30 ksi in accordance with ASTM B26, ASTM B221, ASTM B85 or ASTM A240.

995-7.4.5 Support Tube: Support tubes used in mast arm mounting assemblies must be aluminum or stainless steel and must have a minimum yield strength of 25 ksi and a minimum ultimate tensile strength of 30 ksi in accordance with ASTM B221 or ASTM A240. A gusseted hollow design may be used to provide for the routing of necessary wiring. The tube cross-sectional area's principal moments of inertia must average; at a minimum, that of a 1.5-inch standard aluminum Schedule 40 pipe and the cross-sectional metal area must not be less than that of a 1.5-inch Schedule 40 pipe. The bottom portion of the tube that supports the vertical load of the hanging device must be threaded using National Pipe Thread Taper (NPT), National Pipe Thread Straight (NPS), non-threaded U-bolt secured, or a continuous arm support tube. Threaded support tubes that are fully slotted must have an aluminum insert in the 3/4-inch slot extending a minimum of 1/2-inch beyond the threaded section. To provide easy installation of wiring, the tube must have a minimum 0.562-inch wire entrance slot running the full length of the tube, or either stopping a minimum of 8 inches above the threaded or U-bolt secured end. Edges of slot must be supported with internal gusseting. The tube interior and slot must be free of sharp edges that may damage wiring. Provide an easily installed and removable UV stabilized seal to completely fill the wire entrance slot after installation.

995-7.4.6 Top Support Arm: The top support arm of the mounting assembly must be of one-piece solid construction, or continuous arm with support tube, and capable of holding the signal head firmly in place. Top support arms must be aluminum with a minimum ultimate tensile strength of 30 ksi and minimum yield strength of 18 ksi in accordance with ASTM B26, or be die cast with a minimum ultimate tensile strength of 27 ksi and a minimum yield strength of 24 ksi.

A one or two piece top arm is acceptable. For a one-piece top arm, use at least two 1/4-inch minimum diameter Type 316 or 304 stainless steel set screws to secure its position on the support tube. When a two-piece top arm is used, hardware required to connect components of the top arm must be 3/8-inch minimum diameter, Type 316 or 304 stainless steel.

The top support arm must have three 1/4 inch - 20 UNC-2B threaded holes to accept bolts for a tri-stud washer and gasket, or at least one imbedded or tapped and locked 5/16 inch - 18 threaded stud within the industry's standard 72-tooth serrated circular design that facilitates 5 degree increment positioning. Provide 0.090-inch thick (minimum) Type 316 or 304 stainless steel washers, nuts, and lock washers for attaching signal heads. A rubber washer, with dimensions similar to the large stainless-steel washer, must be provided for traffic signals. When mast arm clamps are used to support illuminated signs with tri-stud arrangements, a rubber washer with dimensions similar to the steel washer must also be used.

995-7.4.7 Bottom Support Arm: The bottom support arm, when not continuous arm with support tube, must be hollow to allow the routing and enclosing of all signal wiring. Bottom support arms must be aluminum with a minimum ultimate tensile strength of 30 ksi and minimum yield strength of 18 ksi in accordance with ASTM B26, or be die cast with a minimum ultimate tensile strength of 27 ksi and a minimum yield strength of 24 ksi. Plastic bottom arm

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covers must be constructed of ABS with a UV inhibitor and be strong enough to contain the signal cable in the bottom arm cavity without bending during installation and warping over time.

The end of the bottom support arm that attaches to the support tube must have a 1.5-inch steel coupling imbedded and cast directly into the part during the solidification of the aluminum, or a 1-1/2 inch NPT or NPS pipe thread cut directly into the casting. For non-threaded versions, the arm must allow the support tube to sit a minimum of 2 inches into an arm pocket and be secured to the arm with minimum 5/16-inch full U-shape U-bolt to distribute the load evenly to the lower arm casting.

The end of the bottom support arm that connects to the signal must have either three equally spaced and plumb imbedded 5/16-inch Type 316 or 304 stainless steel threaded studs located in the center of the 72-tooth serrated circular design, or three 1/4 inch – 20 UNC-2B tapped holes to accept bolts for a tri-stud washer.

995-7.4.7.1 Arms with Steel Coupling: If a threaded steel coupling is imbedded into the casting, the bottom arm must be aluminum alloy 535.0-F in accordance with ASTM B26, with a minimum ultimate tensile strength of 23 ksi, meeting all standards listed in ASTM B26, including chemical composition listed in Table 1 and material mechanical properties listed in Table 2. The end of the bottom support arm must have at least two 1/4-inch diameter Type 316 or 304 stainless steel set screws to secure its position on the support tube.

995-7.4.7.2 Threaded Arms: If threads are cut directly into the casting, the bottom arm must be aluminum alloy 535.0-F in accordance with ASTM B26, with a minimum ultimate tensile strength of 35 ksi and elongation of 9.0% in a 2-inch section, meeting all standards listed in ASTM B26, including chemical composition listed in Table 1 and material mechanical properties listed in Table 2. As an alternative, the arm can be die cast in aluminum with a minimum ultimate tensile strength of 27 ksi and a minimum yield strength of 24 ksi. The end of the bottom arm must have at least two 1/4-inch minimum diameter Type 316 or 304 stainless steel set screws to secure its position on the support tube.

995-7.4.7.3 Non-threaded Arms: Lower arm must be aluminum 356 having a minimum ultimate tensile strength of 30 ksi and meeting all standards listed in ASTM B26, including chemical composition listed in Table 1 and material mechanical properties listed in Table 2. The arm must have a locator tab to receive the support tube and be secured by a U-bolt.

995-7.4.7.4 Continuous Arm Support Tube: The continuous arm support tube must be of single form construction to support the weight of any combination of signal indicators with all accessories such as backplates and visors. Continuous support tubes must be Type 316 or 304 stainless steel with a minimum ultimate tensile strength of 75 ksi and a minimum yield strength of 30 ksi in accordance with ASTM A554, or aluminum with a minimum yield strength of 25 ksi and a minimum ultimate tensile strength of 30 ksi in accordance with ASTM B221.

The continuous arm support tube attachment to the signal head must have a minimum of two 5/16-18 Type 316 or 304 stainless steel bolts, nuts and washers. A rubber seal must be provided between the support tube and signal head.

995-7.5 Span Wire Mounting Assemblies: Span wire mounting assemblies must include a span wire clamp, a hanging device such as a drop pipe, adjustable hanger, or adjustable pivotal hanger with extension bar, messenger clamp, disconnect hanger, and multi-brackets.

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995-7.5.1 Span Wire Clamp: Span wire clamps must be aluminum or stainless steel and must have a minimum ultimate tensile strength of 32 ksi and minimum yield strength of 22 ksi in accordance with ASTM B28, ASTM B108, ASTM B85, or ASTM A240.

995-7.5.2 Drop Pipe: Drop pipe hangers must be galvanized 1.5-inch steel aluminum having a minimum yield strength of 35 ksi and a minimum ultimate tensile strength of 42 ksi in accordance with ASTM B221 and have NPT on each end for assembly.

995-7.5.3 Aluminum Adjustable Hanger: Aluminum adjustable hangers must be aluminum alloy 535.0-F in accordance with ASTM B26 with a minimum ultimate tensile strength of 35 ksi and elongation of 9.0% in a two-inch section, meeting the chemical composition listed in Table 1 and material mechanical properties listed in Table 2 in ASTM B26.

995-7.5.4 Stainless Steel Adjustable Hanger: Stainless steel adjustable hangers must be Type 316 or 304 stainless steel with a minimum ultimate tensile strength of 75 ksi and a minimum yield strength of 30 ksi in accordance with ASTM A276.

995-7.5.5 Aluminum Adjustable Pivotal Hanger: Aluminum pivotal hangers must be aluminum alloy 535.0-F in accordance with ASTM B26 with a minimum ultimate tensile strength of 35 ksi and elongation of 9.0% in a two-inch section, meeting the chemical composition listed in Table 1 and material mechanical properties listed in Table 2 in ASTM B26.

995-7.5.6 Stainless Steel Adjustable Pivotal Hanger: Stainless steel pivotal hangers must be either Type 316 or 304 stainless steel with a minimum ultimate tensile strength of 75 ksi and a minimum yield strength of 30 ksi in accordance with ASTM A276.

995-7.5.7 Aluminum Extension Bar: Extension bars used to extend the length of the adjustable hanger must be T6061-T6 extrusion aluminum having a minimum yield strength of 35 ksi and a minimum ultimate tensile strength of 42 ksi in accordance with ASTM B221.

995-7.5.8 Stainless Steel Extension Bar: Stainless steel extension bar used to extend the length of adjustable hangers must be Type 316 or 304 stainless steel with a minimum ultimate tensile strength of 75 ksi and a minimum yield strength of 30 ksi in accordance with ASTM A276.

995-7.5.9 Disconnect Hanger: The disconnect hanger must be supplied with the following as a minimum:

1. Wired screw type/compression terminal block and wiring rated at 600 V_{AC} Root Mean Square (rms) with 12 or 18 circuits. The terminal block must be easily accessible for connection of the field wiring. Attach the terminal block to the disconnect with Type 316 or 304 stainless steel or brass fastening hardware.

2. Weather resistant grommets in each signal cable entrance of the disconnect hanger to prevent insect and animal access and to protect the signal cable from chafing.

3. A 2-inch opening in the top of the disconnect hanger with an integral serrated area (or 1.5-inch NPT threaded top section) to interface with the hanger method employed above it.

4. A securable door that allows access to all areas of the interior. The door securing device must be Type 316 or 304 stainless steel and captive. Hinge or groove pins for the door must be Type 316, 304, 303, or 302 stainless steel.

995-7.5.10 Multi-Brackets: Top and bottom (multi) brackets used in the assembly of span wire mounted multi-directional signals must be constructed of aluminum having a minimum yield strength of 13 ksi and a minimum ultimate tensile strength of 23 ksi per ASTM B26.

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Top brackets must be of one-piece hollow design, with a cross-sectional diameter of at least 1-1/2 inch I.D. for receiving signal wires. The wall thickness must be at least 3/16 inch. Each top bracket (2-way, 3-way, and 4-way) must have a two-inch diameter hole (with integral serrated boss as specified above) in the top side of the bracket for receiving a 1-1/2 inch entrance fitting. The underside of the top bracket must have a covered hole of at least three inches in diameter for the installation of the signal wires.

Bottom brackets must be of one-piece solid construction and must hold the signal heads firmly in place.

For the five-section cluster configuration, provide 3/8-inch-thick Type 316 or 304 stainless steel tri-stud washers and nylock nuts with lock washers to secure the top and lower signal sections of the cluster to the top multi bracket. Washer distortion must not occur after assembly of the five-section cluster. Multi-brackets must include all fastening hardware necessary to attach to the signal.

995-7.6 Pole (Pedestal and Post) Mounting Assemblies: All trunnions, brackets, and suspensions used in mounting vehicular and pedestrian signals to concrete, steel, aluminum, or wood poles must be an aluminum alloy cast fitting, pipe or equivalent as approved by the Engineer. The aluminum alloy must have a minimum ultimate tensile strength of 35 ksi in accordance with ASTM B221, ASTM B85, or ASTM B26.

Pole side-mount brackets used for pedestrian signals may be constructed of polycarbonate material.

995-7.7 Mounting Assemblies for Signs, Cameras, Detectors, and Other Traffic Control Devices: Mounting assemblies or assembly components used for signs, cameras, detectors, and other traffic control devices must be constructed of the same material and meet the same mechanical and chemical properties as mounting assemblies for signals.

995-7.8 Miscellaneous Mounting Components: Miscellaneous mast arm, span wire, and pole mounting components and accessories included with assemblies must meet the mechanical properties for its associated main assembly components or be listed separately on the APL. Mounting assemblies not approved with a specific primary device (such as a camera, detector, etc.), must be approved and listed separately on the APL.

995-8 Signal Priority and Preemption Systems.

995-8.1 General:

Signal priority and preemption system equipment may utilize optical, GPS, and radio frequency technologies.

995-8.2 Functional Requirements: Ensure that in-vehicle equipment operates without requiring any action from the vehicle operator or occupants once power is applied.

995-8.2.1 Security: The system must include features that secure the system and restrict its configuration and operation to authorized users and vehicles only.

995-8.2.2 Vehicle Identification: The system must be able to assign a unique identifier for each authorized vehicle. The system must be able to associate the identifier with vehicle information such as vehicle classification (e.g., fire, police, rescue, transit), owner/operator, and priority level.

995-8.2.3 Configuration and Management: The system must allow authorized local and remote users to set and read all user-programmable features and retrieve data collected by the system. The manufacturer must provide computer software required to configure, operate, and maintain the system at no additional cost to the Department.

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995-8.2.4 Logging: The system installed in the field cabinet must store a record of events, including time, vehicle ID, class, priority level, and approaching direction for all vehicles detected. The log must operate on a first-in, first out (FIFO) principle with a minimum capacity of 5,000 events.

995-8.2.5 Detection Range and Accuracy: The priority and preemption system must be capable of detecting and identifying multiple authorized vehicles at various ranges up to 2,500 feet. The system must be able to determine the approaching direction of authorized vehicles. The detection range and programming of emergency (high priority) and transit signal (low priority) preemption shall be adjustable from within the traffic signal cabinet. High priority calls must override low priority calls.

The system must service preemption calls having equal priority on a first-come, first-served basis.

995-8.3 Preemption System Cabinet Electronics: The priority and preemption system must be compatible with NEMA TS 1, NEMA TS 2, Type 170, and Type 2070 traffic signal controllers and their respective cabinets.

The system must be able to provide calls to the controller via input file and detector rack. The system must include two channel or four channel detector card units. The system must include a shelf mount option.

The system must be able to provide emergency preemption (high priority) and transit signal (low priority) preemption calls to the controller. Detectors must include programmable timers that allow the operator to configure detector call extension as well as limit the length of channel output calls.

Channel outputs must deliver a constant signal while emergency vehicles are detected for high priority preemption activation. Channel outputs must deliver a pulsed output for low priority preemption activation. Inputs and outputs must be optically isolated.

995-8.3.1 Serial Interface: Ensure that the serial ports support data rates up to 115 kbps; error detection procedures utilizing parity bits (i.e., none, even, and odd); and stop bits (1 or 2). Serial interface ports may utilize RJ-45 connectors, D-sub connectors, or screw terminals.

995-8.3.2 Network Interface: Ensure that LAN connections support the requirements detailed in the IEEE 802.3 Standard for 10/100 Ethernet Connections. Ensure that the connector complies with applicable TIA requirements.

995-8.4 Optical Preemption Detectors: Optical preemption detectors must respond to light impulses generated from a visible or infrared light source.

995-8.5 Intersection Radio/GPS Modules: Radio/GPS preemption systems must include radio/GPS modules that transmit a beacon signal and receive data transmitted by Radio/GPS vehicle equipment.

995-8.6 Mechanical Specifications: Ensure that every conductive contact surface or pin is gold-plated or made of a noncorrosive, conductive metal. Do not use self-tapping screws on the exterior of the assembly.

All external parts must be made of corrosion-resistant materials, such as plastic, stainless steel, anodized aluminum, brass, or gold-plated metal.

Detector cards must include indicators for power and vehicle detection. Detector cards must include a test switch that can be used to manually generate detector calls that the system provides during normal operations.

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995-8.7 Electrical Specifications: Provide equipment that operates on a nominal voltage of 120 volts V_{AC}. If the device requires operating voltages of less than 120 V_{AC}, supply the appropriate voltage converter.

995-8.8 Environmental Specifications: Ensure system electronics perform all required functions during and after being subjected to the environmental testing procedures described in NEMA TS 2-2021, Sections 2.2.7, 2.2.8, and 2.2.9. Detectors and detector connections that are exposed to the elements must be weatherproof and designed for outdoor use.

995-9 Pedestrian Detection System.

995-9.1 General: The components of the pedestrian detection system include pushbuttons, pedestrian actuation signs, electronics, wiring, and mounting hardware.

995-9.2 Standard Pedestrian Pushbutton Detector: Pushbuttons must be raised from or flush with their housings and be a minimum of 2 inches in the smallest dimension. The pushbutton must require no more than 5 pounds of force to activate. The detector must be weather-tight and tamper resistant.

995-9.2.1 Housing: The housing must be a two-piece unit consisting of a base housing and a removable cover. The housing must be cast aluminum meeting the physical characteristics and chemical content established in ASTM B26 for alloys S5A and CS72A.

The housing or adapter (saddle) must conform to the shape of a pole and provide a flush, secure fit. Saddles must be of the same material and construction as the housing. Pushbuttons for wood pole mounting must have threaded holes for 1/2-inch conduit provided in the housing top or bottom. A 3/4-inch hole with an insulated bushing shall be provided through the back of the housing. Unused openings shall be closed with a weatherproof closure and painted to match the housing.

The housing must have a powder-coat finish and painted in accordance with Military Standard MIL-PRF-24712A.

995-9.2.2 Pushbutton: The pushbutton must include a normally open, mechanical phenolic enclosed, positive-acting, spring-loaded, audible (i.e., click) snap-action switch with single pole, single throw contacts, or a Piezo driven solid state switch rated for a minimum of 50 V. The Piezo driven solid state switch, when activated, must give an audible (i.e., two-tone chirp) indication of actuation. A visual indication of actuation is optional. The visual indication must remain illuminated until the pedestrian's WALKING PERSON (symbolizing WALK) signal indication is displayed. Switch connections inside the housing must allow wiring and installation without binding. The switch must have a design life of one million operations (minimum) at rated load.

995-9.2.3 Electrical Requirements: The wiring must be No. 18 AWG stranded (minimum) with 600 V outdoor insulation rating.

995-9.3 Accessible (Audible/Tactile) Pedestrian Pushbutton Detector: The accessible pedestrian pushbutton detector must consist of all electronic control equipment, wiring, mounting hardware, pushbuttons, and pedestrian actuation signs designed to provide both a pushbutton with a raised, vibrating tactile arrow on the button as well as a variety of audible indications for differing pedestrian signal functions.

995-9.3.1 Electronic Control Equipment: The accessible pedestrian pushbutton detector must include electronic control equipment that is programmable and adjustable using a laptop computer or vendor supplied programmer. Electronic control equipment must be able to be installed within a traffic controller cabinet or within a pedestrian signal housing. Electronic control equipment installed within a traffic controller cabinet must allow the use of up to

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16 pushbuttons (4 maximum per channel) with a single traffic controller cabinet. The accessible pedestrian pushbutton detector must receive timing from Walk and Don't Walk signals.

995-9.3.1.1 Audible Messages: Audible messages must be programmable. All audible messages and tones must emanate from the accessible pedestrian pushbutton housing. The accessible pedestrian pushbutton detector must utilize digital audio technology. The system shall have, at a minimum, three programmable locator tones. The accessible pedestrian pushbutton detector must have independent minimum and maximum volume limits for the Locator Tone, Walk, and Audible Beaconing features. The Wait message must only annunciate once per actuation.

995-9.3.1.2 Pushbutton locator tone: The accessible pedestrian pushbutton detector must provide independent ambient sound adjustment for the locator tone feature. The accessible pedestrian pushbutton detector must allow the locator tone to be deactivated.

995-9.3.1.3 Vibrating Pushbutton (VPB): The accessible pedestrian pushbutton detector must include a Vibrating Pushbutton (VPB). The VPB must be a single assembly containing an ADA compliant, vibro-tactile, directional arrow button, weatherproof audible speaker, and pedestrian actuation sign with optional placard Braille messages. The VPB tactile arrow must be 2 inches in length, be field adjustable to two directions, and require no more than 5 pounds of applied force to activate.

995-9.3.1.4 Conflict Monitoring: The accessible pedestrian pushbutton detector must monitor the Walk condition for conflict operation. The accessible pedestrian detector system must disable the Walk functionality if a conflict is detected.

995-9.3.1.5 Cabinet Control Unit (CCU): The accessible pedestrian pushbutton detector may include a CCU for interfacing and connecting the system. The CCU shall have labeled LED indicators for each channel operation. The CCU must reset upon loss of internal communication.

995-9.3.2 Inputs and Outputs: All inputs and outputs must use Mil-Spec Multi-pin connectors.

995-9.3.2.1 Inputs: Walk and Don’t Walk inputs must be optically isolated 80-150 volts AC/DC, 5mA max. General purpose inputs must be optically isolated 10-36 volts AC/DC, 10mA max.

995-9.3.2.2 Outputs: Outputs must be optically isolated 36 volts AC/DC peak, 300mA solid state fused contact closures. CCUs must include a normally open relay contact fault output.

995-9.3.3 Communication: The CCU must include an Ethernet interface. The CCU must have an integral web server that provides information on audible/tactile pedestrian-pushbutton detector status, access to event logs, and provides for remote Configuration of accessible pedestrian pushbutton detector system options. VPBs must include an Ethernet, serial, USB, or Bluetooth programming interface.

995-9.4 Passive Detectors: The passive detector must consist of all electronic control equipment, wiring, and mounting hardware.

995-9.4.1 General: A passive detector system uses one or more sensors and analytics hardware and software to detect the presence and direction of pedestrians and activate the traffic control device without any required action by the pedestrian.

995-9.4.2 Configuration and Management: Ensure that the passive detector is provided with software that allows local and remote configuration and monitoring. Ensure that

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the system can display detection zones and detection activations overlaid on live passive detector inputs. Ensure that the passive detector allows a user to edit previously defined configuration parameters, including size, placement, and sensitivity of detection zones.

Ensure that the passive detector retains its programming in nonvolatile memory. Ensure that the detection system configuration data can be saved to a computer and restored from a saved file. Ensure that all communication addresses are user programmable.

995-9.4.3: Solid State Detection Outputs: Ensure outputs meet the requirements of NEMA TS2-2021, 6.5.2.26.

995-9.4.4: Electrical Requirements: Ensure the system operates using a nominal input voltage of 120 V_{AC}. Ensure that the system will operate with an input voltage ranging from 89 to 135 V_{AC}. If a system device requires operating voltages other than 120 V_{AC}, supply a voltage converter.

995-9.5 Electrical: All wiring must meet applicable NEC requirements. The accessible pedestrian pushbutton detector must operate using a nominal input voltage of 120 V_{AC}. If any device requires nominal input voltage of less than 120 V_{AC}, furnish the appropriate voltage converter.

Accessible pedestrian pushbutton detector control electronics that are mounted in a pedestrian signal head must be able to receive power from the Walk and Don't Walk circuits of the signal head. Control electronics shall not require more than four wires for each pushbutton connection, and no more than two wires for each controller pedestrian input. Voltage at the pushbutton shall not exceed 24 V_{AC}.

995-9.6 Mechanical: Do not use self-tapping screws on the exterior of the assembly.

Ensure that all parts are made of corrosion-resistant materials, such as plastic, stainless steel, anodized aluminum, brass, or gold-plated metal. Ensure that all assembly hardware, including nuts, bolts, external screws and locking washers less than 5/8-inch in diameter, are Type 304 or 316 passivated stainless steel. Stainless steel bolts, screws and studs must meet ASTM F593. Nuts must meet ASTM F594. All assembly hardware greater than or equal to 5/8-inch in diameter must be galvanized. Bolts, studs, and threaded rod must meet ASTM A307. Structural bolts must meet ASTM F3125, Grade A325.

Enclosures must have a NEMA 4X rating. Pushbutton housings for intersections must be black.

995-9.7 Environmental: Ensure equipment performs all required functions during and after being subjected to the environmental testing procedures described in NEMA TS2-2021, Sections 2.2.7, 2.2.8, and 2.2.9.

995-10 Traffic Controllers.

Traffic controllers must meet the industry standards in Table 995-6.

Table 995-6
Traffic Controller Standards

Device	Standard
NEMA TS2 Controller	NEMA TS2-2021
Model 2070 Controller	CALTRANS TEES, 2020
Note: All controllers must meet AASHTO/ITE/NEMA ATC 5201, v06.25.	

All controllers must provide functionality that meets or exceeds operational characteristics, including NTCIP support, as described in NEMA TS2-2021.

All controllers must:

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1.Capture all mandatory event-based data elements listed in supplemental requirement SR-671-2, Supplemental Traffic Controller High Resolution Data Logging Requirements, as published on the Department's State Traffic Engineering and Operations Office website at the following URL: https://www.fdot.gov/traffic/Traf-Sys/Product-Specifications.shtm.

2. Provide and make Management Information Bases (MIBs) available for Traffic Signal Controller Broadcast Messages (TSCBM) to local agencies and FDOT that are compatible with SAE J2735.

3. Support programming of destination Internet Protocol (IP) addresses via controller front panel for interface with Roadside Units (RSU) and other devices or systems.

995-11 Traffic Cabinets.

995-11.1 General: Cabinets must be permanently marked with a label including the manufacturer's name or trademark, model/part number, and the year and month of manufacture. Place the label on the inside of the main door using a water-resistant method. The label must be visible after installation.

Painted and unpainted cabinets must meet the applicable requirements in Aluminum Cabinets, NEMA TS2-2021.

995-11.2 NEMA Traffic Signal Controller Cabinets: Provide NEMA traffic signal controller cabinets with all terminals and facilities necessary for traffic signal control meeting the following requirements:

NEMA TS1 Controller Cabinet .....NEMA TS1-1989
NEMA TS2 Controller Cabinet .....NEMA TS2-2021

995-11.2.1 Documentation: Provide four paper copies of the cabinet wiring diagram with each cabinet. The nomenclature of signal heads, vehicular movements and pedestrian movements on the wiring diagram must be in accordance with the signal operating plan.

Documentation must include a list identifying the termination points of cables used for vehicular and pedestrian signal heads, detector loop lead-ins, and pedestrian pushbutton wires.

A heavy duty, resealable plastic opaque bag must be mounted on the backside of main cabinet door for storing cabinet documentation.

995-11.2.2 Police Switches: Provide the following police switches with Type 3 and larger controller cabinets. The switches must be mounted on the police panel and identified as to their function.

1. AUTO-FLASH: When this switch is in the FLASH position, all signal indications must immediately transfer to the flashing mode. AC power shall be removed from the load switches and stop timing applied to the controller unit. When this switch is placed in the AUTO position the controller unit must operate in accordance with the appropriate specification.

2. MANUAL ON-OFF: When this switch is in the on position, a logic ground must be applied to the manual control enable input of the controller unit.

3. MANUAL JACK: Install a manual jack on the police panel. The jack must mate with a three circuit, 1/4 inch diameter phone plug. Connect the tip and ring (middle) circuits of the jack to the logic ground and the interval advance inputs of controller unit. When the manual hand cord is plugged into the jack and the pushbutton is pressed, logic ground must be connected to the interval advance input of the controller unit.

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Provide a manual pushbutton with Type 3 and larger cabinets. The pushbutton cord must have a minimum length of six feet with a 1/4 inch diameter three circuit plug connected to one end and a hand held manual pushbutton at the other end. With the exception of the vehicular yellow and all red clearance intervals, a complete cycle (push-release) of the manual pushbutton shall terminate the controller unit interval that is active. Cycling the push-button during the vehicular yellow or all red clearance intervals must not terminate the timing of those intervals.

995-11.2.3 Service Switches: Service switches must be mounted on the service panel or other locations approved by the Department and identified as to their functions. Provide the following service switches with Type 3 and larger cabinets.

1. SIGNALS ON-OFF: When this switch is in the off position, AC power shall be removed from all signal heads. The SIGNALS ON-OFF switch must be connected to the control input of a contactor (displacement relay). Current supplied to the switch must not exceed five amperes (amps) total. Do not directly route the main signal head power bus and cabinet power through the service or police switches.

2. AUTO-FLASH: When this switch is in the FLASH position, all signal indications must transfer to the flashing mode in accordance with the Uniform Code Flash (UCF) requirements. AC power shall be removed from the load switches when the signal indications transfer to the flashing mode. The controller unit must operate in accordance with appropriate specifications during the flashing mode. When the switch is placed in the AUTO position, transfer from the flash mode to normal operation shall be made in accordance with UCF requirements.

3. CONTROLLER ON-OFF: When this switch is in the off position, AC power shall be removed from the controller.

4. AUX POWER ON-OFF: When this switch is in the off position, AC power shall be removed from all circuits of the cabinet except for the duplex receptacle, cabinet light and ventilation fan.

5. VEHICLE DETECTORS: A detector test switch must be provided for each phase of the controller unit. Detector test switches must include a position for normal operation (phase receives calls from detectors), a position that provides a constant call, and a position that provides a momentary call.

995-11.2.4 Doors and Locks: Provide Type 3 and larger cabinets with a hinged, rain tight and dust tight police door which allows access to the police switches and manual jack.

Locate the police door in the bottom half of the main door for Type 3 and 4 pole mount cabinets. Locate the police door in the upper half of the main door for Type 4 and larger base mount cabinets.

Hinges and hinge pins must be constructed of stainless steel and prevent the door (main or police) from sagging. Hinges for the main and police doors must be 14 gauge and be located on the right side (viewed from the front).

Type 3 and larger cabinets must be furnished with a three point draw roller latching system consisting of the following latching points:

1. Center of the cabinet (lock)
2. Top of the cabinet--controlled by the door handle
3. Bottom of the cabinet--controlled by the door handle

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The latching points on the top and bottom of the cabinet must remain in the locked position until the main cabinet door lock is unlocked. The locking mechanism must be equipped with nylon rollers to secure the top and bottom of the door.

Type 3 and larger cabinets must be furnished with a door stop which retains the main door open in a 90 degree and 120 degree position.

995-11.2.5 Police and Service Panels: Provide a police service panel with Type 3 and larger cabinets. The panels may be constructed of either sheet aluminum or cast aluminum. Locate the police panel behind the police door attached to the main door. The service panel must be mounted on the back side of the police panel. The police panel must have the following minimum dimensions:

1. Height – 4 inches
2. Width – 8 inches
3. Depth – 2-1/2 inches

995-11.2.6 Ventilation: Type 1 and 2 cabinets must be vented to allow dissipation of the heat generated by the equipment housed inside the cabinet.

Type 3 and larger cabinets must have dual, UL listed, thermostatically controlled fans, rated for continuous duty with a service life of at least 3 years. Mount thermostats on the inside top of the cabinet. Thermostats must be user adjustable to allow temperature settings ranging from a minimum of 70°F to a maximum of 140°F and capable of activating the fans within plus or minus 5 degrees of the set temperature. The intake vent must be rain tight, located on the bottom half of the cabinet, and covered with a removable filter.

995-11.2.7 Shelves: Type 2 cabinets must be furnished with one shelf. Type 3 and larger cabinets must be furnished with two adjustable shelves. Shelves must be adjustable in a maximum of 2-inch increments from the top of the load panel to 12 inches from the top of the controller cabinet.

995-11.2.8 Mounting Hardware: Type 1, 2, and 3 cabinets must be supplied with hardware for attaching the top and bottom half of the cabinet onto a flat or round surface. Optional wall or pole mount hardware must be provided for mounting Type 4 cabinets in specific installations.

Type 4 cabinets must have rigid tabs attached to the bottom of the cabinet. Type 5 cabinets must have rigid brackets attached to the bottom of the cabinet. Rigid brackets and tabs must be constructed of the same material used for the cabinet.

Type 4 and larger cabinets must be provided with one of the following alternatives for fastening to a concrete base:

1. Galvanized anchor bolts, nuts, lock washers, and flat washers in accordance with ASTM A153. The anchor bolts must be at least 1/2 inch in diameter, seven inches in vertical length with at least three inch horizontal, or
2. Heavy duty machine bolt anchors, flat washers, lock washers and machine screws with at least 1/2 inch thread diameter.

995-11.2.9 Electrical: Fabricate ground busbars of copper or aluminum alloy material compatible with copper wire and provide at least two positions where No. 2 AWG stranded copper wire can be attached.

Mount a ground busbar on the side of the cabinet wall adjacent to the power panel for the connection of AC neutral wires and chassis ground wires.

If more than one ground busbar is used in a cabinet, a minimum of a No. 10 AWG copper wire must be used to interconnect them.

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995-11.2.9.1 Wiring: All wiring must be laced. All conductors in the cabinet must be stranded copper.

All inputs and outputs must be terminated on terminal strips. A connector harnesses for the controller, conflict monitor, vehicle detectors, and other controller accessory equipment must be furnished and wired into the cabinet circuitry.

A vehicle detector harness or rack must be furnished with the cabinet. Terminal strip circuits must be provided for connection of the loop lead-in cable.

995-11.2.9.2 Terminal Strips: The voltage and current rating of terminal strips must be greater than the voltage and current rating of the wire which is terminated on the terminal strip.

Conductors must be terminated on terminal strips with insulated terminal lugs. A calibrated ratchet crimping tool must be used to terminate the conductor in the terminal lug.

When two or more conductors are terminated on field wiring terminal strip screws, a terminal ring lug shall be used for termination of those conductors. All terminal strip circuits must be numbered.

995-11.2.9.3 Cabinet Light and Receptacle: For Type 3 and larger cabinets, provide one or more light fixtures that illuminate the entire interior of the cabinet. All lighting fixtures must automatically turn on when the cabinet doors are opened and off when the doors are closed.

Mount and wire a three-wire 115 V_{AC} duplex receptacle in all cabinets. The receptacle must be protected by a 15A circuit breaker. Do not mount the receptacle on the main cabinet door or police and service switch panels.

995-11.2.9.4 Main Circuit Breaker: Provide a 15A circuit breaker with Type 1 and 2 cabinets, and a 30A circuit breaker with Type 3 and larger cabinets.

The main circuit breaker must turn off all power to the cabinet and shall not be used for the power switch located in the service panel.

995-11.2.9.5 Radio Interference Suppression: A radio interference suppressor must be provided in series with the AC power before it is distributed to any equipment inside the cabinet. The suppressor must provide a minimum attenuation of 50 decibels over a frequency range of 200 kHz to 75 MHz when used with normal installations and shall be hermetically sealed in a metal case.

The radio interference suppressor must have the same minimum current rating as the main circuit breaker.

The ground connection of the radio interference suppressor must be connected only to AC neutral and shall not be connected to earth ground directly.

995-11.2.9.6 Optically Isolated Inputs: The Opto common input is the common reference pin for four optically isolated inputs.

The Opto inputs are intended to provide optical isolation for pedestrian detector and remote interconnect inputs. The Opto inputs are intended to connect through external 27 K ohm, 1 W resistors for 120 V_{AC} operation and are intended for direct connection to 12 V_{AC} from the cabinet power supply for pedestrian detector applications. These inputs may alternatively be used for low-true DC applications when the Opto common pin is connected to the 24 V supply.

The Opto inputs shall provide electrical isolation of 10 megohms minimum resistance and 1000 V_{AC} RMS minimum breakdown to all connector pins except the

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Opto common pin. These inputs shall exhibit nominal impedance to the Opto common pin of 5 K ohm, plus or minus 10 percent, and shall require 2.4 mA, plus or minus 10 percent, from a nominal 12 V_{AC} supply. The Opto inputs shall not recognize 3 V_{AC} RMS or less relative to the common input and recognize 6 V_{AC} RMS or more relative to the common input. Any steady state voltage applied between an Opto input and the Opto common shall not exceed 35 V_{AC} RMS. Opto inputs shall not be acknowledged when active for 25 ms or less, and shall be acknowledged when active for 50 ms or more.

995-11.2.9.7 Load Resistors: A load resistor or capacitor must be installed between the AC (common) and each signal field wiring terminal for the yellow, green and walk indication. All load resistors and capacitors must be on the front side of any panel used in the cabinet.

995-11.2.9.8 Surge Protection: Furnish surge protective devices (SPDs) for the main AC power input, all signal head field wiring terminals, interconnect cable terminals and loop lead-in cable terminals which are located in the cabinet. SPDs must be unobstructed and accessible from the front side of any panel used in the cabinet. Cabinets utilizing Din rail mounted SPDs must be grounded with a conductor to the cabinet busbar.

The SPD for the main AC power input of the cabinet must be connected on the load side of the cabinet circuit breaker.

SPDs for signal and interconnect cable field wiring terminals must meet the following:

1. Clamp the surge voltage to a level no greater than twice the peak operating voltage of the circuit being protected.
2. Withstand a surge current of 1000A with an 8 by 20 µs waveform six times (at 1 second intervals between surges) without damage to the suppressor.

SPDs for loop lead-in cables must be designed in accordance with the following requirements:

1. Protect the detector unit loop inputs against differential (between the loop lead) surges, and against common mode (between loop leads and ground) surges.
2. Clamp the surge voltage to 25 V or less when subjected to repetitive 300A surges.
3. Withstand repetitive 400A surges with an 8 by 20 µs waveform without damage.

SPDs must be installed according to the SPD manufacturer's instructions and not affect the operation of detectors. SPD leads must be kept as short as possible.

995-11.3 Type 170 Traffic Signal Controller Cabinets: Provide Type 170 traffic signal controller cabinets with all terminals and facilities necessary for traffic signal control and meeting the following requirements:

Model 332, 334 and 336S Cabinets…….CALTRANS TEES 2009

Model 336S cabinet must incorporate input surge protection mounted on a fold-down termination panel at the input file.

Model 332 cabinets must incorporate a lower input termination panel. Model 332 and 334 cabinets must be base mounted. The Model 332 cabinet must have an auxiliary MODEL 420 output file, and be configured for 8 vehicle, 4 pedestrian, and 4 overlaps.

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Model 552A designation is given to Model 332 cabinet assemblies that include a swing-out EIA 19-inch rack cage.

Model 662 designation is given to Model 552A cabinets with a 66 inch height.

Cabinets must comply with figures for traffic control signals and devices available on the Department's State Traffic Engineering and Operations Office website at the following URL:
https://www.fdot.gov/traffic/Traf_Sys/Product-Specifications.shtm.

All terminals and facilities on panels must be clearly identified using permanent silk-screened text.

995-11.3.1 Base Plate and Mounting Brackets: Provide cabinets with a standard base mounting bolt pattern and a minimum of two aluminum plates welded inside for anchoring to a concrete or composite base.

995-11.3.2 Output File: Fabricate the output file using a "hard wired" harness. Printed board circuit boards are not acceptable.

995-11.3.3 Shelf: Provide an aluminum shelf with storage compartment in the rack below the controller (for remote secondary monitor/lap top computer use). The storage compartment must have telescoping drawer guides for full extension. The compartment top must have a non-slip plastic laminate attached. Provide an RS-232 connector for communications to the C2S port.

995-11.3.4 Loads: Provide dummy loads consisting of 4.7k resistors rated at five watts minimum for Greens, Peds, and Yellows. The dummy loads must be mounted on a terminal block in the rear of the output file or other approved location. Wire one side of each dummy load to AC return in a manner that allows a technician to easily attach the load to outputs from selected load switches.

995-11.3.5 Cabinet Light: Provide one or more light fixtures that illuminate the entire interior of the cabinet. All lighting fixtures must automatically turn on when the cabinet doors are opened and off when the doors are closed.

995-11.3.6 Surge Protection: Provide each cabinet with devices to protect equipment from surges. Surge protector termination panels must be attached to the cabinet rack assembly and allow sufficient space for connections, access, and surge protector replacement. AC isolation terminals must be on the same side of the cabinet as the AC service inputs. DC terminals and loop detector terminals must be installed on the opposite side of the cabinet from the AC power lines.

Surge protection for 332A cabinets must be mounted on the lower input termination panel.

Surge protection for 336S cabinets must be mounted on a custom fold down termination panel at the input file.

Under no circumstance (normal operation or short-circuit condition) shall the amperage capacity of the internal wiring and printed circuit board traces be less than the protecting threshold of circuit breakers and surge protectors provided.

995-11.3.6.1 Power Distribution Assembly Protection: The power distribution assembly (PDA) SPD must be a two-stage series/parallel device that meets or exceeds the following:

1. Maximum AC line voltage: 140 V_{AC}

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2. 20 pulses of peak current, each of which will rise in 8 microseconds and fall in 20 microseconds to one-half the peak: 20kA.

3. The protector must include the following terminals:

a. Main line (AC Line first stage terminal)

b. Main Neutral (AC Neutral input terminals)

c. Equipment Line Out (AC Line second stage output terminal, 10A)

d. Equipment Neutral Out (Neutral terminal to protected equipment)

e. Ground (Earth connection)

4. The main AC line in and the equipment line outer terminals must be separated by a 200 microhenry (minimum) inductor rated to handle 10A AC service

5. The first stage clamp shall be between Main Line and ground terminals

6. The second stage clamp shall be between Equipment Line Out and Equipment Neutral

7. The protector for the first and second stage clamp must have a metal oxide varistor (MOV) or similar solid state device, rated 20 kA.

The main neutral and equipment neutral output shall be connected together internally and shall have an MOV (or similar solid state device, or gas discharge tubes) rated at 20 kA between main neutral and ground terminals.

The PDA SPD must have a peak clamp voltage of 250V at 20 kA (voltage measured between equipment line out and equipment neutral out terminals, current applied between main line and ground terminals with ground and main neutral terminals externally tied together).

The PDA SPD must have a maximum let through voltage not exceeding 500 Vpk using an 8 by 20 µs/1.2 by 50 µs; 6 kV, 3 kA surge. The SPD must either be epoxy-encapsulated in a flame retardant material or utilize thermally protected varistors and be designed for continuous service current of 10A at 120 V_{AC} RMS. Power to the Type 170E controller and to the 24V power supply must be provided from the equipment line out terminal of the PDA SPD.

995-11.3.6.2 Inductive Loop Detector Protection: Protect each inductive loop detector input channel with an external SPD that meets or exceeds the following:

1. The SPD must be a three-terminal device, two of which shall be connected across the signal inputs of the detector. The third terminal shall be connected to chassis ground to protect against common mode damage.

2.The SPD must instantly clamp differential mode surges (induced voltage across the loop detector input terminals) via a semiconductor array. The array shall be designed to appear as a very low capacitance to the detector.

3. The SPD must clamp common mode surges (induced voltage between the loop leads and ground) via solid state clamping devices.

4. Peak Surge Current

a. Differential Mode: 400A (8 by 20 µs)

b. Common Mode: 1000A (8 by 20 µs)

c. Estimated Occurrences: 500 @ 200A

5. Response Time: 40 ns

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6. Input Capacitance 35 pF typical
7. Clamp Voltage
    a. 30V max @ 400A (Differential Mode)
    b. 30V max @1000A (Common Mode)

995-11.3.6.3 Signal Load Switch Protection: The outputs of each load switch in the output file shall be provided with a MOV connected from the AC positive field terminal to the chassis ground. The MOV must be rated 150 V_{AC} and shall be a V150LA20A (or approved equal).

995-11.3.6.4 Communication Input Protection: Each low voltage communication input must be protected as it enters the cabinet with a hybrid two-stage SPD that meets or exceeds the following:

1. The SPD must be a dual pair (four-wire) module with a double-sided, gold-plated printed circuit board connector.
2. The SPD must be installed in a ten-circuit card edge terminal block (PCB1B10A).
3. The SPD must be utilized as two independent signal pairs. The data circuits must pass through the SPD in a serial fashion.
4. Peak Surge Current
    a. 10kA (8 by 20 µs)
    b. Occurrences at 2000A: greater than 100
5. Response Time: less than 1 ns
6. Clamp Voltage: 30V maximum
7. Series Resistance: greater than 15 ohms per line
8. Primary Protector: 3 element gas tube
9. Secondary Protector: Solid state clamp (1.5 kW minimum)

The line side of the SPD must be connected to the communication field wires, the load side connected to the communication connector of the controller, and the ground terminal connected to chassis ground.

995-11.3.6.5 Low Voltage DC input protection: Each DC input must be protected by an SPD that meets or exceeds the following:

(a) The SPD must be a 5 terminal device. Two terminals must be connected to the line side of the low voltage pair, two terminals must be connected to the input file side, and the fifth terminal connected to chassis ground.

(b)Peak Surge Current
    2 kA (8 by 20 µs)
    Occurrences at peak current: 100 (typical)

(c) Response Time: 5-30 ns
(d) Shock: Must withstand 10-foot drop on concrete
(e) Clamp Voltage: 30V
(f) Series Resistance: greater than 15 ohms each conductor

995-11.3.6.6 Preemption and 115V AC signal input protection: Each preemption or AC signaling input channel must be protected by an external SPD that meets or exceeds the following requirements:

(a) The SPD must be a 3 terminal device
(b) Peak Surge Current

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2000A (8 b 20 µs)

Occurrences at peak current: 25 (minimum)

(c) Response Time: less than 200 ns

(d) Peak Surge Trip Point: less than 890V nominal

995-11.3.7 Red Monitor Harness: A connector and terminal assembly designated as P20 for monitoring the absence of red, shall be an integral part of the output file. The connector must terminate, and be compatible with, the cable and connector of a Type 170 conflict monitor unit (CMU), capable of monitoring the absence of red. Provide the pin assignments of the P20 connector and terminal assembly with the cabinet plans. The P20 connector shall be physically like the cable and connector of a Type 170 CMU to prevent the absence of red cable connector from being inserted into the P20 connector 180 degrees out of alignment.

995-11.3.7.1 Programming of Unused Red Channels: Provide all cabinet assemblies with a means of programming unused red channels by installing jumpers from red monitor inputs to 115 V_{AC}. The connecting terminals for the jumpers must be accessible and located in the same terminal block for all 16 channels to assure full compatibility of all cabinet assemblies with "210 Plus" conflict monitor units.

995-11.3.8 Police Door and Panel: Provide cabinets with police doors and panels. The police panel must include text informing officers that yellow and all-red clearance intervals are timed internally.

Police switch panels must include a manual jack. The jack must mate with a three circuit, 1/4-inch diameter phone plug. Connect the tip and ring (middle) circuits of the jack to the logic ground and the interval advance inputs of controller unit. When the manual hand cord is plugged into the jack and the pushbutton is pressed, logic ground must be connected to the interval advance input of the controller unit.

The pushbutton cord must have a minimum length of six feet with a 1/4-inch diameter three circuit plug connected to one end and a hand held manual pushbutton at the other end. With the exception of the vehicular yellow and all red clearance intervals, a complete cycle (push-release) of the manual pushbutton shall terminate the controller unit interval that is active. Cycling the push-button during the vehicular yellow or all red clearance intervals must not terminate the timing of those intervals.

995-11.3.9 Technician Service Panel: Provide cabinets with a technician service panel which is mounted on the back side of the police panel (inside the main cabinet front door).

There must be two switches located on the technician service panel, clearly labeled according to the following functions:

(a) UCF – This toggle switch shall:

Place the intersection into Flashing Operation.

After meeting requirements for Flashing Operations, all power shall be removed immediately from signal load switches.

(b) Signal On/Off – This toggle switch shall disconnect all power to the signal lights through the use of a 60A contact switch placed in series with the load switch packs.

Labels must be silk screened directly on the panel.

995-11.3.10 Swing-out Rack Assembly: Provide 552-A cabinets with a pullout and rotatable rack assembly as well as an interface panel mounted on the top of the rack assembly and attached to the top shelf. The rack assembly must be constructed to house

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components designed to be installed in a standard EIA 19-inch rack and shall house the Controller, Input File, Output File No. 1, PDA No. 2, and a storage compartment.

Construct the rack and slide/hinged mounting brackets so that when the rack assembly (fully loaded) can be pulled out with one hand with complete ease of operation including rotation of the assembly.

The rack assembly must have a spring-loaded latch mechanism to secure the rack assembly inside the cabinet while in the "rest" position. When pulled out of the cabinet at any point from its resting position (inside cabinet) to its full extension and rotation, the fully loaded rack assembly shall not cause any member of the assembly to bend, warp or bind. The rack must be made of one-inch square aluminum tubing with welded joints and extend and retract smoothly without noticeable friction or stress on roller guides, extension brackets, or other mechanical components. Maximum deflection of the entire rack assembly (with all equipment installed) shall not exceed 1/8 inch.

The rack assembly must have 12 technician test switches mounted to the interface frame assembly. Technician test switches must be of the momentary type and shall have eight vehicle and four pedestrian inputs.

The front of the rack assembly must be tapped with 10-30 threads with EIA universal spacing for 19-inch electrical equipment racks.

The rack assembly must be attached to the left cabinet wall through combination slide/hinged mounting brackets.

The slide/hinged mounting brackets must be fabricated from aluminum and/or stainless steel only.

Mounting bracket guides must utilize 7/8-inch stainless steel ball bearing rollers and allow extension and retraction of a loaded rack with minimal effort.

The rack assembly must be capable of rotating 210 degrees from its rest position after full extension from the cabinet.

The rack assembly must have a minimum 7/16-inch diameter aluminum rack stop rod attached to the inside left cabinet wall from the left side of the rack assembly to lock the rack into final position.

All cabinet harnesses must be long enough to maintain cabinet connections and functionality when the rack assembly is fully extended and rotated to its maximum limit. Harnesses must not bind or crimp when the rack is fully retracted, extended, or in motion.

995-11.3.11 Service Panels for 552A: The 552A cabinet must include a field service panel, auxiliary field service panel, and interface panel, all constructed of aluminum with a 1/8-inch minimum thickness. All components must be accessible from the front of the panels. Do not mount components or attach wires behind panels.

995-11.3.11.1 Field Service Panel: The field service panel must consist of terminal strips, circuit breakers, transient protection devices, load resistors, capacitors, cable tie mounts and associated wiring for making all field wiring connections. Mount the field service panel in the cabinet on the lower right exterior cabinet wall.

The field service panel must provide the necessary interconnecting junction points between the rack assembly and cabinet for the field service wires. The panel must be grouped for internal connections (jumpers) between terminals boards, wiring from the panel to the rack assembly, and wiring from the panel to the cabinet.

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The field service panel wiring harness must have flexible wire covered by a flexible non-metallic conduit from the field service panel to the PDA, output file, and interface panel. The harness must have a metal clamp with a rubber grommet center attached to the field service panel to secure the harness to the panel for proper orientation of the harness with the rack assembly. Terminal strips for the panel shall be as listed below:

1. TBS1 - Terminal Block, Deadfront type, 3 position, No. 4 to No. 14 AWG wire range, 70A, 600V.
2. TBS2 - Terminal Block, Barrier, 16 position, .375 Density, 5-40 x 3/16 BH Screw, Open Bottom, Double Row, No. 16 AWG (max), 15A, 250V.
3. TBS3 - Terminal Block, Barrier, 20 position, .375 Density, 5-40 x 3/16 BH Screw, Open Bottom, Double Row, No 16 AWG (max), 15A, 250V.
4. TBS4 &TBS5 - Terminal Block, Barrier, 12 position, .438 Density, 6-32 x 1/4 BH Screw, Open Bottom, Double Row, No. 14 AWG (max), 20A, 250V.

The panel must have a main cabinet circuit breaker rated at 30A and a cabinet accessory circuit breaker rated at 15A for cabinet fans and light. Mount the circuit breakers near the back cabinet door on the panel.

The panel must include load resistors for all Walk, Green, Green Arrow, Yellow and Yellow Arrow Switch Pack outputs to prevent the conflict-voltage monitor from going into "Flash" due to a failed signal lamp. Load resistors must be 2K, 10 watt.

MOVs must be physically tied to one side of each terminal on TBS4 and TBS5 and be physically secured to the field service panel with a 6-32 screw.

995-11.3.11.2 Auxiliary Field Service Panel: The auxiliary field service panel must be mounted on the lower left interior cabinet wall and consist of a minimum of four terminal strips, 18 detector surge protectors and one pedestrian button isolation board assembly. The 18 surge protectors must be a three-terminal device, two of which are connected across the signal inputs of the detector for differential mode protection and the third terminal is grounded to protect against common mode damage. Mount the pedestrian button isolation board on the auxiliary field service panel. Terminal strips for the panel shall be Terminal Block, Barrier, 12 position, .438 Density, 6-32 x 1/4 BH Screw, Open Bottom, Double Row, No. 14 AWG (max), 20A, 250V.

Install a four-button pedestrian isolation board on the auxiliary field service panel to provide for the connection of the pedestrian buttons on phases 2, 4, 6 and 8. The board must provide electrical isolation of the field wiring to the internal cabinet wiring. The inputs to this isolation board shall be wired to terminal block TBA5 for connection to field wiring. The outputs of this board shall be carried through the harness to the input file to the proper wires that go to the interface extension panel of the controller.

The pedestrian button isolation board must include a PC board mounted on an aluminum panel with the following minimum dimensions:

Height: 2 inches
Width: 8 inches
Thickness: 1/8 to 3/16 inch

995-11.3.11.3 Interface Panel: The interface panel must consist of eight terminal strips, one telephone line suppressor and mounting fixture, two 24 V_{DC} relays and mounting fixtures, and all associated wiring for connecting the required interface equipment modules.

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The front of the panel must be covered by a 1/4-inch clear plexiglass sheet, supported from the panel by four 1-1/2 inch standoffs. Secure the panels and cover using wing nuts that are removable without the use of tools. The plexiglass cover shall have 1/2-inch slot, centered over each of the terminal strips. All covers and panels must be interchangeable.

The panel wiring must provide the necessary interconnecting junction points between interface equipment cable harnesses and controller cabinet input and output signal. The panel wiring provides the functional wiring information for connecting the interface equipment in the cabinet.

The panel wiring must be grouped for internal connections (jumpers between terminal boards) as well as wiring from the controller and related cabinet functions to the terminal boards on the interface panel.

Ground wires must be No. 14 AWG wire, minimum. The internal harnesses must be located between TB1, TB2 and TB3. The external and internal wiring must be located outside of TB1 and TB4, between TB2 and TB3.

Terminal strips shall be Barrier type, .375 Density, 5-40 x 3/16 BH Screw, Open Bottom, Double Row, No. 16 AWG (max), 15A, 250V. Terminals must use nickel/cadmium plated brass screws. All terminals and facilities on panels must be clearly identified using permanent silk-screened

The K1P and K2F relays shall be 15A miniature relays with polycarbonate cover, 2 form C (CO) contact arrangement, DC coil input, socket mount, .187 inch quick connect/solder terminals, AgCdO (15A) contacts, and 24 V_{AC} coil voltage with matching socket and hold down spring. All screws on the relay socket must be brass with nickel/cadmium plating.

995-11.3.12 Storage Compartment: Mount an aluminum storage compartment in the rack assembly. The storage compartment must have telescoping drawer guides for full extension of drawer from rack assembly and have a continuous front lip for opening the compartment top for storage. The top of the compartment must be non-slip plastic laminate.

Install a communication port on the right hand side of the drawer at the front for connecting to the communications port of the controller unit via the cabinet harness.

995-11.3.13 Cabinet Rails: Provide the cabinet with four cabinet rails for mounting wiring panels and various brackets. Rails must be keyhole design with slots 2 inches on center with a top opening diameter of 5/8 inch to allow the insertion of a 5/8 inch by 1 inch carriage bolt. The rails must be approximately 1-1/2 to 2 inches wide by 1/2 inch deep. Do not use unistruts or other rails.

995-11.3.14 Electrical: Do not use printed circuit boards in any controller cabinet subsystem file or panel, including but not limited to the output file (except for the red monitor program board), service panel, interface panel, and input file.

995-11.3.14.1 Wiring: Cut all wires to the proper length and neatly laced into cables with nylon lacing. No wire shall be doubled back to take up slack. Cables in the cabinet must not interfere with the routing and connection of field wiring. Cables must be secured with nylon cable clamps, unless specified otherwise. The position of cables between the components must be such that when the door is closed, it does not press against the cables or force the cables against the various components inside the controller cabinet.

Fabricate ground busbars of a copper or aluminum alloy material compatible with copper wire and provide at least two positions where a No. 2 AWG stranded

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copper wire can be attached. Mount a 6 inch ground busbar with screw terminals on the bottom flange on each side of the cabinet for connection of AC neutral wires and chassis ground. Attach a flexible ground strap between the left side ground busbar and the left side bottom rear of the rack assembly. Wiring harnesses must be covered by a flexible non-metallic conduit. Panel wire size must be a minimum of No. 18 AWG unless otherwise specified.

995-11.3.14.2 Terminals: Terminal connections must be soldered or constructed using a calibrated ratchet type crimping tool. Wiring must be traceable and without entanglement.

995-11.4 Controller Cabinet Flashing Operation: When a non-emergency flashing operation is required, the selected operation shall be performed by the UCF format. The following shall utilize UCF format:

1. Flash Switch located on the cabinet service panel
2. Time Base Coordination Flash
3. Time Switch

When flashing operation is initiated, the controller assembly shall transfer from normal operation to flashing operation only at the end of the common major street red interval, the common minor street yellow interval, or the all red interval.

UCF shall be an internal function of the controller unit and must not be inhibited by the hold command. External logic will not be allowed to provide this function.

In the event of an emergency when flashing operation is required, the controller assembly shall immediately place the intersection on flash. Emergency flash may be initiated by the following:

1. Auto/Flash Switch - A switch located on the cabinet police panel
2. Conflict-Voltage Monitor senses a conflicting indication or system error

The transfer of the controller assembly from flashing operation to normal operation shall cause the controller unit to revert to its start-up sequence unless the conflict-voltage monitor has transferred the controller assembly to flashing operation. If transferred to flashing operation by the conflict-voltage monitor, the controller assembly shall remain in flashing operation until the monitor unit is reset and automatic operation can be implemented through the normal start-up sequence.

995-11.5 Intelligent Transportation System Cabinets: The cabinet shell must conform to NEMA 3R requirements, be constructed of unpainted sheet aluminum alloy 5052-H32 with a minimum thickness of 0.125 inch and have a smooth, uniform natural aluminum finish without rivet holes, visible scratches or gouges on the outer surface. Other finishes are acceptable if approved.

The dimensions for cabinets are listed below.

Table 995-7
Cabinet Dimensions in Inches

Cabinet Type	Height	Width	Depth
340	66” - 68”	44” - 46”	26” - 28”
336	36” - 39”	24” - 26”	20’ - 22”
336S	46” - 48”	24” - 26”	22” - 24”
334	66” - 68”	24” - 26”	30” - 32”
332D	66” - 68”	48” - 50”	30” - 32”
P44	55” - 59”	44” - 46”	26” - 29”

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The cabinet must be weather resistant and constructed with a crowned top to prevent standing water. All exterior cabinet welds must be gas tungsten arc (TIG) welds and all interior cabinet welds must be gas metal arc (MIG) or TIG welds. All exterior cabinet and door seams must be continuously welded and smooth and all inside and outside edges of the cabinet must be free of burrs, rounded and smoothed for safety. All welds must be neatly formed and free of cracks, blow holes and other irregularities. Use ER5356 aluminum alloy bare welding electrodes conforming to AWS A5.10 requirements for welding on aluminum. Procedures, welders and welding operators must conform to AWS requirements as contained in AWS B3.0 and C5.6 for aluminum.

The cabinet must have a lifting eye plate on both sides of the top of the cabinet for lifting and positioning it. Each lifting eye must be secured with a minimum of two bolts to the cabinet body and have a lift point opening diameter of 0.75 inch and capable of supporting a weight load of 1,000 pounds. All external bolt heads must be tamperproof.

Ground-mount cabinets must include a removable base plate and two aluminum plates, welded inside, for anchoring the cabinet. Fabricate the plates from aluminum alloy 5052-H32 a minimum of 4 inches wide by 0.125 inch thick. Provide the cabinet with four 1 inch diameter holes for anchoring.

995-11.5.1 Doors: Provide cabinets with front and rear doors, each equipped with a lock and handle. Doors must be full size, matching the height and width dimensions of the cabinet enclosure, with no fewer than three Type 4 or larger stainless steel hinges or; alternately, one full-length “piano” hinge. Hinges must be constructed of 14 gauge stainless steel with stainless steel hinge pins that are spot-welded at the top. Mount the hinges so that they cannot be removed from the door or cabinet without first opening the door. Brace the door and hinges to withstand 100 pounds per vertical foot of door height load applied to the outer edge of the door when standing open. Ensure there is no permanent deformation or impairment of any part of the door or cabinet body when the load is removed.

Door opening must provide a flange that allows the door gasket to mate with a flat surface. Include a gasket made of closed-cell material resistant to UV, weathering, elevated temperatures, and permanent deformation that is permanently bonded to the inside of each door forming a weather-tight seal when the door is closed.

995-11.5.2 Latches: Provide all cabinets with a three-point draw roller latching system for the doors. The latching system must have the following latching points.

1. Center of the cabinet (lock).
2. Top of the cabinet – controlled by the door handle.
3. Bottom of the cabinet – controlled by the door handle.

The latching points on the top and bottom of the cabinet must remain in the locked position until the main cabinet door lock is unlocked. The locking mechanism must be equipped with nylon rollers to secure the top and bottom of the door.

Provide the cabinet with a door stop that retains the main door open in a 90 degree and 120 degree position.

Outfit the doors with an industrial standard pin tumbler lock with No. 2 key, or an approved alternate, and hardware that allows the door to be secured using a padlock. Provide two keys for each cabinet lock.

995-11.5.3 Rails: Provide the cabinet with four cabinet rails that form a cage for mounting miscellaneous wiring panels and various mounting brackets. Use rails constructed of

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either 0.1345 inch thick plated steel or 0.105 inch thick stainless steel that extend the length of the cabinet's sides, starting from the bottom of the enclosure. Rails must be keyhole designed with slots 2 inches on center with a top opening of 5/8 inch in diameter to allow the insertion of a 5/8 inch by 1 inch carriage bolt. Rails must be 1-1/2 to 2 inches wide by 1/2 inch deep, drilled and tapped for 10-32 screws or rack screws with EIA universal spacing. Do not use unistruts or other rail types.

995-11.5.4 Racks: The cabinet must include a standard 19-inch EIA/TIA equipment rack centered in the cabinet for mounting devices to be installed inside. Clearance in the rack between the rails must be 17-3/4 inches.

995-11.5.5 Shelf: Provide a level, rollout internal shelf with a minimum work area measuring 10 inches by 10 inches. The shelf must be capable of sustaining a constant 20 pound load and the shelf position must be adjustable.

995-11.5.6 Sunshield: Sunshields must be mounted with tamper resistant hardware to standoffs that provide an air gap of at least one inch between the exterior cabinet walls and the sunshields. Sunshield standoffs located on the roof of the cabinet must be welded to the cabinet body. Construct sunshields of 0.125 inch thick 5052-H32 aluminum sheet with corners that are rounded and smoothed for safety.

995-11.5.7 Ventilation: Provide ventilation through the use of a louvered vent at the bottom of the door. Vent depth must not exceed 0.25 inch. Provide an air filter a minimum of 192 square inches and 1 inch thick behind the vent. The filter must be removable and held firmly in place so that all intake air is filtered.

Provide a bottom trough and a spring-loaded upper clamp to hold the filter in place. The bottom trough must drain any accumulated moisture to the outside of the field cabinet.

ITS field cabinets must have dual thermostatically controlled fans, with one thermostat per fan, rated for continuous duty with a service life of at least 3 years. Mount thermostats on the inside top of the cabinet. Thermostats must be user adjustable to allow temperature settings ranging from a minimum of 70°F to a maximum of 140°F and capable of activating the fans within plus or minus 5 degrees of the set temperature. Use UL listed exhaust fans having a minimum air flow rating of 100 cubic feet per minute. Electric fan motors must have ball or roller bearings. Vent the exhaust air from openings in the roof of the field cabinet.

995-11.5.8 Electrical Requirements: All equipment must conform to applicable UL, NEC, EIA, ASTM, ANSI, and IEEE requirements. SPD's must be accessible from the front of any panel used in the cabinet. Connect the SPD for the cabinet's main AC power input on the load side of the cabinet circuit breaker. All wiring must be laced. All conductors must be stranded copper.

995-11.5.8.1 Service Panel Assembly: Provide a service panel assembly to function as the entry point for AC power to the cabinet and the location for power filtering, transient suppression and equipment grounding. Provide branch circuits, SPDs, and grounding as required for the load served by the cabinet, including ventilation fans, internal lights, electrical receptacles, etc.

995-11.5.8.2 Terminal Blocks: Terminate electrical inputs and outputs on terminal blocks. The voltage and current rating of the terminal block must be greater than the voltage and current rating of the wire fastened to it.

Terminate conductors on terminal blocks using insulated terminal lugs large enough to accommodate the conductor to be terminated. When two or more

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conductors are terminated on field wiring terminal block screws, use a terminal ring lug for termination of those conductors. Number all terminal block circuits and cover the blocks with a clear insulating material to prevent inadvertent contact.

995-11.5.8.3 Ground BusBar: Fabricate ground busbars of copper or aluminum alloy material compatible with copper wire and provide at least two positions where a No. 2 AWG stranded copper wire can be attached.

Mount the ground busbar on the side of the cabinet wall adjacent to the service panel assembly for the connection of AC neutral wires and chassis ground wires. If more than one ground busbar is used in a cabinet, use a minimum of a No. 10 AWG copper wire to interconnect them. Connect the equipment rack to the ground busbar in the cabinet to maintain electrical continuity throughout the cabinet.

Follow the PANI recommendations of USDA-RUS-1751 for connections to the ground busbar. Producer (P) or electrical power and sources of stroke current connections shall be on the left end of the busbar. Absorbing (A) or grounding wires shall be connected immediately right of the P connections. Non-isolated (N) connections such as doors and vents shall be connected to the right of the A connections. Isolated (I) equipment grounds from equipment in the cabinet shall be connected on the right end of the busbar.

995-11.5.8.4 Power Distribution Assembly: Furnish a power distribution assembly that fits in the EIA 19-inch rack and provides for protection and distribution of 120 V_{AC} power.

995-11.5.8.5 Interior Lighting: Provide one or more light fixtures that illuminate the entire interior of the cabinet. All light fixtures must automatically turn on when the main cabinet door is opened and turn off when the door is closed.

995-11.5.9 Adapter Bracket: Provide an adapter bracket for pole mounted cabinets that is slotted or otherwise designed to allow banding straps to be installed to avoid pole handholes.

995-11.6 Generator and Auxiliary Power Connection: Traffic signal controller cabinets and ITS cabinets must include a generator and auxiliary power connection.

Cabinets with generator and auxiliary power connection must include provisions for the connection of an external power source, such as a portable generator, through a weatherproof, secure interface. This feature must allow authorized personnel to access, connect, and secure an external power source to the cabinet in order to restore power within five minutes of arrival time at the cabinet. A 10 AWG, 600V UL rated cable, fabricated with L5-30 connectors, a minimum of 12 feet in length, must be supplied with cabinet assemblies for field connection between generator and cabinet. The generator access door and cable entrance must include means to prevent access to insects when cable is not present.

995-11.6.1 Automatic Transfer Switch: The transfer switch must meet UL 1008 and be rated equal to or higher than the design load of the cabinet's main breaker and the generator input twist-lock connector rating. The transfer switch must provide a means of switching between normal utility power and auxiliary backup generator power. Switching time cannot exceed 250 milliseconds. Ensure that the transfer switch does not allow simultaneous active power from more than one source and does not allow generator backflow into normal utility AC circuits.

995-11.6.2 Generator Access Panel: Include a generator connection panel consisting of, at a minimum, the automatic transfer switch with a three-prong, 30 amp L5-30P twist-lock connector with recessed male contacts for generator hookup. Locate the access panel

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as close as possible to the main AC circuit breaker with the bottom of the access panel no less than 24 inches above the bottom of the cabinet. Do not place the generator access panel on the main cabinet door or back door. Locate and label the transfer switch and twist lock connector on a panel easily accessible behind a weatherproof lockable exterior access door equipped with a tamper-resistant hinge. Label this access door "Generator Access Door". Provide the access door with a No. 2 lock.

The access door and cable entrance must include means to prevent access to insects when cable is not present. The generator hookup compartment must be recessed no more than six inches into the cabinet but be deep enough to allow closing and locking of the access door when the generator cable is connected. Avoid blocking access to any other equipment in the cabinet.

995-11.7 Small Equipment Enclosures: Small equipment enclosures must be a minimum NEMA 3R rated and smaller than 16 inches wide by 24 inches tall by 12 inches deep. The enclosure must be constructed of aluminum or non-metallic materials. Enclosures must include a safe means of removing power from the installed equipment for servicing and replacement, such as a switch, fuse, or breaker. Discrete markings, such as manufacturer name and model, are permitted on the outside of small enclosures.

All fasteners less than 5/8 inch exposed to the elements must be Type 304 or 316 stainless steel.

Construct aluminum enclosures of 5052 sheet aluminum alloy with a minimum thickness of 0.090 inch. Aluminum enclosures must have a uniform natural finish or be powder coat painted in accordance with AAMA-2603-02 specifications. All welds, bends, and seams must be neatly formed and free of cracks, blow holes and other irregularities. All inside and outside edges of the enclosure must be free of burrs, rivet holes, visible scratches, and gouges and have a smooth, uniform finish.

Non-metallic enclosures must be designed for outdoor use, and resist chemicals, corrosion, and ultraviolet rays.

Enclosure doors must include a vandal resistant hinge and be secured with a locking latch or a minimum of two quick-release Type 304 or 316 stainless steel latches with padlock hasps. Removal of the hinge or hinge pin must not be possible while the enclosure is closed. Provide two sets of keys with each lock.

Enclosures may be vented. Holes larger than 1/8 inch must be covered by heavy duty screen.

Post mounted enclosures must be supplied with mounting hardware for attaching the enclosure to a 4-1/2 inch (OD) aluminum post.

995-12 Traffic Controller Accessories.

995-12.1 General: Traffic controller accessories must meet the industry standards in Table 995-8 as well as the environmental requirements of those standards.

Table 995-8
Traffic Controller Accessory Standards

Device	Standard
Conflict Monitor	NEMA TS1-1989, Section 6
Malfunction Management Unit	NEMA TS2-2021, Section 4
Power Supply	NEMA TS2-2021, Section 5.3.5
Load Switch	NEMA TS2-2021, Section 6.2

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Flasher	NEMA TS2-2021, Section 6.3
Bus Interface Unit	NEMA TS2-2021, Section 8
Model 206L Power Supply Unit	CALTRANS TEES, 2020, 3.4
Model 208 Monitor Unit	CALTRANS TEES, 2020, 3.5
Model 210 Monitor Unit	CALTRANS TEES, 2020, 3.6
Power Distribution Assembly	CALTRANS TEES, 2020, 6.4.3
Input File	CALTRANS TEES, 2020, 6.4.4

995-12.2 Time Switch: Ensure the time switch is a 24-hour timer which controls the daily switching operation of circuit contacts at preselected times.

Type 1 time switches must contain a single circuit contact and a solid state timer with at least 48 programmable on and off times.

Type 2 time switches must contain two circuit contacts and a solid state timer with at least three independently programmable on and off times per circuit.

Type 3 time switches must contain three circuit contacts and a solid state timer with at least three independently programmable on and off times per circuit.

995-12.2.1 Timing: Solid state timing must be accomplished by digital circuits utilizing the power line 60 Hz frequency as the normal timing reference or GPS Time Sync. Time-of-day must be settable and displayed in maximum increments of one minute.

995-12.2.2 Programming: Programming for selection of contact openings or closures must be provided in maximum increments of one minute for Types 1 through 3 time switches.

A day omit device or circuit must be provided with Types 1 through 3 time switches to omit the programmed switching operation for any combination of up to three days of the week. A positive means of indicating the day of the week must be provided with Types 1 through 3 time switches.

995-12.2.3 Reserve Power: Type 1, Type 2, and Type 3 solid state time switches must be provided with a battery backup circuit which maintains time during a power failure of up to 10 hours. The timing accuracy of battery backup circuits during a power failure must be plus or minus 0.5 seconds.

995-12.2.4 Output Circuit Contacts: Each output circuit contact must be rated for a 3A, 115 V_{AC} load. The output circuit contact must have 115 V_{AC} present when the timer turns the circuit on.

995-12.2.5 Time Switch Housing: Time switches must be enclosed in durable sheet aluminum or approved alternate housing. A terminal strip or screws must be provided with the time switch for AC power and all output circuit contacts.

995-12.3 Model 210 Conflict Monitor with Absence of Red Monitoring: The conflict monitor must be a Model 210 "PLUS" conflict monitor capable of detecting fault sequencing of signals on a per channel basis (i.e., short or absence of yellow interval and/or simultaneous dual indications). All integrated circuits having 14 pins or more must be socket mounted.

995-12.3.1 Absence of Red Monitoring: The conflict monitor must be capable of monitoring for the absence of voltage on all of the inputs of a channel (defined here as red, yellow, and green). If an output is not present on at least one input of a channel at all times, the unit shall begin timing the duration of this condition. If this condition exists for less than 700 milliseconds, the unit shall not trigger. If this condition exists for more than

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1000 milliseconds, the unit shall trigger as if a conflict had occurred, causing the intersection to transfer immediately into a flashing mode, and "stop-time" to be applied to the controller. A red signal shall require the presence of a minimum of 60 $V_{AC,}$ plus or minus 10 $V_{AC,}$ to satisfy the requirements of a red indication. The red input signals shall be brought into the conflict monitor through an auxiliary connector on the monitor's front panel. Provide a similar connector on the output file, with a removable harness connecting the two. Provide an indicator on the front panel of the monitor to identify the triggering of the monitor in response to the absence of red condition.

995-13 System Control Equipment.

995-13.1 Adaptive Signal Control System: Adaptive signal control systems external to the traffic controller place detector calls to the traffic signal controller to adjust signalization timing based on measured traffic conditions independently of the traffic signal controller's preconfigured timings.

The system must interface with the traffic controller using either the Synchronous Data Link Control (SDLC) Port 1 interface and protocol or 24 V_{DC} inputs/outputs available in the traffic controller cabinet. Dynamically modifying controller configuration settings through serial communications is not allowed.

The system must include a user interface that allows the configuration of subcomponents, such as detectors and cameras, and includes remote monitoring and reporting.

The system must include the option of incorporating existing vehicle detection in addition to the primary detection used by the adaptive signal control system.

The system must not affect the normal operation of the traffic signal controller upon any failure of communication, detection, or system component.

Ensure adaptive signal control system hardware is permanently marked with manufacturer name or trademark as well as part number and serial number. Ensure that the markings are visible after installation.

995-13.2 Environmental Requirements: Ensure system control equipment performs all required functions during and after being subjected to the transients, temperature, voltage, humidity, vibration, and shock tests described in NEMA TS2-2021, 2.2.7, 2.2.8, and 2.2.9.

995-14 Internally Illuminated Signs.

995-14.1 General: Marking must be accomplished by permanently affixing an indelible label, identification plate, dot peen type stamp, casting, or metal-marking. Signs must not exceed 9 feet in width or be larger than 18.0 square feet or less in area, and must not weigh more than 144 pounds. Internally illuminated sign assemblies must be listed to the requirements of UL48 listed. Light emitting diode (LED) retrofit kits must be listed on the APL.

995-14.2 Housing: The sign housing must be constructed of continuous 5052 or 6063-T5 aluminum. All housing, corners, and door seams must be continuously welded. All exterior surfaces of the assembly must be powder-coat painted in accordance with Military Standard MIL-PRF-24712A or AAMA-2603-02. Finish must meet the requirements of ASTM D3359, ASTM D3363, and ASTM D522. Sign housings with any interior airspace must consist of a box type enclosure and separate hinged door assembly. The sign housing must include provisions to prevent water from entering the sign housing. Drain holes in the sign larger than 0.125 inch must be covered by a screen.

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Signs must have removable sign faces. The sign face must be secured by a method that holds the sign face securely in place. Slide-in grooves are allowed to secure the sign face if the sign is edge lit.

The sign face must be a translucent lens constructed of 0.125-inch thick high impact strength polycarbonate or acrylic meeting UL48. Background must be translucent retroreflective sheeting coated with a transparent, pressure-sensitive adhesive film. Color must meet the criteria as detailed in Section 994. Retroreflective sheeting must meet the requirements of Section 994 and be listed on the APL.

If a door opens upward, it must have a bracket on each side to secure the door in the open position during maintenance. Doors must be permanently and continuously sealed with a foam gasket listed to UL157 to prevent the entry of water into the sign housing. Each door must be secured from opening by stainless steel rotary action draw latches as follows:

Signs of 5 feet up to 7 feet in width must have a minimum of three latches for each sign door.

Signs over 7 feet up to 9 feet in width must have a minimum of four latches for each door.

The rotary action draw latch must be captive and will not become detached or allow the door to open when the sign housing is torqued or twisted

The sign assembly must be designed and constructed to withstand 150 mph wind loads meeting the requirements of the Department's Structures Manual.

995-14.3 Luminance: The sign face must be illuminated evenly across the entire surface. Contrast ratio between the background and legend shall be at least 4:1.

995-14.3.1 Background Luminance: Minimum luminance for the legend portion of the street sign face must be no less than 87.5 lux. The luminance must be determined by averaging a minimum of seven readings. Four of the readings must be taken near the midpoint of a line that would span between the outside corners of the background and the outside corners of the legend. One reading must be taken near the midpoint of a line that would connect the top corner readings. One reading must be taken near the midpoint of a line that would connect the bottom corner readings. One reading must be taken near the vertical and horizontal midpoint of the sign.

995-14.3.2 Border and Lettering Luminance: Minimum luminance of the legend and border must be 350 lux. The luminance must be determined by averaging a minimum of 17 readings. There must be a minimum of one reading from each letter in the legend. Readings within the legend must alternate between the top, middle and bottom portion of each letter. Readings within top and bottom of the border must be perpendicular to the top and bottom readings in the background. Readings within the sides of the border must be taken parallel to the readings taken within each letter.

995-14.4 Mechanical Requirements: All assembly hardware, including nuts, bolts, external screws and locking washers less than 5/8-inch in diameter must be Type 304 or 316 passivated stainless steel. All assembly hardware greater than or equal to 5/8-inch in diameter must be galvanized. Bolts, studs, and threaded rod must meet ASTM A307. Structural bolts must meet ASTM F3125, Grade A325.

995-14.5 Electrical Requirements: Electrical wiring must meet NEC requirements for the light source provided. All wiring must be copper wire. All internal electrical wiring must be tight and secure. The sign must include an accessible electrical power service entrance compartment (internal or external) for connection of field wiring. External compartments must

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be weather-tight. All power supplies and ballasts must be Federal Communications Commission (FCC) approved.

Electrical connections must be protected against corrosion. All signs must have provisions for an integrated photocell.

995-14.6 Environmental Requirements: The illuminated sign assembly must operate properly during and after being subjected to the environmental testing procedures described in NEMA TS 4-2016, Section 2.

995-14.7 Warranty: Internally illuminated signs must have a manufacturer's warranty covering defects for 5 years from the date of final acceptance.

995-15 Highlighted Signs.

995-15.1 General: Highlighted signs must meet the design and functional requirements specified in this Section and Section 2A of the MUTCD. Use LEDs to highlight the sign's shape, color, or message.

Stop, Do Not Enter, Yield, and Wrong Way signs that are highlighted with LEDs must use red LEDs. All other signs must use LEDs which resemble the color of the sign background color.

995-15.2 Performance Requirements: Highlighted signs are capable of automatically dimming to reduce brightness of the LEDs at nighttime.

Highlighted signs that rely upon solar power or batteries must be capable of at least 10 days of continuous operation without the need for charging.

995-15.3 Cabinets: If the highlighted sign includes a cabinet, the cabinet must be currently listed on the APL or meet the requirements of Section 676.

995-15.4 Mechanical Requirements: All assembly hardware, including nuts, bolts, external screws and locking washers less than 5/8-inch in diameter must be Type 304 or 316 passivated stainless steel. All assembly hardware greater than or equal to 5/8-inch in diameter must be galvanized. Bolts, studs, and threaded rod shall meet ASTM A307. Structural bolts must meet ASTM F3125, Grade A325.

995-15.5 Electrical Requirements: Electrical wiring must meet NEC requirements for the light source provided. All wiring must be copper wire. All internal electrical wiring must be tight and secure. The sign must include an accessible electrical power service entrance compartment (internal or external) for connection of field wiring. External compartments must be weather-tight. All power supplies and ballasts must be Federal Communications Commission (FCC) approved.

Electrical connections must be protected against corrosion. All signs must have provisions for an integrated photocell.

995-15.6 Environmental Requirements: The highlighted must operate properly during and after being subjected to the environmental testing procedures described in NEMA TS 4-2016, Section 2.

995-15.7 Warranty: Highlighted signs must have a manufacturer's warranty covering defects for 3 years from the date of final acceptance.

995-16 Dynamic Message Signs.

995-16.1 General: Dynamic message signs (DMS) must meet the requirements of NEMA TS4-2016. DMS are classified by the type of sign display and the type of mechanical construction. Use only equipment and components that meet the requirements of these minimum specifications and are listed on the APL. DMS LED retrofit kits must be listed on the APL.

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995-16.1.1 Front Access DMS: Front access signs must meet the requirements of NEMA TS 4-2016, Section 3.2.6.

995-16.1.2 Walk-In DMS: Walk-in signs must meet the requirements of NEMA TS 4-2016, Section 3.2.8.

995-16.1.3 Embedded DMS: Embedded DMSs must be mounted to ground traffic signs, overhead traffic signs, or overhead cantilever traffic signs.

995-16.2 Sign Housing Requirements for all DMS: The external skin of the sign housing must be constructed of aluminum alloy 5052 H32. The interior structure must be constructed of aluminum. Internal frame connections or external skin attachments must not solely rely upon adhesive bonding or rivets.

The sign enclosure must meet the requirements of NEMA TS 4-2016, Section 3.1.1. All drain holes and other openings in the sign housing must be screened to prevent the entrance of insects and small animals.

The sign housing must comply with the fatigue resistance requirements of the AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals. Design and construct the DMS unit for continuous usage of at least 20 years. The sign assembly must be designed in accordance with the Department's Structures Manual, including a wind load of 150 miles per hour.

The top of the housing shall include multiple steel lifting eyebolts or equivalent hoisting points. Hoist points are positioned such that the sign remains level when lifted. The hoist points and sign frame allow the sign to be shipped, handled, and installed without damage.

All assembly hardware, including nuts, bolts, screws, and locking washers less than 5/8-inch in diameter, must be Type 304 or 316 passivated stainless steel and meet the requirements of ASTM F593 and ASTM F594. All assembly hardware greater than or equal to 5/8-inch in diameter must be galvanized and meet the requirements of ASTM A307.

All exterior, excluding the sign face, and all interior housing surfaces must be a natural aluminum mill finish. Signs must be fabricated, welded, and inspected in accordance with the requirements of the current ANSI/AWS Structural Welding Code-Aluminum.

The sign housing must meet the requirements of NEMA TS 4-2016, Section 3.2.9 for convenience outlets.

995-16.2.1 Sign Housing for Walk-In DMS: Exterior seams and joints, except the finish coated face pieces, must be continuously welded using an inert gas welding method. Limit the number of seams on the top of the housing to a maximum of three. Stitch weld the exterior housing panel material to the internal structural members to form a unitized structure.

The exterior mounting assemblies must be fabricated from aluminum alloy 6061-T6 extrusions a minimum of 0.1875 inch thick. Include a minimum of three 6061-T6 structural aluminum Z members on the rear of the sign housing in accordance with the Standard Plans. The structural aluminum Z members must run parallel to the top and bottom of the sign housing and are each a single piece of material that spans the full width of the sign. The structural aluminum Z members must be attached to the internal framework of the sign.

The hoist points must be attached directly to structural frame members by the sign manufacturer.

Housing access must be provided through an access door that meets the requirements of NEMA TS 4-2016, Section 3.2.8.1. The access door must include a keyed tumbler lock and a door handle with a hasp for a padlock. The door must include a closed-cell neoprene gasket and stainless steel hinges.

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The sign housing must meet the requirements of NEMA TS 4-2016, Section 3.2.8.3 for service lighting. If incandescent lamps are provided, they must be fully enclosed in heavy-duty shatterproof, protective fixtures. The incandescent fixtures must include aluminum housing and base, a porcelain socket, and clear glass inner cover. All removable components must be secured with set screws. If fluorescent lamps are provided, they must be fitted with shatter proof protective guards.

The sign housing must include emergency lighting that automatically illuminates the interior in the event of a power outage. Emergency lighting must be capable of operation without power for at least 90 minutes.

995-16.2.1.1 Walk-In DMS Work Area: The walk-in DMS must have a work area that meets the requirements of NEMA TS 4-2016, Section 3.2.8.2. All edges of the walkway are finished to eliminate sharp edges or protrusions.

995-16.2.2 Sign Housing for Front Access and Embedded DMS: Front access and embedded signs must meet the requirements of NEMA TS 4-2016, Section 3.2.5 and Section 3.2.6. Accessing the sign housing must not require specialized tools or excessive force to open.

995-16.2.3 Housing Face Requirements for all DMS: The sign face must meet the requirements of NEMA TS 4-2016, Section 3.1.3. All sign face surfaces are finished with a matte black coating system that meets or exceeds American Architectural Manufacturers Association (AAMA) Specification No. 2605. Submit certification that the sign face parts are coated with the prescribed thickness. Except for embedded DMS, the sign face must include a contrast border that meets the requirements of NEMA TS 4-2016, Section 3.1.6.

995-16.2.3.1 Housing Face for Walk-In DMS: No exposed fasteners are allowed on the housing face. The display modules shall be easily and rapidly removed from within the sign without disturbing adjacent display modules.

995-16.2.3.2 Housing Face for Front Access and Embedded DMS: Any exposed fasteners on the housing face must be the same color and finish as the housing face. Only captive fasteners may be used on the housing face.

995-16.2.3.3 External Fascia Panels: If the sign includes external fascia panels, they must be constructed using aluminum. Each fascia panel is finished with a matte black coating system that meets or exceeds AAMA Specification No. 2605.

995-16.2.3.4 Lens Panel Assembly: If the sign includes lens panel assemblies, they must be modular in design, removable, and interchangeable without misalignment of the lens panel and the LED pixels. The lens panel assembly must consist of an environmental shielding layer coating to protect and seal the LED and internal electronics. The coating must be a minimum 90% UV opaque. Lens panels must have a matte black coating that meets or exceeds AAMA Specification No. 2605. Lens panels must include a mask constructed of 0.080 inch minimum thickness aluminum. The mask must be perforated to provide an aperture for each pixel on the display module. The apertures must not block the LED output at the required viewing angle.

995-16.2.4 Sign Housing Ventilation System: The ventilation systems for walk-in, front-access, and embedded DMS must meet the requirements of NEMA TS 4-2016, Section 3.1.2.

Air drawn into the sign is filtered upon entry. The ventilation system must be automatically tested once each day and is able to be tested on command from remote and local control access locations. The sign must include a sensor or a sensor assembly to monitor

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airflow volume to predict the need for a filter change. The ventilation system fans must possess a 100,000 hour, L10 life rating.

995-16.2.4.1 Ventilation System for Walk-In DMS: The sign includes a fail-safe ventilation subsystem that includes a snap disk thermostat that is independent of the sign controller. The thermostat is preset at 130°F. If the sign housing's interior reaches 130°F, the thermostat must override the normal ventilation system, bypassing the sign controller and turning on all fans. The fans must remain on until the internal sign housing temperature falls to 115°F.

995-16.2.5 Sign Housing Temperature Sensor: The sign controller must continuously measure and monitor the temperature sensors. The sign must blank when a critical temperature is exceeded and reports this event when polled. Ensure that remote and local computers can read all temperature measurements from the sign controller.

995-16.2.6 Sign Housing Humidity Sensor: Humidity sensors must detect from 0 to 100% relative humidity in 1% or smaller increments. Sensors must operate and survive in 0 to 100% relative humidity, and have an accuracy that is better than plus or minus 5% relative humidity. Use of a humidistat is not acceptable.

995-16.2.7 Sign Housing Photosensors: The sign must meet the requirements of NEMA TS 4-2016, Section 9.1.3. The sensors must provide accurate ambient light condition information to the sign controller for automatic light intensity adjustment. The automatic adjustment of the LED driving waveform duty cycle must occur in small enough increments that the sign's brightness changes smoothly, with no perceivable brightness change between adjacent levels. Stray headlights shining on the photoelectric sensor at night must not cause LED brightness changes.

The brightness and color of each pixel must be uniform over the sign's entire face within a 30 degree viewing angle in all lighting conditions.

995-16.3 Display Modules: Display modules manufactured by one source and fully interchangeable throughout the manufacturer's sign system shall be provided. The removal or replacement of a complete display module or LED board must be accomplished without the use of special tools.

Display modules must contain solid-state electronics needed to control pixel data and read pixel status.

The sign must have a full matrix display area as defined in NEMA TS 4-2016, Section 1.6.

995-16.3.1 LED and Pixel Specifications: LED lamps must have a minimum viewing angle of 30 degrees.

All pixels in all signs in a project, including operational support supplies, must have equal color and on-axis intensity. The sign display must meet the luminance requirements of NEMA TS 4-2016, Section 5.4, for light emitting signs connected at full power. Amber displays must produce an overall luminous intensity of at least 9200 candelas per square meter when operating at 100% intensity. Provide the LED brightness and color bins that are used in each pixel to the Engineer for approval. The LED manufacturer must demonstrate testing and binning according to the International Commission on Illumination (CIE) 127-1997 Standard.

All LEDs must operate within the LED manufacturer's recommendations for typical forward voltage, peak pulsed forward current, and other ratings. Component ratings must not be exceeded under any operating condition.

Ensure that the operational status of each pixel in the sign can be automatically tested once a day. Ensure that the pixel status test determines the functional status

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of the pixel as defined by the pixel Failure Status object in National Transportation Communications for ITS Protocol (NTCIP) 1203 v02.39 and does not affect the displayed message for more than half a second.

LEDs must be individually mounted directly on a printed circuit board (PCB).

995-16.3.2 Optical, Electrical, and Mechanical Specifications for Display Modules: The display modules must be rectangular and have an identical vertical and horizontal pitch between adjacent pixels. The separation between the last column of one display module and the first column of the next module must be equal to the horizontal distance between the columns of a single display module. Full matrix DMS must have the ability to display messages with 20mm pixel pitch (resolution).

The LED circuit board must be a NEMA FR4-rated, single 0.062 inch, black PCB. No PCB shall have more than two PCB jumper wires present. All PCBs shall be finished with a solder mask and a component-identifying silk screen.

PCBs with conformal coating meeting the material requirements of IPC-CC-830 or MIL-I-46058C Military Standard, United States Department of Defense (USDOD) must be provided.

Any devices used to secure LEDs must not block air flow to the LED leads or block the LED light output at the required viewing angle. All components on the LED side of a PCB must be black.

There must be a minimum of two power supplies that are wired in a parallel configuration for redundancy. If one, or 25% of the supplies in a group, whichever is greater, completely fails, the sign shall still be supplied with enough power to run 40% of all pixels at a 100% duty cycle with an ambient operating temperature of 165°F.

The sign controller must continuously measure and monitor all LED module power supply voltages and provide the voltage readings to the TMC or a laptop computer on command.

LEDs must be protected from external environmental conditions, including moisture, snow, ice, wind, dust, dirt, and UV rays. Epoxy must not be used to encapsulate the LEDs.

995-16.3.3 Display Area for Walk-In DMS: The display area must be capable of displaying three lines with a minimum of 15 characters per line, using an 18 inch font that meets the height to width ratio and character spacing in the MUTCD, Section 2L.04, paragraphs 05, 06, and 08.

995-16.4 Characters, Fonts, and Color: The signs must be capable of displaying American Standard Code for Information Interchange (ASCII) characters 32 through 126, including all uppercase and lowercase letters, and digits 0 through 9, at any location in the message line. Submit a list of the character fonts to the Engineer for approval.

All signs must be loaded (as a factory default) with a font in accordance with or that resembles the standard font set described in NEMA TS 4-2016, Section 5.6. For signs with a pixel pitch of 35 mm or less, the sign must be loaded (as a factory default) with a font set that resembles the FHWA Series E2000 standard font.

DMS fonts must have character dimensions that meet the MUTCD, Section 2L.04, paragraph 08.

Full-color signs must display the colors prescribed in the MUTCD, Section 1A.12.

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995-16.5 Main Power Supply and Energy Distribution Specifications: A nominal single-phase power line voltage of 120/240 V_{AC} must be provided. The DMS must meet the requirements of NEMA TS 4-2016, Section 10.2.

All 120 V_{AC} wiring must have an overall nonmetallic jacket or be placed in metal conduit, pull boxes, raceways, or control cabinets and installed as required by the NEC. Do not use the sign housing as a wiring raceway or control cabinet.

Surge protective devices (SPD) must be installed or incorporated in the sign system by the manufacturer to guard against lightning, transient voltage surges, and induced current. SPDs must meet or exceed the requirements of Section 996. SPDs must protect all electric power and data communication connections.

995-16.6 Uninterruptible Power Supply (UPS): Walk-in DMS must include a UPS that can be installed within the sign housing or within the ground mounted control cabinet. Front access and embedded signs must include a UPS that can be installed within the ground mounted control cabinet. The UPS system must be capable of displaying the current messages on a sign when a power outage occurs. Signs with an UPS must be able to operate on battery power and display text messages for a minimum of two hours. The system must use sealed absorbed glass mat (AGM) batteries.

995-16.7 Operational Support Supplies: Furnish the operational support supplies listed in Table 995-8. Promptly replace any of the supplies used to perform a warranty repair.

For every group of 10 or fewer DMSs provided or required, provide one set of supplies as follows:

Table 995-9
Operational Support Supplies

1 each	Sign controller and I/O board(s)
1 per DMS	LED display modules
1 each	Display power supply
1 each	Uninterruptible power supply
2 each	Surge suppression sets
1 each	Fan assembly

995-16.8 Components: All components must meet the requirements of NEMA TS 4-2016, Section 8.

995-16.8.1 Mechanical Components: All fasteners, including bolts, nuts, and washers less than 5/8 inch in diameter, must be passivated stainless steel, Type 316 or 304 and meet the requirements of ASTM F593 and ASTM F594 for corrosion resistance. All bolts and nuts 5/8 inch and over in diameter must be galvanized and meet the requirements of ASTM A307. Self-tapping screws must not be used. All parts must be fabricated from corrosion resistant materials, such as plastic, stainless steel, aluminum, or brass. Construction materials must be resistant to fungus growth and moisture deterioration. All dissimilar metals must be separated with an inert, dielectric material.

995-16.8.2 Sign Controller: The sign controller must monitor the sign in accordance with NEMA TS 4-2016, Section 9. The sign must monitor the status of any photocells, LED power supplies, humidity, and airflow sensors. Sign controllers must use fiber optic cables for data connections between the sign housing and ground-level cabinet.

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The sign controller must meet the requirements of NEMA TS 4-2016, Sections 8.3 and 8.4. The sign controller must be capable of displaying a self-updating time and date message on the sign. Sign controllers within ground cabinets must be rack-mountable, designed for a standard Electronic Industries Alliance (EIA) EIA-310 19 inch rack, and includes a keypad and display.

995-16.8.3 Display System Hardware: The sign must utilize a system data interface circuit for communications between the sign controller and display modules. Except for embedded DMS, the following components must reside inside the sign housing: sign controller, display system interface circuits, display modules, power supplies, local and remote control switches, LED indicators, EIA-232 null modem cables (minimum of 4 feet long for connecting laptop computer to sign controller), and surge protective devices.

995-16.8.4 Control Cabinet: A control cabinet that meets the requirements of Section 676 shall be provided. The minimum height of the cabinet must be 46 inches.

A ground control cabinet that includes the following assemblies and components: power indicator, surge suppression on both sides of all electronics, communication interface devices, connection for a laptop computer for local control and programming, a 4 foot long cable to connect laptop computers, a workspace for a laptop computer, and duplex outlets shall be provided.

All telephone, data, control, power, and confirmation connections between the sign and ground control box, and for any required wiring harnesses and connectors shall be provided.

995-16.8.5 Sign Controller Communication Interfaces: The sign controller must have communication interfaces in accordance with NEMA TS 4-2016, Section 8.3.2. Ensure that EIA-232 serial interfaces support the following:

Table 995-10
Communication Interface Requirements

Data Bits	7 or 8 bits
Parity	Even, Odd, or None
Number Stop Bits	1 or 2 bit

The sign controller must have a 10/100 Base TX 8P8C port or a 100 Base FX port Ethernet interface.

The TMC or a laptop computer must be able to remotely reset the sign controller.

995-16.9 Message and Status Monitoring: The DMS must provide two modes of operation: (1) remote operation, where the TMC commands and controls the sign and determines the appropriate message or test pattern; and (2) local operation, where the sign controller or a laptop computer commands and controls the sign and determines the appropriate message or test pattern.

The sign must perform the following functions:

1. Control Selection – Ensure that local or remote sign control can be selected. Ensure that there is a visual indicator on the controller that identifies whether the sign is under local or remote control.

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2. Message Selection – Ensure that the sign controller can select a blank message or any one of the messages stored in the sign controller's nonvolatile memory when the control mode is set to local.

3. Message Implementation – Ensure that the sign controller can activate the selected message.

Ensure that the sign can be programmed to display a user-defined message, including a blank page, in the event of power loss.

Ensure that message additions, deletions, and sign controller changes may be made from either the remote TMC or a local laptop computer. Ensure that each font may be customized, and modifications to a font may be downloaded to the sign controller from the TMC or a laptop computer at any time without any software or hardware modifications.

Ensure that there is no perceivable flicker or ghosting of the pixels during sign erasure and writing periods.

995-16.10 TMC Communication Specification for all DMS: The sign controller must be addressable by the TMC through the Ethernet communications network using software that complies with the NTCIP 1101 base standard (formerly the NEMA TS 3.2-1996 Standard), including all amendments as published at the time of Contract letting, the NTCIP Simple Transportation Management Framework, and conforms to Compliance Level 1. The software must implement all mandatory objects in the supplemental requirement SR-700-4.1.1, Dynamic Message Sign NTCIP Requirements, as published on the Department's State Traffic Engineering and Operations Office web site at the following URL: https://www.fdot.gov/traffic/Traf-Sys/Product-Specifications.shtm.

The sign must comply with the NTCIP 1102v01.15, 2101v01.19, 2201v01.15, 2202v01.05, and 2301v02.19 Standards. The sign must comply with NTCIP 1103v02.17, Section 3.

Ensure that the controller's internal time clock can be configured to synchronize to a time server using the network time protocol (NTP). NTP synchronization frequency must be user-configurable and permit polling intervals from once per minute to once per week in one-minute increments. The controller must allow the user to define the NTP server by IP address.

995-16.11 Sign Control Software: The sign must be provided with computer software from its manufacturer that allows an operator to program, operate, exercise, diagnose, and read current status of all sign features and functions using a laptop computer. The sign control software must provide a graphical representation that visibly depicts the sign face and the current ON/OFF state of all pixels as well as allows messages to be created and displayed on the sign.

995-16.12 Environmental Requirements: The DMS must meet the requirements of NEMA TS 4-2016, Section 2.

995-16.13 Warranty: The DMS system and equipment must have a manufacturer's warranty covering defects for a minimum of 5 years from the date of final acceptance.

995-17 Electronic Display Sign.

995-17.1 General: All electronic display signs (EDS) must meet the physical display and operational requirements for warning, guide, or regulatory signs described in the MUTCD and the SHS.

The term EDS refers to a general category of electronically enhanced signs that includes electronic road signs (ERS) with warning, regulatory, or guide legends; electronic speed feedback signs (ESFS); and blank-out signs (BOS).

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EDS must allow attachment to vertical and horizontal support structures as part of a single or double sign post configuration. Bolts must be used for load bearing attachments.

995-17.2 Requirements Common to all EDS: All EDS must be designed to withstand the loads defined in the Department's Structures Manual without deformation or damage. EDS, other than BOS, must provide an option to include flashing beacons. Printed circuit boards must be protected with conformal coating. Housings that contain electronics must be constructed of aluminum alloy sheet a minimum of .090 inch thick. Welding used during the construction of EDS must be accordance with Section 965.

Signs included on the APL will be designated with a size and type category and may be listed with restrictions, such as "requires District Traffic Operations Engineer approval", "school zones only", or "low speed only".

995-17.2.1 Electronic Display Sign with Static Sign Panel: EDS that include both a static sign panel and dynamic display may be a modular system comprised of a static sign panel with an attached electronic display. Static sign panels must meet the Department's requirements for highway signing found in this Section.

995-17.2.2 Electronic Display: Electronic displays must appear completely blank (dark) when not energized. No phantom characters or graphics will be allowed under any ambient light conditions.

995-17.2.3 Housing: The housing must protect and seal the dynamic display and other internal electronics. Any polycarbonate material used on the sign face must be a minimum 90% UV opaque and resistant to fading and yellowing. The housing must be NEMA 3R rated and prevent unauthorized access. The housing must include weather tight cable entry or connection points for any required power or data connections.

995-17.2.4 Cabinet: Any equipment cabinets provided with the EDS must be listed on the APL.

995-17.2.5 Optical, Electrical, and Mechanical Specifications for Display Modules: All LEDs must operate within the LED manufacturer's recommendations for typical forward voltage, peak pulsed forward current, and other ratings. Component ratings must not be exceeded under any operating conditions.

995-17.2.6 LED and Pixel Specifications: All LEDs used in the display must have a wavelength output that varies no more than plus or minus two nanometers from the specified peak wavelength. The display and LED pixel cone of vision must be a minimum of 15 degrees (centered around the optical axis, or zero point, of the pixel). The cone perimeter is defined by the point where light output intensity is 50% of the intensity measured at the zero point of the pixel. For all colors other than white, the sign display must produce an overall luminous intensity of at least 9200 candelas per square meter when operating at 100% intensity. For white or full color matrix displays, the sign display must produce white with an overall luminous intensity of at least 12,400 candelas per square meter when operating at 100% intensity. Submit documentation that indicates the LED brightness and color bins that are used in each pixel. LEDs must be individually mounted on a PCB and must be able to be removed and replaced using conventional electronic repair methods. Encapsulated LEDs within a pixel are not allowed. ERS LEDs must be arranged and powered in a manner that maintains a discernible message in the event of a single LED or pixel failure.

995-17.2.7 Character Size, Fonts, and Graphics: The minimum numeral and letter size of the electronic display must meet or exceed the numeral and letter sizes prescribed in

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the MUTCD and the SHS. Fonts and graphics must mimic the characteristics of fonts and graphics defined in the MUTCD and SHS.

995-17.2.8 Electronic Display Controller: Any electronic display controller required for the operation of the EDS shall be housed within the sign and be equipped with a security lockout feature to prevent unauthorized use. The controller shall have the capability to provide a stipulated default message upon loss of controller function. A blank message is acceptable.

995-17.2.9 Communication: The electronic display controller shall possess a minimum of one serial, Ethernet, USB, or Bluetooth interface with the ability to connect to a laptop computer. The serial data interface shall support multiple data rates from 9,600 bps to 115,200 bps.

995-17.2.10 Configuration and Management: Ensure that the sign is provided with computer software from its manufacturer that allows a user to program, operate, exercise, diagnose, and read current status of all sign features and functions using a laptop. Configuration and management functions must be password protected.

995-17.2.11 Operation and Performance: Ensure that the EDS is visible from a distance of at least 1/4 mile and legible from a distance of 400 feet for applications on roads with a speed limit less than 45 mph and visible from a distance of at least 1/2 mile and legible from a distance of at least 650 feet for roads with speed limits 45 mph or higher. In both cases, the requirements must be met under both day and night conditions.

The electronic display shall automatically adjust brightness for day and night operation. The EDS must be equipped with a light sensor that accurately measures ambient light level conditions at the sign location. The EDS must automatically adjust LED intensity based on the ambient light conditions in small enough increments that the sign's brightness changes smoothly, with no perceivable brightness change between adjacent levels. Stray headlights shining on the photoelectric sensor at night must not cause LED brightness changes.

Flashing messages must not exceed 150 flashes per minute.

995-17.2.12 Mechanical Specifications: EDS mounting provisions and mounting hardware must accommodate sign weight and wind loading requirements of the Department's Structures Manual. BOS must be designed to accommodate overhead attachment using a tri-stud signal hanger. Multiple tri-stud attachment points may be used to meet weight and wind loading requirements. Tri-stud attachment points must be weather-tight and structurally reinforced.

995-17.2.13 Fasteners and Attachment Hardware: Ensure that all assembly hardware, including nuts, bolts, external screws and locking washers less than 5/8 inch in diameter, are Type 304 or 316 passivated stainless steel. Stainless steel bolts, screws and studs must meet ASTM F593. Nuts must meet ASTM F594. All assembly hardware greater than or equal to 5/8 inch in diameter must be galvanized. Bolts, studs, and threaded rod must meet ASTM A307. Structural bolts must meet ASTM F3125, Grade A325.

995-17.2.14 Electrical Specifications: All power inputs must be fuse and reverse polarity protected. All EDS must be able to recover from power loss and return to their operational state without user intervention.

995-17.2.14.1 Solar Power: Solar powered signs must be capable of fully autonomous operation 24 hours per day, 365 days per year. Batteries must be a standard 12 volt deep cycle battery suitable for the application and operating environment. Flooded lead-acid batteries are prohibited.

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Batteries must be capable of providing 10 days of continuous operation without sunlight. Charging system must use a solar charge controller with temperature compensation. The system must provide for automatic battery charging, overcharge protection, and have indications that display current status and faults.

995-17.2.14.2 AC Power: Fluctuations in line voltage must have no visible effect on the appearance of the display.

995-17.2.15 Environmental Requirements: The EDS assembly must operate properly during and after being subjected to the environmental testing procedures described in NEMA TS 4-2016, Section 2. Fog, frost, or condensation must not form within the dynamic portion of the sign. Electronics must meet FCC Title 47, Subpart B Section 15.

995-17.2.16 Warranty: The EDS systems and equipment furnished must have a manufacturer's warranty covering defects for a minimum of 3 years from the date of final acceptance.

995-17.3 Electronic Warning Signs: EWS must include a secure wireless connection to communicate with a nearby laptop.

995-17.3.1 EWS Foreground/Background Colors: If a black background is used on the changeable electronic display, the color used for the legend must match the background color that would be used on a standard sign for that type of legend, in accordance with the MUTCD. Black EWS display backgrounds must be flat black (FED-STD-595-37038) with a reflectance value not exceeding 25%. EWS must utilize yellow LEDs with a peak wavelength of either 585 or 590 nanometers. EWS must have a minimum one-inch contrasting margin around illuminated characters or graphics.

995-17.3.2 Speed Detector: EWS that detect or display the speed of approaching vehicles must be programmable for the posted speed limit and the maximum speed to display. When the detected speed exceeds the maximum programmed speed (high speed cut-off) threshold, the display must automatically blank. Alternately, the display may show an alert message such as "SLOW DOWN" when speeds above the maximum programmed speed threshold are detected.

The EWS must detect when the posted speed is exceeded by one mph and then activate the alert. When the alert is activated, the display shall be able to flash. When no advancing traffic is detected, the display must be blank. The speed detector must not activate alerts for vehicles outside the display cone of vision.

The speed detector must meet the requirements of FCC Title 47, Part 90 and not require an FCC operating license. The speed detector must operate on 10.8 to 16.6 V_{DC} and draw less than three amperes. The EWS must monitor and display the speed of approaching traffic only. The EWS detector must be able to accurately detect and determine the speed of approaching vehicles. The EWS must be capable of measuring and displaying speeds of approaching traffic only between 10 and 99 mph with an accuracy of plus or minus one mph, 1,000 feet in advance of the sign.

995-17.4 Electronic Regulatory Signs: Display modules for ERS must have a minimum two-inch contrasting margin around digits, text, or graphics. ERS must utilize LED technology for the dynamic display.

995-17.4.1 ERS Battery Backup System: AC powered signs must include a battery backup system that maintains full operation of the sign for a minimum of two hours in the event of utility power loss. Operation on battery backup can have no visible effect on the appearance of the display.

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995-17.4.2 Variable Speed Limit Signs: Variable speed limit signs (VSLS) must be able to display speed limits from 5-70 mph in five mph increments and mimic the physical appearance of a static regulatory speed limit sign as shown in the MUTCD and SHS. VSLS must use black characters on a white background. VSLS must log the time and date of any speed limit change to internal non-volatile memory. The log must be able to record a minimum of 1,000 events in a first-in, first-out fashion.

995-17.4.2.1 VSLS Controller Communications: VSLS must be equipped with a sign controller that includes a minimum of one Ethernet 10/100 Base TX 8P8C port.

995-17.4.2.2 Configuration and Management Requirements for VSLS: VSLS must support remote management from a TMC and local management using a laptop computer. Remote and local computers must be able to reset VSLS sign controller. VSLS must log and report status, errors, and failures, including data transmission errors, receipt of invalid data, communication failure recoveries, power failures, power recoveries, display errors, fan and airflow status, temperature status, power supply status, and information on the operational status of the temperature, photocell, airflow, humidity, and LED power supply sensors.

The sign controller must be addressable through an Ethernet communication network using software that complies with the NTCIP requirements published online by the Department's Transportation Traffic Engineering Research Laboratory (TERL) at: https://www.fdot.gov/traffic/. The sign must implement any NTCIP standards required to achieve interoperability and interchangeability. Any additional objects implemented by the software must not interfere with the standard operation of any mandatory objects. VSLS must be compatible with the Department's SunGuide® software.

995-17.5 Blank-Out Signs: BOS must have a black exterior finish (FED-STD-595-37038) with a reflectance value not exceeding 25%. Overhead BOS must include a visor.

995-17.6 Electronic Speed Feedback Signs: The ESFS display background must be flat black (FED-STD-595-37038) with a reflectance value not exceeding 25%. ESFS must utilize amber LEDs with a peak wavelength of 590 nanometers. ESFS shall have a minimum one-inch contrasting margin around illuminated characters or graphics.

995-17.6.1 Speed Detector: The ESFS must be programmable for the posted speed limit and the maximum speed to display**.** When the detected speed exceeds the maximum programmed speed (high speed cut-off) threshold, the display must automatically blank. Alternately, the display may show an alert message such as "SLOW DOWN" when speeds above the maximum programmed speed threshold are detected. The ESFS must detect when the posted speed is exceeded by one mph and then activate the alert. When the alert is activated, the display must flash at a rate of 50 to 60 cycles per minute. When no advancing traffic is detected, the display must be blank. The speed detector must not activate alerts or display speeds for vehicles outside the display's cone of vision. The ESFS must meet the requirements of FCC Part 90 and not require an FCC operating license. The speed detector must operate on 10.8 to 16.6 V_{DC}. The ESFS must be capable of measuring speeds of approaching traffic between 10 and 99 mph with an accuracy of plus or minus one mph, 1,000 feet in advance of the sign.

995-18 Sign Beacon.

995-18.1 General: Flashing beacon assemblies incorporating a circular traffic signal must meet the design and functional requirements set forth in MUTCD Chapter 4L. All circular beacons must have a minimum nominal diameter of 12 inches and meet the requirements of Section 650. All beacons must use a LED light source.

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995-18.1.1 School Zone Beacon: Beacons designed for use with school zone signing must include a means of calendar scheduling to program days and times of operation.

995-18.1.2 Vehicle Activated Beacon: Vehicle activated beacons must utilize a vehicle detection system listed on the APL.

995-18.1.3 Pedestrian Activated Beacon: Pedestrian activated beacons must utilize a pedestrian detector listed on the APL.

995-18.2 Cabinets, Housings, and Hardware: Flashing beacon cabinets must be currently listed on the APL or meet the requirements of Section 676.

All housings, other than pole-mounted cabinets, must be powder coated dull black (FED-STD-595-37038) with a reflectance value not exceeding 25% as measured by ASTM E1347. Cabinets and housings must prevent unauthorized access.

Flashing beacon assemblies must allow installation on 4-1/2 inch outer diameter posts.

Ensure all exposed assembly hardware including nuts, bolts, screws, and locking washers less than 5/8 inch in diameter, is Type 304 or 316 passivated stainless steel and meets the requirements of ASTM F593 and ASTM F594. All assembly hardware greater than or equal to 5/8 inch in diameter must be galvanized and meet the requirements of ASTM A307.

995-18.3 Electrical Specifications: Provide equipment that operates on solar power or a nominal voltage of 120 V_{AC}. If the device requires operating voltages of less than 120 V_{AC}, supply the appropriate voltage converter. Solar powered beacon systems must be designed to provide 10 days of continuous operation without sunlight and must automatically charge batteries and prevent overcharging and over-discharging. Solar powered systems must include a charge indicator.

995-18.4 Environmental Specifications: All electronic assemblies must operate as specified during and after being subjected to the transients, temperature, voltage, humidity, vibration, and shock tests described in NEMA TS 4-2016, Section 2. All electronic equipment must comply with FCC Title 47 Subpart B Section 15.

995-18.5 Warranty: Ensure all flashing beacons have a manufacturer's warranty covering defects for a minimum of 3 years from the date of final acceptance. Ensure the manufacturer will furnish replacements for any part or equipment found to be defective during the warranty period at no cost to the Department or maintaining agency within 30 calendar days of notification.

995-19 In-Street Signs.

995-19.1 General: In-Street signs consist of the R1 6a or R1 6c In Street Pedestrian Crossing Sign assemblies including the sign base.

995-19.2 Materials: The sign assembly includes the vertical panel, retroreflective sign sheeting, a rebounding boot support, and a base. The vertical panel is bolted to a flexible boot which is fastened to a plastic, recycled PVC, or rubber base. The sign assembly shall contain no upright metal parts.

The vertical panel shall yield (bend) fully upon vehicle impact, then return to vertical position plus or minus 10 degrees with no delaminating. The face of the vertical panel shall resist twisting and remain oriented to the installed direction after vehicle impact. The vertical panel shall not split, crack, break, or separate from base. Use only UV stabilized, ozone and hydrocarbon resistant outdoor-grade thermoplastic polymer, polycarbonate, recycled PVC, or HDPE materials. UV stabilization testing shall be in accordance with ASTM D1435.

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Use Type XI fluorescent yellow-green retroreflective sign sheeting meeting the requirements of Section 994 on both sides of the vertical panel. The surface of the panel shall be smooth and free of defects, suitable for adherence of appropriate retroreflective sheeting.

995-19.2.1 Base:

995-19.2.1.1 Sign Base (Fixed): The base shall be constructed with high-impact materials using ozone and hydrocarbon resistant outdoor grade thermoplastic polymer, polycarbonate, or HDPE materials meeting the general provisions for all In-Street sign bases.

995-19.2.1.2 Sign Base (Portable): Portable base assemblies shall consist of a lightweight plastic, recycled PVC, or rubber material that may be easily moved or relocated by a single person.

995-19.2.1.3 Color: Sign bases shall be either black, or the same color as the adjacent pavement marking.

995-19.2.2 Approved Product List (APL): In addition to the APL requirements of 995-1.2, provide the following:

1. Product Drawings, which at a minimum includes:
    a. Model Number
    b. Allowable sign panel size and substrate
    c. Dimensions of sign base and mounting heights
2. Crash Test Reports demonstrating MASH compliance
3. All FHWA Eligibility Letters
4. When requested, submit product sample

995-19.3 Vertical Panel Messages: Fabricate vertical panel messages in accordance with Section 994. Vertical panels of 9 inches in width x 27 inches in height or 12 inches x 36 inches are acceptable. See Standard Plans Section 700-102

995-19.4 Connection Method: Products will be categorized as either Fixed Base or Portable. Fixed base will be installed in accordance with the manufacturer's instructions. Portable base will be limited to temporary applications at school crossings where a crossing guard is present during school arrival and departure times or when children are present.

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SECTION 996
INTELLIGENT TRANSPORTATION SYSTEM DEVICE MATERIALS

996-1 Description.

996-1.1 General: This Section governs the requirements for all permanent intelligent transportation system devices. All equipment shall be permanently marked with manufacturer name or trademark, part number, and date of manufacture or serial number.

996-1.2 Product Acceptance: All specified products shall be items listed on the Department's Approved Product List (APL), unless otherwise noted below. Manufacturers seeking evaluation of products for inclusion on the APL shall submit an application in accordance with Section 6 and include the following documentation. A separate application must be submitted for each product to be evaluated, showing that the product meets the applicable requirements.

Table 996-1

Documentation	Requirements
Assembly and Installation Instructions	Include any surface preparations, assembly/installation instructions, operation manual, troubleshooting guides, and repair procedures.
Independent Laboratory Test Results	Product meets requirements of this Section.
Product Label Photo	Labeling shows the manufacturer's name, trademark, and product model number/name. Label shows the date of manufacture and/or the manufacturer's batch number. Additional label requirements, as listed within this Section.
Product Photo	Displays the significant features of the product as required in this section.
Compliance Matrix	Include completed compliance matrix at https://www.fdot.gov/traffic/traf-sys/product-specifications.shtm
Manufacturer's Product Specifications	Include product specifications showing electrical requirements, voltages, etc.
Product Drawings or Cut Sheet	Show mounting points, mechanical details, block diagrams, schematics, etc.
Parts List	List major parts and field serviceable components.

996-1.3 Abbreviations: The following abbreviations are used in this Section:

Alternating Current (AC)
Closed Circuit Television (CCTV)
Direct Current (DC)
Electronic Industries Alliance (EIA)
Hypertext Transfer Protocol (HTTP)
Internet Protocol (IP)
Local Area Network (LAN)

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Network Time Protocol (NTP)
Pan, Tilt, Zoom (PTZ)
Telecommunications Industry Association (TIA)
Uniform Resource Locator (URL)
Ultraviolet (UV)

996-2 Video Equipment.

996-2.1 General: All CCTV camera equipment shall be listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6. All parts shall be constructed of corrosion-resistant materials, such as plastic, stainless steel, anodized aluminum, brass, or gold-plated metal. All fasteners exposed to the elements shall be Type 304 or 316 passivated stainless steel.

996-2.2 CCTV Camera:

996-2.2.1 Camera: CCTV cameras shall be compliant with the Code of Federal Regulations Section 200.216 Prohibition on certain telecommunications and video surveillance services or equipment https://www.ecfr.gov/current/title-2/subtitle-A/chapter-II/part-200/subpart-C/section-200.216. CCTV cameras shall be compatible with the current version of the Department's SunGuide® software system. Camera types include dome pan-tilt-zoom (PTZ), external positioner-PTZ, and fixed. Video types include analog and internet protocol (IP). Analog camera shall produce a National Television System Committee (NTSC) composite video output of 1V peak-to-peak (Vp-p) at 75 ohms with a minimum resolution of 470 horizontal and 350 vertical TV lines.

Analog and IP cameras shall provide the following features and capabilities:

1. Day (color)/night (monochrome) switchover.
2. Manual and automatic focus.
3. Automatic iris.
4. Ability to produce clear, detailed, and usable video images of the areas, objects, and other subjects visible from a roadside CCTV field site. Video produced by the camera is true, accurate, distortion free, and free from transfer smear, oversaturation, and any other image defect that negatively impacts image quality under all lighting and weather conditions in both color and monochrome modes.
5. User-selectable automatic gain control (AGC) that is peak-average adjustable to 28 dB.
6. A minimum signal-to-noise ratio of 50 dB.
7. Automatic color balance that references the white areas of the scene through the lens.
8. An automatic electronic shutter that is user selectable from 1/60 to 1/10,000 of a second.
9. PTZ cameras shall include a minimum 10x digital zoom.
10. PTZ cameras shall include programmable azimuth and compass display with ability to display pan and tilt position with a 1 degree resolution.

CCTV cameras shall provide titling and masking features including, but not limited to, programmable camera title, programmable preset titles for each preset position, and programmable privacy zones. Programmable titles shall allow a minimum of 18 characters per line.

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996-2.2.2 Lens: Standard definition PTZ cameras shall include a minimum 22x motorized optical zoom lens with automatic iris. High definition PTZ cameras shall include a minimum 18x motorized optical zoom lens with automatic iris. Fixed cameras shall have a 3-9 mm varifocal lens with automatic iris unless otherwise shown in the Plans. The lens shall have a maximum aperture of at least f/1.6 and the depth of field shall provide a clear image of roadside areas under all lighting conditions.

996-2.2.3 Pan/Tilt Mechanism for Dome-Type Cameras: Dome PTZ cameras shall meet the following requirements:

1. Have an integrated pan/tilt mechanism that provides 360 degree continuous pan with a minimum 90 degree tilt range (i.e., 0 degrees to minus 90 degrees);
2. Provide for variable speed control;
3. Have a preset position return accuracy of plus or minus 0.36 degree, or less than 0.10% or better;
4. Support a minimum of 64 presets; support a minimum of one tour with a minimum of 32 presets; and support a minimum of eight programmable blackout zones.

The positioner within the dome-type CCTV camera shall have a minimum automatic pan speed of 240 degrees per second to a preset camera position, a maximum manual pan speed of 80 degrees per second minimum and a maximum manual tilt speed of 40 degrees per second minimum.

996-2.2.4 Pan/Tilt Mechanism for External Positioner-Type Cameras: External positioner-type CCTV cameras shall include a pan/tilt mechanism that provides 360 degree continuous pan with a minimum 115 degree tilt range (i.e., minus 90 to plus 25 degrees), provide for variable speed control, have a preset position return accuracy of plus or minus 0.36 degree or less than 0.10% or better, and support a minimum of 32 presets.

996-2.2.5 Communication: Analog CCTV cameras shall support the National Transportation Communications for ITS Protocol (NTCIP) 1205 v1.08. The camera shall communicate with other devices using Telecommunications Industry Association/Electronic Industries Alliance (TIA/EIA)-232 or TIA-422 at a rate of 9600 bps, transmission control protocol (TCP)/IP, or user datagram protocol (UDP)/IP. All CCTV cameras shall provide for remote firmware upgrades via the communication interface.

IP cameras shall support either NTCIP 1205v01.08 or the Open Network Video Interface Forum (ONVIF) Core, Streaming, and Media Service specifications.

The camera shall implement all objects, operations, and commands required by SR-682-1.2.1-01, Supplemental CCTV Camera NTCIP and ONVIF Requirements, as published on the Department's State Traffic Engineering and Operations Office website at the following URL: https://www.fdot.gov/traffic/Traf_Sys/Product-Specifications.shtm.

996-2.2.6 Electrical Requirements: Cameras shall operate on a nominal voltage of 120 V_{AC}. Provide an appropriate voltage converter for devices that require operating voltages of less than 120 V_{AC}.

996-2.2.7 Mechanical Requirements: Camera housings shall include a sunshield to reduce the solar heating of the camera. The total weight of dome-type CCTV cameras (including the housing, sunshield, and all internal components) shall be less than 17.0 lbs. The lower dome of the camera housing shall be constructed of distortion free clear plastic.

Pressurized dome-type housings shall be capable of pressurization at 5 psi using dry nitrogen, have a low-pressure alarm feature, and a NEMA 4X/IP-67 rating.

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If a non-pressurized dome-type housing enclosure is used, the unit shall be vented with a thermostat-controlled heater and blower. The non-pressurized enclosure shall have a NEMA 4/IP-66 rating.

The total weight of external positioner-type CCTV cameras (including housing, sunshield, all internal components, and external pan and tilt mechanism) shall be less than 35 lb.

996-2.2.8 Environmental Requirements: CCTV cameras shall perform all required functions during and after being subjected to the environmental testing procedures described in NEMA TS 2-2021, Sections 2.2.7, 2.2.8, and 2.2.9.

All CCTV cameras, mounting hardware, and any other camera-related material that is exposed to the environment shall be designed for 150 mph wind speeds and meet the requirements of the Department's Structures Manual.

996-2.2.9 Additional Requirements for IP Cameras:

996-2.2.9.1 Video Encoding: The camera shall utilize the Moving Picture Experts Group's MPEG4 part 10 (H.264) video compression technology in accordance with the ISO and IEC requirements detailed in the ISO/IEC 14496-10:2009 Standard.

Cameras shall establish unicast and multicast sessions using the Real-Time Streaming Protocol (RTSP). The encoded video shall transmit using programmable bit rates and the camera supports, at a minimum, a fixed bit rate mode.

996-2.2.9.2 Encoded Video Requirements: The camera's encoded video shall support resolutions that include; but are not limited to, those defined in Table 996-1. The camera shall deliver color and monochrome video at 30 frames per second (fps), regardless of resolution.

Table 996-1
Minimum Resolution Requirements

Format	Vertical Resolutions
H.264	240, 480

Note: The resolutions attained depend on the data transmission rate.

996-2.2.9.3 Network Interface: The camera's Local Area Network (LAN) connection shall support the requirements detailed in the IEEE 802.3 Standard for 10/100 Ethernet connections. The camera shall have a minimum of one 10/100 Base-TX connection Ethernet port.

Unshielded twisted pair/shielded twisted pair network cables shall be compliant with the EIA/TIA-568-B Standard. The network communication shall conform to TCP, UDP, Version 4 of the IP, RTSP, and Version 2 of the Internet Group Multicast Protocol (IGMP), at a minimum. If the camera supports NTCIP, then the camera shall be able to be controlled via TCP/IP or UDP/IP.

996-2.2.9.4 Configuration Management: The camera shall support local and remote configuration and management via serial login, telnet login, or a web-based interface. Configuration and management functions shall include access to all user-programmable features including, but not limited to, network configuration, video settings, device monitoring, and security functions.

996-2.3 Video Display Control System:

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996-2.3.1 Display Control System: The video display control system shall allow the operator to control and manage the display of video and computer-generated graphics on the display equipment connected to the system as well as provide selection and switching of multiple sources for display, including video streams available on the Traffic Management Center (TMC) Ethernet network. The display control system shall also allow for operator control of all displays from the same workstation that is used for the SunGuide® operator interface. The video display control system shall decode and display all video streams produced by encoders listed on the APL.

The video display control system simultaneously displays a minimum of 32 video windows, each containing streaming video at a minimum resolution of 720 pixels by 480 pixels and frame rate of 30 fps. The system shall allow any display window to be sized from 1/32 of the total display area up to the total display area, and any size in between.

The video display control system hardware shall be designed to be rack mounted and secured in an EIA 19 inch equipment rack. Any system incorporating Personal Computer (PC) hardware shall use current microprocessor technology and commercial, off-the-shelf components, including RAM, hard disk drives, and network interface cards sufficient to provide the functional requirements of the system.

The video display control system shall be expandable and scalable to support any combination of inputs and outputs.

The video display control system shall have a minimum configuration of 4 composite video inputs, 4 component (red, green, and blue (RGB) video inputs, and 4 High-Definition Multimedia Interface (HDMI) inputs as well as network connections, decoders, and associated hardware and software required to display 32 inputs simultaneously at a minimum resolution of 720 pixels by 480 pixels and a frame rate of 30 fps.

The video display control system shall have a minimum configuration of 4 composite video outputs, 2 component (RGB video outputs), and 4 HDMI outputs.

996-2.3.2 Display Control Software: The display control software shall allow multiple operators to control all features and functions of the video display control system. These features and functions include, but are not limited to, selection of video sources for display; adjusting the size, location, and layout of video and other graphic information the system displays; and system configuration and setup. The control software shall be able to operate a video wall composed of multiple display components as though it were a single, high-resolution display.

The display control software shall include a non-proprietary Software Development Kit (SDK) including, but not limited to, an Application Programming Interface (API) that describes interfaces and protocols which can be used to integrate system features and functions with third-party applications.

996-2.3.3 Controller Inputs and Outputs: The video display control system shall support and display a variety of video and data inputs simultaneously, including composite and component NTSC video, HDMI, Digital Visual Interface (DVI), Video Graphics Array (VGA), Super Video Graphics Array (SVGA), and Super Extended Graphics Array (SXGA) computer graphics. All inputs and outputs shall allow for operator control in order to display any or all of this information on any number of display devices within the system. All inputs and outputs shall be sized with and without constrained proportions across multiple screens and moved at will around any display area and combination of displays.

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The video display control system shall be expandable and scalable to support any combination of inputs and outputs. The video display control system with a minimum configuration of 4 composite video inputs, 4 component (RGB video inputs), and 4 HDMI inputs as well as network connections, decoders, and associated hardware and software required to display 32 inputs simultaneously at a minimum resolution of 720 pixels by 480 pixels and a frame rate of 30 fps, or as shown in the Plans. Provide the video display control system with a minimum configuration of 4 composite video outputs, 2 component (RGB video outputs), and 4 HDMI outputs. The video display control system can be expanded to accommodate at least 128 discreet inputs and outputs.

A single input shall be able to be routed to multiple displays simultaneously and multiple inputs can be routed to a single display simultaneously for viewing in separate windows. All inputs and outputs shall be synchronized by the video display control system and switching between inputs or outputs does not cause displayed images to unlock, roll, or otherwise exhibit visible distortion.

996-2.3.3.1 Analog Video: The video display control system shall be able to accept S-video, composite, and component video sources, and can digitize these signals for manipulation and display on any display device attached to the system. All analog video inputs shall use BNC connectors.

Analog video sources shall display within their own windows and can be resized up to or beyond their native resolution to conform to the wall display size.

996-2.3.3.2 Digital Video: The video display control system shall be able to accept digital video sources and can manipulate and display these signals on any display attached to the system. All digital video outputs shall use HDMI connectors unless otherwise directed.

Each MPEG video stream shall display within its own window and be freely movable and sizable up to or beyond its native resolution to conform to the wall display size.

996-2.3.3.3 RGB Video: Include an analog input that enables the TMC operator to project an exact copy of his or her workstation desktop display on the video wall display. Analog RGB inputs shall allow native images up to 1,280 pixels by 1,024 pixels at 60 Hz to be displayed on the video wall.

RGB inputs shall be sizable up to or beyond their native resolution to conform to the wall display size.

996-2.3.3.4 Streaming Media: The video display control system shall be able to display a minimum of 32 compressed video streams simultaneously in MPEG-2 over TCP/UDP/RTP over IP and supports multicasting as defined in Version 2 of the IGMP. The video display control system can display MPEG-4 and H.264. The MPEG video input interface is, at minimum, a 10/100 megabit per second network port per every 15 streams.

996-2.3.3.5 Primary Display Output: Video display control system can process the various signal input types to be viewed, such as the RGB feeds from monitor outputs and streaming video feeds. The unit shall provide direct digital streaming video through cable feeds using a digital video decoder. The video display control system shall provide the layout definitions for each signal to be displayed and save the predefined layouts and shall also permit switching of the predefined layouts and accept external alarm triggers to change the layouts.

The output capacity shall have sufficient memory and processing speed to provide fast rendering of video and image displays. The output has, at a minimum, a

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dual HDMI connector that supports 1,280 horizontal pixels by 1,024 vertical pixels or greater resolution. The color depth is a minimum of 24 bits per pixel.

996-2.3.4 Electrical Requirements: Provide equipment that operates on 120 V_{AC} at a frequency of 60 Hz. Furnish a transformer or other necessary means of power conversion for any device that requires another voltage or frequency.

996-3 Network Devices.

996-3.1 General: Network devices shall be listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6.

996-3.2 Managed Field Ethernet Switch:

996-3.2.1 Description: The Managed Field Ethernet Switch (MFES) shall be compliant with the Code of Federal Regulations Section 200.216 Prohibition on certain telecommunications and video surveillance services or equipment https://www.ecfr.gov/current/title-2/subtitle-A/chapter-II/part-200/subpart-C/section-200.216.

The MFES provides wire-speed fast Ethernet connectivity at transmission rates of 100 megabits per second.

Each MFES shall be managed individually and as a group for switch configuration, performance monitoring, and troubleshooting. The MFES shall include Layer 2+ capabilities, including, Quality of Service (QoS), IGMP, rate limiting, security filtering, and general management.

The MFES shall support half and full duplex Ethernet communications.

The MFES shall provide 99.999% error-free operation. The MFES shall comply with the EIA Ethernet data communication requirements using single-mode fiber optic transmission medium and Category 5E copper transmission medium.

The MFES shall have a minimum mean time between failures (MTBF) of 10 years, or 87,600 hours, as calculated using the Bellcore/Telcordia SR-332 standard for reliability prediction.

996-3.2.2 Networking Standards: The MFES shall comply with all applicable IEEE networking standards for Ethernet communications, including but not limited to:

1. IEEE 802.1Q standard for Local and Metropolitan Area Networks - Bridges and Bridged Networks used with port-based Virtual Local Area Networks (VLANs) and Rapid Spanning Tree Protocol (RSTP).
2. IEEE 802.1P standard for QoS.
3. IEEE 802.3 standard for LAN and Metropolitan Area Network (MAN) access and physical layer specifications.
4. IEEE 802.3u supplement standard regarding 100 Base TX/100 Base FX.
5. IEEE 802.3x standard regarding flow control with full duplex operation.

996-3.2.3 Optical Ports: All fiber optic link ports operate at 1,310 or 1,550 nanometers in single mode. All optical ports are Type ST, SC, LC, or FC only. Mechanical transfer registered jack (MTRJ) type connectors are not allowed.

MFES shall provide a minimum of two optical 100 Base FX ports capable of transmitting data at 100 megabits per second. MFES shall provide optical ports designed for use with a pair of fibers; one fiber will transmit (TX) data and one fiber will receive (RX) data. The optical ports shall have an optical power budget of at least 15 dB.

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996-3.2.4 Copper Ports: MFES shall include a minimum of four copper ports. All copper ports shall be Type RJ-45 and shall auto-negotiate speed (i.e., 10/100 Base) and duplex (i.e., full or half). All 10/100 Base TX ports shall meet the specifications detailed in this section and shall be compliant with the IEEE 802.3 standard pinouts.

Ethernet over very high speed digital subscriber line (EoVDSL) ports shall support standard telephone-grade twisted copper pair and automatically negotiate the fastest data rate possible depending on cable length and quality.

996-3.2.5 Management Capability: The MFES shall support all Layer 2 management features and certain Layer 3 features related to multicast data transmission and routing. These features shall include, but not be limited to:

1. An MFES that is a port-based VLAN and supports VLAN tagging that meets or exceeds specifications as published in the IEEE 802.1Q standard and has a minimum 4-kilobit VLAN address table.
2. A forwarding/filtering rate that is a minimum of 14,880 packets per second for 10 megabits per second and 148,800 packets per second for 100 megabits per second.
3. A minimum 4 kilobit MAC address table.
4. Support of, at a minimum, IGMP Version 2.
5. Support of remote and local setup and management via secure shell (SSH) and secure Web-based GUI.
6. Support of the Simple Network Management Protocol (SNMP) version 1/2/3. Verify that the MFES can be accessed using the resident EIA-232 management port or a telecommunication network.
7. Support of Remote Authentication Dial-In User Service (RADIUS) or Terminal Access Controller Access-Control System Plus (TACACS+)
8. Support of remote monitoring (RMON) of the Ethernet agent and the ability to be upgraded to switch monitoring (SMON), if necessary.
9. Support of Secure Copy (SCP) or Secure File Transfer Protocol (SFTP) and either Network Time Protocol (NTP) or the Simple Network Time Protocol (SNTP). Ensure that the MFES supports port mirroring for troubleshooting purposes when combined with a network analyzer.

996-3.2.6 Mechanical Requirements: Every conductive contact surface or pin shall be gold-plated or made of a noncorrosive, nonrusting, conductive metal. Do not use self-tapping screws on the exterior of the assembly. All parts shall be made of corrosion-resistant materials, such as plastic, stainless steel, anodized aluminum, brass, or gold-plated metal.

996-3.2.7 Electrical Requirements: The MFES shall operate on a nominal Voltage of 120 V_{AC}. Supply an appropriate voltage converter for devices that require operating voltages of less than 120 V_{AC}. The MFES shall have diagnostic Light Emitting Diodes (LEDs), including link, TX, RX, and power LEDs.

996-3.2.8 Environmental Requirements: MFES shall operate properly during and after being subjected to the environmental testing procedures described in NEMA TS 2 2021, Sections 2.2.7, 2.2.8., and 2.2.9.

996-3.3 Managed Hub Ethernet Switch:

996-3.3.1 Description: The Managed Hub Ethernet Switch (MHES) shall be compliant with the Code of Federal Regulations Section 200.216 Prohibition on certain telecommunications and video surveillance services or equipment https://www.ecfr.gov/current/title-2/subtitle-A/chapter-II/part-200/subpart-C/section-200.216.

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The MHES shall provide Ethernet connectivity at transmission rates of 10/100/1000/10000 megabits per second. The MHES shall support half and full duplex Ethernet communications. The MHES must support 12000 IPv4 routes and 2000 IPv6 routes and all routing protocols shall be in performed hardware to ensure maximum speed.

The MHES shall support management individually and as a group for switch configuration, performance monitoring, and troubleshooting. The MHES shall include Layer 2 capabilities, including, QoS, IGMP, rate limiting, security filtering, and general management.

The MHES shall include full Layer 3 capabilities, including Open Shortest Path First (OSPF) routing protocol, Routing Information Protocol (RIP), and Protocol Independent Multicasting (PIM). The MHES includes all license(s) required to utilize all Layer 3 features.

996-3.3.2 Networking Standards: The MHES shall comply with all applicable IEEE networking standards for Ethernet communications, including:

1. IEEE 802.1Q Standard for Local and Metropolitan Area Networks - Bridges and Bridged Networks used with port-based Virtual Local Area Networks (VLANs) and Rapid Spanning Tree Protocol (RSTP).
2. IEEE 802.1P standard for QoS.
3. IEEE 802.3 standard for Local Area Network (LAN) and metropolitan area network (MAN) access and physical layer specifications.
4. IEEE 802.3u supplement standard regarding 100 Base TX/100 Base FX.
5. IEEE 802.3x standard regarding flow control with full duplex operation.
6. IEEE 802.3z supplement standard regarding 1000 Base X.

996-3.3.3 Optical Ports: All fiber optic link ports operate at 1,310 or 1,550 nanometers in single mode. Provide Type LC connectors unless otherwise directed. Mechanical transfer registered jack (MTRJ) type connectors are not allowed.

MHES shall provide a minimum of 6 optical ports capable of transmitting data at 10/100/1000/10000 megabits per second. MHES shall provide optical ports designed for use with a pair of fibers; one fiber will transmit (TX) data and one fiber will receive (RX) data. The optical ports shall have an optical power budget of at least 15 dB.

996-3.3.4 Copper Ports: MHES shall include a minimum of 12 10/100/1000 Base TX copper ports. All copper ports shall be Type RJ-45 and shall auto-negotiate speed (i.e., 10/100/1000 Base) and duplex (i.e., full or half). All 10/100/1000 Base TX ports shall meet the specifications detailed in this section and shall be compliant with the IEEE 802.3 standard pinouts.

996-3.3.5 Management Capability: MHES shall support all Layer 2 management features and all Layer 3 features as defined by this Section. Layer 2 and Layer 3 features must include:

1. Port-based VLAN and VLAN tagging that meets or exceeds specifications as published in the IEEE 802.1Q standard and has a minimum 4-kilobit VLAN address table.
2. A forwarding/filtering rate that is a minimum of 14,880 packets per second for 10 megabits per second, 148,800 packets per second for 100 megabits per second, and 1,488,000 packets per second for 1000 megabits per second.
3. A minimum 4 kilobit MAC address table.

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4. Support of IGMP Version 2.

5. Support of remote and local setup and management via secure shell and secure Web-based GUI.

6. Support of the Simple Network Management Protocol (SNMP) version 2 and version 3.

7. Support of Remote Authentication Dial-In User Service (RADIUS) or Terminal Access Controller Access-Control System Plus (TACACS+).

8. Support of remote monitoring (RMON) of the Ethernet agent and the ability to be upgraded to switch monitoring (SMON), if necessary.

9. Support of SCP or SFTP and either Network Time Protocol (NTP) or the Simple Network Time Protocol (SNTP). Ensure that the MHES supports port mirroring for troubleshooting purposes when combined with a network analyzer.

10. Sampled Flow Network Monitoring export protocol capable of being turned on or off on individual Ethernet ports without affecting traffic.

12. OSPF routing protocol. 12000 IPv4 routes and 2000 IPv6 routes.

12. RIP.

13. Virtual Router Redundancy Protocol (VRRP).

996-3.3.6 Mechanical Specifications. Ensure the MHES is no greater than 1-Rack Unit tall.

Every conductive contact surface or pin shall be gold-plated or made of a noncorrosive, nonrusting, conductive metal. Do not use self-tapping screws on the exterior of the assembly. All parts shall be made of corrosion-resistant materials, such as plastic, stainless steel, anodized aluminum, brass, or gold-plated metal.

996-3.3.7 Electrical Specifications. MHES must shall operate on a nominal voltage of 120 V_{AC}. Supply an appropriate voltage converter for devices that require operating voltages of less than 120 V_{AC}. The MHES shall have diagnostic LEDs, including link, TX, RX, and power LEDs.

996-3.3.8 Environmental Specifications. Ensure that the MHES has an operating temperature range of -34° Celsius to 74° Celsius. Ensure that the MHES can withstand 90 percent non-condensing relative humidity at 40° Celsius.

996-3.4 Device Server:

996-3.4.1 Description: The device server allows the connection of serial devices with EIA-232, EIA-422, and EIA-485 connections to an Ethernet network. The device server provides a TCP/IP interface to one or more field devices using EIA-232/422/485 standard connections. The device server supports TCP/IP, UDP/IP, Dynamic Host Configuration Protocol (DHCP), Address Resolution Protocol (ARP), Internet Control Message Protocol (ICMP), Simple Network Management Protocol (SNMP), Hypertext Transfer Protocol (HTTP), and telnet.

The device server shall provide 99.999% error-free operation and EIA-compatible Ethernet data communication by way of a Category 5E copper or fiber optic transmission medium.

The device server is resistant to all electromagnetic interference.

Data security shall comply with Version 2 of the Secure Shell Protocol (SSHv2), or the NIST requirements as defined in the Federal Information Processing Standard (FIPS) Publication (PUB)-197 for the Advanced Encryption Standard (AES).

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The device server has a minimum mean time between failures (MTBF) of 10 years, or 87,600 hours.

996-3.4.2 Serial Interface: The device server provides a minimum of one serial data interface and connector that conforms to EIA-232/422/485 standards. The serial interface supports 2-wire and 4-wire EIA-485 connections. The serial ports support data rates up to 230 kbps; error detection procedures utilizing parity bits (i.e., none, even, and odd); and stop bits (1 or 2).

The device server provides flow control (request to send [RTS]/clear to send [CTS] and transmit on/transmit off [XON/XOFF]), as well as allow control of the Data Terminal Ready (DTR), Data Carrier Detect (DCD), Data Set Ready (DSR), CTS, and RTS signals. The device server supports RTS toggle for half-duplex emulation.

996-3.4.3 Network Interface: The device server includes a minimum of one Ethernet port, which shall provide a 10/100 Base TX or a 10/100 Base FX connection as specified in the Plans. All copper-based network interface ports utilize registered jack (RJ)-45 connectors. The optical ports are Type ST, SC, LC, or FC only. Mechanical transfer registered jack (MTRJ) type connectors are not allowed.

996-3.4.4 Configuration and Management: The device server shall support local and remote configuration and management, which shall include access to all user-programmable features, including but not limited to addressing, port configuration, device monitoring, diagnostic utilities, and security functions. The device server shall support configuration and management via SNMP, telnet login, and browser-based interface.

996-3.4.5 Mechanical Requirements: Do not use self-tapping screws on the exterior of the assembly. All parts are made of corrosion-resistant materials, such as plastic, stainless steel, anodized aluminum, brass, or gold-plated metal.

996-3.4.6 Electrical Requirements: The device server operates using a nominal input voltage of 120 V_{AC} If the device requires nominal input voltage of less than 120 V_{AC}, furnish the appropriate voltage converter. The maximum power consumption shall not exceed 12 watts. The device server has diagnostic LEDs, including link, TX, RX, and power LEDs.

996-3.4.7 Environmental Requirements: The device server performs all required functions during and after being subjected to the environmental testing procedures described in NEMA TS 2-2021, Sections 2.2.7, 2.2.8, and 2.2.9.

996-3.5 Digital Video Encoder and Decoder:

996-3.5.1 Description: The Digital Video Encoder (DVE) and Digital Video Decoder (DVD) are specialized network-based hardware devices and software which allow video and data signals to be transmitted across IP networks. The video and data packets produced by the DVE and placed onto the network allow reconstruction of digital video signals by hardware-based and software-based DVDs that are also attached to the network.

996-3.5.2 Software: All setup, control programs, and diagnostic software related to the DVE or DVD shall be provided. All equipment licenses, where required for any software or hardware in the system, shall be provided.

996-3.5.3 MPEG-2 Format: DVE and DVD components utilize the Moving Picture Experts Group's MPEG-2 video compression technology in accordance with the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) requirements detailed in the ISO/IEC 13818 standard. The DVE and DVD are capable of unicast and multicast operation. DVEs support the Session Announcement Protocol (SAP) as recommended by the Internet Engineering Task Force (IETF) RFC 2974. The

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DVE provides 99.999% error-free operation. The MPEG-2 DVE and DVD equipment support programmable bit rates. MPEG-2 equipment supports fixed bit rate mode.

996-3.5.4 H.264 Format: DVE and DVD components utilize the video compression technology in accordance with the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) requirements detailed in the ISO/IEC 14496-10:2009 standard. The DVE and DVD are capable of unicast and multicast operation. DVEs shall support the Session Announcement Protocol (SAP) as recommended by the Internet Engineering Task Force (IETF) RFC 2974, and Real Time Streaming Protocol (RTSP). The DVE provides 99.999% error-free operation. H.264 DVE and DVD equipment support programmable bit rates. H.264 equipment supports fixed bit rate mode.

996-3.5.5 Digital Video Encoder: The DVE is a hardware-based network device that is able to accept a minimum of one analog NTSC video input and digitize it for transport across IP networks. The DVE provides a minimum of one serial data interface for transmission of command and control data to other devices (typically camera PTZ commands), as well as console and configuration functions. Provide compatible decoder software along with the DVE.

996-3.5.6 Hardware-based Decoder: The hardware-based DVD has a minimum of one video output. The DVD that has a minimum of one data interface for configuration functions. The DVD includes an Ethernet interface for connection to IP networks.

996-3.5.7 Interoperability: The DVE is compatible and fully interoperable with software and hardware DVDs from the DVE manufacturer, as well as a minimum of two software and hardware DVDs from other manufacturers. The DVD is compatible and fully interoperable with DVEs from the DVD manufacturer, as well as a minimum of two other DVEs from other manufacturers. The DVE and DVD can be controlled using SunGuide® or support stream selection and switching using ONVIF commands.

996-3.5.8 Video Requirements: Composite video inputs and outputs utilize BNC connectors. Analog video inputs and outputs support 1 volt peak-to-peak (Vp-p) NTSC composite video. The DVE and DVD operate with both color and monochrome video, and DVEs allow the user to select and adjust video resolution. The DVE and DVD support resolutions that include, but are not limited to, those defined in Table 996-2. The DVE and DVD are capable of delivering color and monochrome video at 30 fps regardless of resolution.

Table 996-2
Resolution Requirements

Format	Resolutions
MPEG-2	352 x 240, 352 x 480, 720 x 480
H.264	176 x 120, 352 x 240, 720 x 480

Note: The resolutions attained depend on the data transmission rate.

996-3.5.9 Serial Interface: Hardware-based DVEs provide a minimum of one serial data interface that support EIA/TIA-232 and TIA-422. The serial ports support data rates up to 115 kbps; error detection procedures utilizing parity bits (i.e., none, even, and odd); and stop bits (1 or 2).

Hardware-based DVEs provide a TCP/IP interface to their serial port using a network socket connection with configurable IP address and port number. Serial interface ports may utilize RJ-45 connectors, D-sub connectors, or screw terminals.

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996-3.5.10 Network Interface: The DVE/DVD LAN connection supports the requirements detailed in the IEEE 802.3 standard for 10/100 Ethernet connections. The DVE/DVD has a minimum of one Ethernet port, which shall be a 10/100 Base TX connection or a 100 Base FX ST, SC, LC or FC interface. The connector complies with applicable EIA and TIA requirements. Copper-based network interface ports shall utilize RJ-45 connectors. Fiber ports are single mode with a minimum link budget of 30 dB.

The network communication conforms to UDP, Version 4 of the Internet Protocol (IP) and IGMP Version 2.

996-3.5.11 Front Panel Status Indicators: DVEs and DVDs have LED displays, Liquid Crystal Displays (LCDs), or similar illuminated displays to indicate status for power and data activity.

996-3.5.12 Configuration and Management: DVEs and DVDs shall support local and remote configuration and management. Configuration and management functions shall include access to all user-programmable features, including but not limited to addressing, serial port configuration, video settings, device monitoring, and security functions. DVE and DVD support configuration and management via serial login, telnet login, web browser, or Simple Network Management Protocol (SNMP).

996-3.5.13 Mechanical Requirements: Do not use self-tapping screws on the exterior of the assembly. All equipment uses parts made of corrosion-resistant materials, such as plastic, stainless steel, anodized aluminum, brass, or gold-plated metal.

996-3.5.14 Electrical Requirements: All equipment operates on a nominal voltage of 120 V_{AC}. If the device requires operating voltages of less than 120 V_{AC}, supply the appropriate voltage converter.

996-3.5.15 Environmental Requirements: DVEs and DVDs installed in roadside cabinets shall perform all required functions during and after being subjected to the environmental testing procedures described in NEMA TS 2-2021, Sections 2.2.7, 2.2.8, and 2.2.9. Hardware DVD installed in a climate-controlled environment, such as a TMC computer room, has an operating temperature range of 32 to 104°F.

996-3.6 Media Converter:

996-3.6.1 Description: The media converter connects different transmission media for the purposes of transmitting Ethernet data.

996-3.6.2 Network Interface: The media converter LAN connection supports the requirements detailed in the IEEE 802.3 standard for 10/100 Ethernet connections. The media converter has a minimum of one Ethernet port, which shall be, at a minimum, a 10/100 Base TX connection or a 100 Base FX ST, SC, LC or FC interface. The connector complies with applicable EIA and TIA requirements. Copper-based network interface ports utilize RJ-45 connectors. Fiber ports are single mode with a minimum link budget of 30 dB.

996-3.6.3 Mechanical Requirements: Every conductive contact surface or pin shall be gold-plated or made of a noncorrosive, nonrusting, conductive metal. Do not use self-tapping screws on the exterior of the assembly. All parts shall be made of corrosion-resistant materials, such as plastic, stainless steel, anodized aluminum, brass, or gold-plated metal.

996-3.6.4 Electrical Requirements: Ethernet to coax media converters shall operate using Power Over Ethernet (POE). Media converters shall operate on a nominal voltage of 120 V_{AC} if POE is unavailable. Supply an appropriate voltage converter for devices that require operating voltages of less than 120 V_{AC}. Ensure that the media converter has diagnostic LEDs, including link, TX, RX, and power LEDs.

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996-3.6.5 Environmental Requirements: Ensure media converters perform all required functions during and after being subjected to the environmental testing procedures described in NEMA TS 2-2021, Sections 2.2.7, 2.2.8, and 2.2.9.

996-4 Grounding and Lightning Protection.

996-4.1 General: Surge Protective Devices for traffic control devices, including intelligent transportation system (ITS), shall be listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6.

996-4.2 Surge Protective Device:

996-4.2.1 Description: Surge Protective Devices (SPDs) protect electronics from lightning, transient voltage surges, and induced current.

996-4.2.2 SPD for 120 Volt or 120/240 Volt Power: The SPD shall include L-N, L-G, and N-G protection and have a maximum surge current rating of 50 kA per phase or greater. The SPD shall meet the requirements of UL 1449, Third Edition and be listed by a NRTL.

The SPD shall have a visual indication system that monitors the weakest link in each mode and shows normal operation or failure status and also provides one set of normally open (NO)/normally closed (NC) Form C contacts for remote alarm monitoring. The enclosure for a SPD shall have a NEMA 4 rating.

996-4.2.3 SPD at Point of Use: The SPD shall comply with the minimum functional requirements shown in Table 996-3. The units shall be rated at 15 or 20 amps load and are configured with receptacles.

The units shall have internal fuse protection and provide common mode (L+N-G) protection.

996-4.2.4 SPD for Low-Voltage Power, Control, Data and Signal Systems: The SPD devices shall comply with the minimum functional requirements shown in Table 996-3 for all available modes (i.e., power L-N, N-G; L-G, data and signal center pin-to-shield, L-L, L-G, and shield-G where appropriate).

Table 996-3

SPD Minimum Requirements

Circuit Description	Clamping Voltage	Data Rate	Surge Capacity	Maximum Let-Through Voltage
12 V_{DC}	15-20 volts	N/A	5kA per mode (8x20 µs)	<150 Vpk
24 V_{AC}	30-55 volts	N/A	5kA per mode (8x20 µs)	<175 Vpk
48 V_{DC}	60-85 volts	N/A	5kA per mode (8x20 µs)	<200 Vpk
120 V_{AC} at POU	150-200 volts	N/A	20kA per mode (8x20 µs)	<550 Vpk

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Table 996-3				
SPD Minimum Requirements				
Circuit Description	Clamping Voltage	Data Rate	Surge Capacity	Maximum Let-Through Voltage
Coaxial Composite Video	4-8 volts	N/A	10kA per mode (8x20 µs)	<65 Vpk (8x20 µs/1.2x50µs; 6kV, 3kA)
RS422/RS485	8-15 volts	10 Mbps	10kA per mode (8x20 µs)	<30 Vpk
T1	13-30 volts	10 Mbps	10kA per mode (8x20 µs)	<30 Vpk
Ethernet Data	7-12 volts	1 Gbps	1kA per mode (10x1000 µs)	<30 Vpk
PoE	60-70 volts	1 Gbps	5kA per mode (8x20 µs)	<200Vpk (100kHz 0.5µs; 6kV, 500A)
PoE+, PoE++	<150	1 Gbps	1kA L-G (8x20 µs)	<350V

SPDs for PoE, PoE+, and PoE++ applications shall meet IEEE 8802-3.

The SPDs shall meet the requirements of UL 497B or UL 497C, as applicable, and are listed by a NRTL.

996-4.2.5 Mechanical Specifications: All parts shall be made of corrosion-resistant materials, such as plastic, stainless steel, anodized aluminum, brass, or gold-plated metal.

996-4.2.6 Environmental Specifications: The SPDs shall operate properly during and after being subjected to the temperature and humidity test described in NEMA TS 2-2021, Section 2.2.7, and the vibration and shock tests described in NEMA TS 2-2021, Sections 2.2.8 and 2.2.9.

996-5 Pull and Splice Boxes.

996-5.1 General: Pull and splice boxes shall be listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6.

The box bodies and covers shall be free of flaws such as cracks, sharp, broken, or uneven edges, and voids.

Ensure in-ground boxes have an open bottom design.

996-5.2 Marking: The following information shall be permanently cast or engraved into the top surface of all pull and splice box covers. If used, identification plates shall be UV stable, mechanically fastened, bonded with adhesive material suitable for outdoor applications, and capable of installation in the field

1. Mark application as follows:

FDOT TRAFFIC SIGNAL for signalized intersections
FDOT FIBER OPTIC CABLE for fiber optic cable
FDOT LIGHTING for highway lighting
FDOT TRAFFIC MONITORING for traffic monitoring

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2. Manufacturer's name or logo
3. FDOT APL approval number
4. TIER rating

The date of manufacture (month/day/year, or date code) shall be permanently located on the top or bottom of the cover. The interior of the box body shall have a permanent marking that includes the manufacturer part/model number and date of manufacture near the top of box in a location that is visible after installation when the cover is removed.

996-5.3 Dimensions: For signalized intersection and lighting applications, pull boxes with nominal cover dimensions of 13 inches wide by 24 inches long or larger and no less than 12 inches deep shall be provided. The inside opening area shall be a minimum of 240 square inches and no inside dimension shall be less than 12 inches.

For fiber optic cable applications, pull boxes with nominal cover dimensions of 24 inches wide by 36 inches long or larger and no less than 24 inches deep shall be provided.

Rectangular splice boxes with nominal cover dimensions of 30 inches wide by 60 inches long or larger and no less than 36 inches deep shall be provided. Round splice boxes with a nominal cover diameter of 36 inches or larger and no less than 36 inches deep shall be provided.

996-5.4 Fabrication: Box covers shall be constructed of concrete, polymer concrete or other materials meeting the requirements of this Section.

Box covers with lifting slots and a flush-seating lockdown mechanism shall be provided. Penta-head or other non-standard, security type lockdown lag bolts shall be used. Lockdown bolts and lifting slots shall be Type 316, 304, or 302 passivated stainless steel or brass. Lockdown bolt assembly shall be designed to prevent seizing and can be removed without damaging the cover or box body. The lockdown bolt threaded insert/nut assembly shall be field replaceable.

996-5.5 Testing Requirements: Pull and splice boxes shall meet or exceed the American National Standards Institute/Society of Cable Telecommunications Engineers (ANSI/SCTE) 77 2017 Specification for Underground Enclosure Integrity for TIER 15 loading requirements with the following additional clarifications and requirements:

1. Apply all environmental tests to the box and its cover.
2. All flexural testing shall be conducted in accordance with an appropriate ASTM standard and clearly stated in the report.
3. Perform repetitions of Cycle 1 in Table X2.1 of ASTM G154 for a minimum duration of 1000 hours for the simulated sunlight exposure test.
4. Use deflection-measuring devices positioned to measure vertical and lateral deflection (wherever maximum deflection occurs) for the vertical sidewall load test.
5. Conduct the lateral sidewall pressure, vertical sidewall load and cover vertical load tests without any removable or permanent wall to wall supporting beams located in the interior or top of the box opening.

When testing pull and splice boxes of various sizes (width x length x depth), the cover impact test, internal equipment protection test, coefficient of friction test, and all environmental tests, can be completed using a single representative box/cover (instead of samples from all box/cover sizes) as long as the test report indicates the following:

1. Materials of construction, compositions, and manufacturing processes are identical for all box and cover sizes submitted for listing on the APL.

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2. Size (width x length x depth) of the representative box/cover.

996-6 Camera Lowering Device.

996-6.1 General: Camera lowering devices shall be listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6.

The lowering device shall provide the electrical connection between the control cabinet and the equipment installed on the lowering device without reducing the function or effectiveness of the equipment. The lowering device system support arm shall be capable of withstanding service tension and shear up to 1 kip minimum.

The lowering device shall include a disconnect unit and power, data, and video cables (as applicable) for connecting equipment, a divided support arm, pole attachment provisions, a rotatable pole-top tenon, and a pole-top junction box.

All external components shall be made of corrosion-resistant materials that are powder-coated, galvanized, or otherwise protected from the environment. All finished castings shall have a smooth finish free from cracks, blow-holes, shrinks, and other flaws. All roller fairlead frames shall be corrosion resistant stainless steel or aluminum. All pulleys used in the lowering device and portable lowering tool shall have sealed, self-lubricated or oil-tight bearings, or sintered bronze bushings.

A minimum of 100 feet of composite power and signal cable prewired to the lowering device at the factory shall be provided. Splices will not be allowed.

Lowering devices shall be designed to withstand the design wind speeds defined in the Department's Structures Manual.

996-6.2 Equipment Connection Box: A 1-1/2 inch National Pipe Thread (NPT) pipe connection point and pipe for attaching a camera shall be included. The pipe between the connection box and camera shall be aluminum. The equipment connection box shall have an ingress protection rating of no less than IP55.

996-6.3 Disconnect Unit: The disconnect units shall have a minimum load capacity of 600 pounds with a 4:1 safety factor and be capable of securely holding the lowering device and any installed equipment. Fixed and movable components of the disconnect unit shall have a locking mechanism between them, with at least two mechanical latches for the movable assembly. The fixed unit shall have a heavy-duty cast tracking guide that allows latching in the same position each time. The load shall be transferred from the lowering cable to the mechanical latches when the system is in the latched position. Interface and locking components shall be constructed of stainless steel or aluminum.

996-6.3.1 Disconnect Unit Housing: The disconnect unit housing shall be weather-proof with an ingress protection rating of no less than IP55.

996-6.3.2 Connector Block: Modular, self-aligning and self-adjusting female and male socket contact halves in the connector block shall be provided. Equip the lowering device with enough contacts to permit operation of all required functions of the camera, up to a maximum of 20 contacts and include at least two spare contacts. Contact connections between the fixed and movable lowering device components that are capable of passing EIA-232, EIA-422, EIA-485, and Ethernet data signals and 1 volt peak to peak (Vp-p) video signals, as well as 120 V_{AC}, 9-24 V_{AC}, and 9-48 V_{DC} power shall be provided. The lowering device connections shall be capable of carrying the signals, voltages, and current required by the devices connected to them under full load conditions.

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Only corrosion-resistant stainless steel hardware shall be used. male contacts used for grounding shall mate first and break last. All contacts and connectors shall be self-aligning and self-adjusting mechanical systems. A spring-assisted contact assembly to maintain constant pressure on the contacts when the device is in the latched position shall be provided.

Connector pins made of brass- or gold-plated nickel, or gold-plated copper shall be provided.

Current-carrying male and female contacts shall be a minimum of 0.09 inch in diameter and firmly affixed to the connector block. Ensure mated connectors do not allow water penetration.

996-6.4 Lowering Tool: A portable metal-frame lowering tool manufactured of corrosion-resistant materials with winch assembly and a cable with a combined weight less than 35 lbs that is capable of securely supporting itself and the load shall be provided. The lowering tool shall include a quick release cable connector, and a torque limiter that will prevent over-tensioning of the lowering cable and be equipped with gearing that reduces the manual effort required to operate the lifting handle to raise and lower a capacity load. Ensure that the lowering tool can be powered using a 1/2-inch chuck, variable-speed reversible industrial-duty electric drill capable of matching the manufacturer-recommended revolutions per minute. An adapter with a clutch mechanism and torque limiter for use with the drill shall be provided.

The winch assembly shall have a minimum drum size width of 3.75 inches and a positive braking mechanism to secure the cable reel during raising and lowering operations, and to prevent freewheeling. The lowering cable shall wind evenly on the winch drum during operation. Provide a manual winch handle that incorporates a non-shear pin type torque limiter that can be used repeatedly and will not damage the lowering system.

Provide a minimum of one lowering tool and any additional tools required to operate the lowering device.

996-6.5 Lowering Cable: The lowering cable shall be 0.125-inch minimum diameter Type 316 stainless steel aircraft cable (7 strands x 19 gauge) with a minimum breaking strength of 1,760 pounds. Additionally, the lowering cable assembly (as installed with thimble and crimps on one end and a cable clamp inside the latch on the lowering device end), shall have a minimum breaking strength of 1,760 lbs.

All lowering cable accessories, such as connecting links, shall have a minimum workload rating that meets or exceeds that of the lowering cable.

Prefabricated components for the lift unit support system shall prevent the lifting cable from contacting the power or video cables.

996-6.6 Wiring: All wiring must meet NEC requirements.

996-6.7 External-Mount Lowering System Enclosure for Mounting to Existing Structures: The system shall include an upper mounting/junction box, winch assembly and all external conduit and cabling necessary for mounting to existing structures.

A NEMA 4 rated lower lockable pole-mounted cabinet, constructed of corrosion-resistant 5052 sheet aluminum with a minimum thickness of 1/8 inch, to house the winch assembly shall be provided. The cabinet shall allow for unobstructed operation of the winch, access for servicing and provide sufficient clear area for operation of the winch manually and with an electric drill. The outside surface of the cabinet shall have a smooth, uniform natural aluminum finish. All inside and outside edges of the winch cabinet shall be free of burrs, and all welds must be neatly formed, free of cracks, blow holes, and other irregularities. Cabinet hinges

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shall be vandal-resistant and constructed of 14 gauge stainless steel or 1/8 inch aluminum with stainless steel hinge pins.

The cabinet door shall be double-flanged and include neoprene closed-cell gaskets permanently secured on the interior door surfaces that contact the door opening. The cabinet door shall not sag. Include a pin tumbler lock keyed for use with a No. 2 key and two keys. The cabinet door handle shall include a lock hasp that will accommodate a padlock with a 7/16-inch diameter shackle.

The upper mounting/junction box shall include a maintenance access door with captive attachment hardware. All necessary mounting hardware, conduits, standoffs, and conduit mounts required for a complete and functional system shall be provided.

The external conduit shall be galvanized Schedule 40 with National Pipe Thread Taper (NPT) threads and have a minimum ID of 3 inches at the lower winch cabinet entrance and allow the lowering cable to wind evenly on the winch drum without binding. All conduit couplings and connections between the pole-mounted cabinet and upper mounting/junction box shall be watertight.

996-7 Traffic Control System Auxiliaries.

996-7.1 General: Traffic Control System Auxiliaries shall be listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6.

996-7.2 Uninterruptible Power Supply (UPS): The UPS shall be either a line interactive or online/double-conversion UPS. UPS assemblies shall be designed for installation in a roadside NEMA 3R enclosure to provide battery backup functionality for traffic control systems, including traffic signal and intelligent transportation system (ITS) devices. UPS assemblies shall include batteries provided by the UPS manufacturer or in accordance with manufacturer's requirements.

Loss of utility power, transfer from utility power to battery power, and transfer back to utility power shall not interfere with normal operation of connected equipment. In the event of UPS failure or battery depletion, connected equipment shall be energized automatically upon restoration of utility power.

The UPS shall operate in hot standby mode with power transfer being accomplished in 40 milliseconds or less.

Removal and replacement of the UPS shall not disrupt the operation of the equipment being protected.

All harnesses necessary to connect and operate the system shall be included. All connectors shall be keyed to prevent improper connection.

996-7.2.1 Configuration and Management: The UPS shall support local and remote configuration and management, including access to all user-programmable features as well as alarm monitoring, event logging, and diagnostic utilities.

Configuration and management functions shall be password protected.

Alarm function monitoring shall include the following: loss of utility power, inverter failure, low battery, voltage, and temperature out of range. The UPS shall include an event log that indicates the date and time of the following events: AC high, AC low, AC frequency error, AC fail/blackout, and over temperature. The UPS event log shall be able to store a minimum of 60 events.

The UPS shall include a front panel display and controls that allows programming of configurable parameters, features, and functions without the need for another

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input device. The UPS shall have visual indications for Power-On, Mode of Operation (utility power or inverter), Battery Status, Alarm Status, Load Levels, and AC Output Voltage.

996-7.2.2 Communication Interfaces: The UPS shall include an Ethernet port (RJ45) for local control using a laptop PC and remote control via a network connection.

996-7.2.3 Batteries: Batteries must be provided by the UPS manufacturer or in accordance with manufacturer's recommendations. Batteries shall be sealed and require no maintenance, cause no corrosion, and be capable of maintaining 80% of original capacity and performance for a minimum of five years.

The UPS shall be supplied with a wiring harness for battery connections. The battery wiring harness shall allow 6 feet of separation between the UPS and its battery bank. Battery terminals shall include a protective covering to prevent accidental spark or shorting.

The UPS shall include battery management functions that includes active or equalized balancing; monitoring of temperature, voltage, and amperage of charge and discharge; and temperature compensated automatic charging to maximize the life of the batteries.

996-7.2.4 Electrical: UPS assemblies used to provide backup power in an ITS cabinet shall provide a minimum of 350 watts (at 120 V_{AC}) of continuous backup power for a minimum of two hours.

UPS assemblies used to provide backup power in a traffic signal controller cabinet shall provide a minimum 400 watts (at 120 V_{AC}) of continuous power for a minimum of 6.5 hours.

Frequency shall be regulated to 60 Hz, plus or minus 0.5 Hz, while the UPS is supplying power. The UPS shall operate on 85 to 140 V_{AC} without requiring assistance from the batteries.

The UPS shall be listed to the requirements of UL 1778. Upstream back feed voltage from the UPS shall be less than 1 $V_{AC.}$

Double-conversion UPS shall be capable of simultaneously producing fully regenerated and regulated, conditioned, True Sine Wave power and hot standby AC output, and have a minimum operating efficiency of 90%.

996-7.2.5 Traffic Signal UPS Cabinet: Cabinets used to house traffic signal UPS assemblies shall be designed to be mounted to the side of a traffic cabinet or base mounted. Cabinets shall meet the requirements of Section 676 and include shelves and rack rails to house all UPS system components including the UPS, batteries, harnesses, switches, surge protective device, power terminal block and a generator hookup with transfer switch. The UPS cabinet shall allow a maintenance technician to safely insert power for traffic signal operation while the UPS or associated equipment is serviced or replaced.

A surge protective device shall be installed where the supply circuit enters the cabinet in accordance with Section 620-2.

The cabinet shall include a 20 A, 120 volt, 60 Hz GFCI receptacle. The receptacle shall be wired to utility power and not regulated by the UPS module. The cabinet shall include a main breaker and a breaker for the technician GFCI outlet.

996-7.2.5.1 Transfer Switch and Generator Access Panel: The cabinet shall include an automatic transfer switch and generator access panel in accordance with Section 676. The generator access door shall not protrude more than 1 inch when closed.

996-7.2.6 Mechanical: All parts shall be made of corrosion-resistant materials such as plastic, stainless steel, anodized aluminum, brass, or gold-plated metal. All fasteners exposed to the elements shall be Type 304 or 316 passivated stainless steel.

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996-7.2.7 Environmental: UPS assemblies, including batteries, shall provide continuous power with specified wattage and operate properly during and after being subjected to the environmental testing procedures described in NEMA TS 2-2021, Sections 2.2.7, 2.2.8, and 2.2.9.

996-7.3 Remote Power Management Unit (RPMU): The RPMU shall be designed for installation in a roadside Traffic Cabinet to provide remote control of electrical receptacles.

996-7.3.1 Configuration and Management: Provide a RPMU that supports local and remote configuration and management, including access to all user-programmable features as well as alarm monitoring, event logging, and diagnostic utilities.

Configuration and management functions shall be password protected.

The RPMU shall include an event scheduler that can store a minimum of 60 events.

The RPMU shall include LED indicators for relay inputs and outlet status.

Upon loss of communications the RPMU shall maintain each receptacle and relay in its currently stored state of operation.

Upon restoration of electrical power after an outage the RPMU shall automatically restore each receptacle and relay to its previously stored state of operation and all configurable parameters shall be retained.

The unit shall support SNMP v2c, including trap notifications of receptacle state changes.

996-7.3.2 Communication Interfaces: The RPMU shall have an Ethernet port (RJ45) for local control using a laptop PC and remote control via a network connection.

996-7.3.3 Electrical: The RPMU shall have a minimum of 6 NEMA 5-15R receptacles, nominal 120 V_{AC}. The RPMU shall have a minimum current capacity of 12 amperes (amps).

996-7.3.4 Mechanical: All parts shall be made of corrosion-resistant materials such as plastic, stainless steel, anodized aluminum, brass, or gold-plated metal. All fasteners exposed to the elements shall be Type 304 or 316 passivated stainless steel.

996-7.3.5 Environmental: The RPMU shall operate properly during and after being subjected to the environmental testing procedures described in NEMA TS 2-2021, Sections 2.2.7, 2.2.8, and 2.2.9.

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SECTION 997
TRAFFIC MONITORING SITE MATERIALS

997-1 Description.

This Section governs the requirements for all traffic monitoring site (TMS) material as shown in the Plans and Standard Plans.

Provide products compatible with all other TMS APL equipment. Any electronics unit or software submitted for approval must be compatible with or convert the data into a format compatible with the Department's polling and processing software. Any substitute software modules submitted must be tested and approved by the Department.

Provide products constructed of corrosion-resistant materials, such as plastic, stainless steel, anodized aluminum, brass, or gold-plated metal. All fasteners exposed to the elements shall be Type 304 or 316 passivated stainless steel.

Provide warranties that are fully transferrable to the Department. Terms and conditions of warranties must be documented when submitting a request to the Department for certification. Include terms for a specified service performance with provisions for repair parts and labor, or for replacement.

Ensure the terms and conditions define the equipment installation date as the date for such warranty to be in effect. The installation date for construction projects is the day the site is accepted by the Engineer. For warehouse purchases, the installation date is the date of visual inspection approval, not to exceed ten days after delivery date.

Furnish replacements within 10 calendar days of notification for any part or equipment found to be defective during the warranty period at no cost to the Department.

997-1.1 Approved Product List Submittal Requirements: All products shall be listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their product for inclusion on the APL shall submit an application in accordance with Section 6 including documentation identified in Table 997-1 and this section. Documentation must demonstrate that the product meets the requirements of this Section.

Table 997-1

Documentation	Requirements
Technical Data Sheets	This document will be used to verify physical and performance properties.
Product Label Photo	Provide equipment permanently marked with manufacturer name or trademark, part number, and date of manufacture or serial number.
Product Sample	When requested, submit a product sample.
Installation Manual	Instructions describing mounting, cabling, and configuration.
Product Photo	Display significant features of the products.

997-2 TMS Vehicle Sensors (Non-Weight).

997-2.1 General: Non-weight vehicle sensors include inductive loops, Class II piezoelectric axle sensors, microwave radar, and video data collection technologies.

997-2.2 Wire for Inductive Loops: Materials used in the creation of the inductive loops must meet the material specification of No. 14 AWG International Municipal Signal Association (IMSA) 51-7 wire.

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997-2.3 Class II Piezoelectric Axle Sensor: In-Roadway Class II piezoelectric axle sensors shall meet the physical characteristics in Table 997-2.

Table 997-2 Physical Characteristics, Class II Piezoelectric Axle Sensor	
Property	Requirements
Sensor Element Dimensions	Approximately 6 ft. to 10 ft. in length, 3/16 in. to 3/8 in. in diameter (varies by manufacturer)
Sensor Element Material	Pressure sensing piezoelectric
Pavement Operating Temperature Range	Minimum 0°F to +150°F
Output Signal	Minimum +200mV or produce a charge signal for a FHWA Class 2 Vehicle.
Environmental Requirements	NEMA TS-2, Section 2

997-2.4 Microwave Radar Sensor: Sensors shall meet the physical characteristics in Table 997-3.

Table 997-3 Physical Characteristics, Microwave Radar Sensor	
Property	Requirement
Detection Range	A minimum of 8 distinguishable lanes within a minimum 200 feet of detection zone.
Direction	Bidirectional
Operating Temperature Range	Ambient temperature of 0°F to 140°F
Enclosure Dimensions	Weatherproof aluminum, stainless steel, or polycarbonate housing. Typically, up to 15” X 12” X 6” Weight typically <10 lbs.
Operating Frequency	Wireless transmission in Federal Communications Commission (FCC) approved band or unlicensed RF range.
Communications	RS-232/RS-485 ports, supports minimum 19,200 baud rate.
Data Interface Compatibility	Compatible with the vehicle speed/classification unit and the Department’s traffic polling system.

997-2.5 Video Sensor: Sensors shall meet the physical characteristics in Table 997-4. Cameras shall be compliant with the Code of Federal Regulations Section 200.216 Prohibition on certain telecommunications and video surveillance services or equipment.

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Table 997-4 Performance Characteristics, Video Sensor	
Property	Requirements
Configuration	Displays detection zones, activations, overlaid on live video inputs.
Configuration	Editable detection zone size, placement, and sensitivity. Parameters stored in and retrieved from nonvolatile memory.
Processor	Video analysis, presence detection, data collection, storage and reporting of detection data.
Communications	TIA-232, 10/100 Base TX, FCC certified secure wireless, or cellular compatible with Agency's carrier. Department must approve carrier.
Communications	CDMA compatible
Solid State Detection Output	NEMA TS2, 6.5.2.26
Environmental Requirements	NEMA TS-2, Section 2.

997-3 TMS Non-Motorized Sensors.

997-3.1 General: Non-Motorized sensors include inductive loops, axle sensors, infrared, and video data collection technologies. Non-intrusive non-motorized sensors detect non-motorized vehicles and pedestrians using passive detection.

997-3.2Wire for Inductive Loops for Non-Motorized Data Collection: Materials used in the creation of the inductive loops must meet the material specification of No. 14 AWG International Municipal Signal Association (IMSA) 51-7 wire.

997-3.3 Axle Sensor for Non-Motorized Data Collection: Non-motorized Class I or II axle sensors shall meet the physical characteristics in Table 997-5.

Table 997-5 Physical Characteristics, Non-Motorized Axle Sensor	
Property	Requirements
Sensor Element Dimensions	3 ft. in length, 3/16 in. to 3/8 in. in diameter (varies by manufacturer)
Sensor Element Material	Pressure sensing piezoelectric
Pavement Operating Temperature Range	0°F to +150°F
Output Signal Range	Minimum +34 mV (front axle) and +65mV (rear axle), 220 lbs. Passenger bicycle, at 7.3 MPH
Environmental Requirements	NEMA TS-2-2016, Section 3.

997-3.4 Infrared for Non-Motorized Sensor Data Collection: Non-motorized infrared sensors shall meet the physical characteristics in Table 997-6.

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Table 997-6 Physical Characteristics, Non-Motorized Infrared Sensor	
Property	Requirement
Temperature Sensitivity	2°F from ambient temp.
Detection Range	3 ft. to 18 ft.
Direction	Bidirectional
Operating Temperature Range	-13°F to 120°F

997-3.5. Video Sensor: Sensors shall meet the physical characteristics in Table 997-7. Cameras shall be compliant with the Code of Federal Regulations Section 200.216 Prohibition on certain telecommunications and video surveillance services or equipment.

Table 997-7 Performance Characteristics, Video Sensor	
Property	Requirements
Configuration	Displays detection zones, activations, overlaid on live video inputs.
Configuration	Editable detection zone size, placement, and sensitivity. Parameters stored in and retrieved from nonvolatile memory.
Processor	Video analysis, presence detection, data collection, storage and reporting of detection data.
Communications	TIA-232, 10/100 Base TX, FCC certified secure wireless, or cellular compatible with Agency's carrier. Department must approve carrier.
Solid State Detection Output	NEMA TS2-2021, 6.5.2.26
Environmental Requirements	NEMA TS-2, Section 2.

997-4 TMS Vehicle Sensors (Weight for Motorized Vehicle Data Collection).

997-4.1 General: Weight sensor arrays include inductive loops with strain gauge sensors or quartz piezoelectric sensors.

997-4.2 Wire for Inductive Loop: Materials used in the creation of the inductive loops must meet the material specification of No. 14 AWG International Municipal Signal Association (IMSA) 51-7 wire.

997-4.3 Strain Gauge Sensor: Weigh-In-Motion (WIM) systems utilize plates with strain gauges bonded to the underside or one-piece gauge strip scale. The strain gauge sensors shall meet the physical characteristics in Table 997-8.

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Table 997-8 Physical Characteristics, Strain Gauge Sensor	
Property	Requirements
Sensor Size	.5 in. to 20 in. wide x 50 in. to 80 in. long
Operating Temperature Range	-50°F to 176°F
Scale Capacity	45,000 pounds per axle and overload protected to 8,0000 pounds per axle
Environmental Requirements	NEMA TS-2, Section 2.

997-4.4 Quartz Piezoelectric Sensor: Quartz piezoelectric sensors use one piece quartz crystal sensors to collect Weigh-In-Motion data. The quartz sensor shall meet the physical characteristics in Table 997-9.

Table 997-9 Physical Characteristics, Quartz Piezoelectric Sensor	
Property	Requirements
Measuring Range wheel load (At a referenced tire contact area)	0 to 34000 pounds (8 in. by 12.6 in.)
Overload (twin wheel)	55000 pounds
Sensitivity – Nominal	7.6 ± 12% pC/lbf
Sensitivity shift over sensor length	<± 3%
Threshold	<0.1 lbf
Linearity	<± 2% Full Scale Output
Hysteresis	≤ 2% Full Scale Output
Natural Frequency	> 5 kHz
Operating Temperature range	-40°F to 176°F
Temperature coefficient of sensitivity	-0.04%/°F
Operating Speed	5 MPH to 100 MPH
Insulation resistance	> 100 GΩ
Capacitance with 130 ft. cable	8 to 12 nF
Environmental Requirements	NEMA TS-2, Section 2

997-5 TMS Solar Power Unit for Motorized Data Collection.

997-5.1 General: Solar power unit consists of the following components: solar panel(s) and mounting hardware; 12 V storage battery; and voltage regulator with wiring and associated mounting hardware.

997-5.2 Solar Panel Configured for Nominal 12 V_{DC}: Solar panels cannot have internal voltage regulators and must be capable of multiple arrays and series or parallel wiring configurations. Meet the physical characteristics in Table 997-10:

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Table 997-10 Physical Characteristics, Solar Panel	
Property	Requirements
Peak power range	85 to 300 watts
Voltage	Maximum power voltage greater than 16.5 V at 77°F
Current	Maximum power current greater than 2.85 A at 77°F
Photovoltaic modules construction	Mono or poly-crystalline cells
Efficiency Rating	Minimum 20%
Frame construction	Anodized aluminum
Mounting hardware construction	Anodized, galvanized or stainless-steel

997-5.3 Battery 12 V: Meet the physical characteristics in Table 997-11:

Table 997-11 Physical Characteristics, Battery 12 V	
Property	Requirements
Battery Chemistry	Rechargeable valve regulated lead-calcium gelled electrolyte or absorbed glass mat for photovoltaic applications
Case Construction	ABS Plastic or Polypropylene
Current discharge rate	Minimum of 100 hours at 0.9 amperes
Dimensions	Maximum of 12 inches by 8 inches by 10 inches

997-5.4 Voltage Regulator Configured for Nominal 12 V_{DC}: Meet the physical characteristics in Table 997-12:

Table 997-12 Physical Characteristics, Voltage Regulator	
Property	Requirements
Voltage for battery charging.	Minimum of 13.5 V_{DC}
Begin Charging-Battery Voltage	13.3 V or less
End Charging-Battery Voltage	Maximum of 14.5 V
Quiescent current	Maximum 15 mA
Charge rating	Minimum of 20 A.
Operating Temperature range	Range: 0 to 122°F
Dimensions	Approximately 2 inches by 5 inches by 1 inch.

997-6 TMS Solar Power Unit for Non-Motorized Data Collection.

997-6.1 General: Solar power unit consists of the following components: solar panel(s) and mounting hardware; 12 V storage battery; and voltage regulator with wiring and associated mounting hardware.

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997-6.2 Solar Panel Configured for Nominal 12 V_{DC}: Solar panels cannot have internal voltage regulators and must be capable of multiple arrays and series or parallel wiring configurations. Meet the physical characteristics in Table 997-13.

Table 997-13 Physical Characteristics, Solar Panel	
Property	Requirements
Peak power range	65 to 300 watts
Voltage	Maximum power voltage greater than 16.5 V at 77°F
Current	Maximum power current greater than 2.85 A at 77°F
Photovoltaic modules construction	Mono or poly-crystalline cells
Efficiency Rating	Minimum 20%
Frame construction	Anodized aluminum
Mounting hardware construction	Anodized, galvanized, or stainless steel

997-6.3 Battery 12 V: Meet the physical characteristics in Table 997-14.

Table 997-14 Physical Characteristics, Battery 12 V	
Property	Requirements
Battery Chemistry	Rechargeable valve regulated lead-calcium gelled electrolyte or absorbed glass mat for photovoltaic applications
Case Construction	ABS Plastic or Polypropylene.
Current discharge rate	Minimum of 21 to 100 hours at 0.9 amperes
Dimensions	Maximum of 12 inches by 8 inches by 10 inches

997-6.4 Voltage Regulator Configured for Nominal 12 VDC: Meet the physical characteristics in Table 997-15.

Table 997-15 Physical Characteristics, Voltage Regulator	
Property	Requirements
Charging Voltage	Minimum of 13.5 V_{DC}
Begin Charging- Battery Voltage	13.3 V or less
End Charging- Battery Voltage	Maximum of 14.5 V
Quiescent current	Maximum 15 mA
Charge rating	Minimum of 20 amps
Operating Temperature range	Range: 0 to 122°F
Dimensions	2 inches by 5 inches by 1 inch

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997-7 TMS System Communications Modem.

Meet the physical characteristics in Table 997-16. Modems shall be compliant with the Code of Federal Regulations Section 200.216 Prohibition on certain telecommunications and video surveillance services or equipment.

Table 997-16
Physical Characteristics, TMS Modem

Property	Requirements
Configuration	1.The device shall be field configurable to be powered from 12 VDC. 2.The device shall have the ability and be configured to utilize a network service that shall be at a minimum 4G LTE with fallback to 3G EV-DO.
Protocols: The device shall have the ability to utilize, at a minimum, the following protocols:	1. Network: TCP/IP, UDP/IP, Domain Name System (DNS) 2. Routing: Network Address Translation (NAT), Host Port Routing, DHCP, Point-to-Point Protocol over Ethernet (PPPoE), VLAN, Virtual Router Redundancy Protocol (VRRP), Reliable Static Route. 3. Application: Short Message Service (SMS), Telnet/SSH, Reverse Telnet, Simple Mail Transfer Protocol (SMTP), SNMP, SNTP, Reliable Static Route 4. Serial: TCP/UDP Packet Assembly Disassembly (PAD) Mode, Modbus (ASCII, RTU, Variable), Point-to-Point Protocol (PPP)
Communication Transmission	Code Division Multiple Access (CDMA) capable.
Event Reporting: The device shall have the capability to record and report, at a minimum, the following events in plain text:	1. Network parameters 2. Data usage 3. Power 4. Device temperature 5. Digital input 6. Global Positioning 7. System/Automatic 8. Vehicle Locator (GPS/AVL) 9. Timer
Security: The device shall have the following security provisions:	1. Ability to establish VPN tunnels. 2. IPsec, Secure Sockets Layer (SSL), and Generic Routing Encapsulation (GRE) VPN client 3. Port forwarding and Demilitarized Zone (DMZ) 4. Port filtering 5. Trusted IP 6. MAC address filtering
Operating Temperature range	Minimum 0 to 158°F
FCC Certification	FCC identification number displayed on an external label on the equipment

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Table 997-16 Physical Characteristics, TMS Modem	
Property	Requirements
Number of SIM slots	Minimum of two SIM slots. SIM cards provided by the Department
Minimum Ethernet Port Speed	10/100 Base-TX

997-8 TMS Modem Antenna.

Meet the physical characteristics in Table 997-17.

Table 997-17 Physical Characteristics, TMS Modem Antenna	
Property	Requirements
Antenna Requirements	1. Dual diversity 2. Minimum NEMA rating of NEMA 3 3. Frequencies: F1 = 824 to 896 MHz, F2 = 1850 to 1990 MHz, F3 = 1850 to 1955 MHz, F4 = 1710 to 1770 MHz, F5 = 2110 to 2170 MHz 4. Voltage Standing Wave Ratio (VSWR) of 1.5:1 or less at resonant point 5. 50 Ω nominal impedance 6. Gain of 3.0 dB to 5.15 dB 7. Omni-directional radiation pattern 8. Vertical polarization 9. Glass-filled polypropylene radome 10. Adhesive mounting or Bolt mount 11. SMA male plug connectors 10 ft. (maximum)coaxial length 12. Antenna shall be compatible with the site modem

997-9 TMS Vehicle Speed/Classification Unit.

Vehicle speed/classification units must meet the physical characteristics in Tables 997-18 and 997-19. Unit must be compatible with the Department's polling software as listed in Table 997-20.

Table 997-18 Performance Characteristics, Vehicle Speed/Classification Unit	
Property	Requirements
Operations	Operates in an unattended mode, accumulating and locally storing real-time data allowing for later retrieval by downloading via the polling computer system. Capable of downloading through direct connection, serial or Ethernet, with a PC, without deleting or marking the files.

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Table 997-18 Performance Characteristics, Vehicle Speed/Classification Unit	
Property	Requirements
Compatibility with software	Outputs data compatible with the Department's polling computer system. If non-compatible, then furnish a software module that converts the data into a format compatible with the Department's polling computer system.
Compatibility with sensors	Compatible with the weigh-in-motion sensors, embedded inductive loops, axle sensors, magnetometers and non-intrusive vehicle sensors in place at the Traffic Monitoring Site.
Count and Classification	Capable of determining the count and classification by type and speed of all vehicles for both directions of traffic on the roadway.
Functional Requirements	Capable of receiving input from two 6-foot by 6-foot embedded inductive loops, spaced 12 to 24 feet apart, leading edge to leading edge, with a single axle sensor located between the loops, in each lane of a six lane (minimum) roadway.
Functional Requirements	Capable of collecting data from each of the lanes of traffic in any combination of counts, classification, speed, or direction.
Electrical Components	Electrical components are designed to be solid-state so that they will not be damaged by jolts and vibrations encountered during shipping and everyday use.
Plug-In Modules	The vehicle speed/classification unit may be constructed utilizing plug in modules; however, when plug in modules are used, each vehicle speed/classification unit must be identical except for the number and type of modules used. Ensure that modules of the same type are identical and interchangeable.
Multiple Vehicle Speed/Classification Units in One Cabinet	Ensure that each vehicle speed/classification unit has a unique, individual unit number. The unit number must reside in non-volatile memory, so that it is not changed when a "cold or warm boot" is performed or by a power interruption.
Data Collection Requirement	Capable of obtaining and providing volume, speed, classification, and classification by speed data simultaneously.
Data Collection Requirement	Capable of obtaining and providing volume data by lane.
Data Collection Requirement	Capable of obtaining and providing speed data by lane in a minimum of 15 bins, programmable in 5 mph increments.

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Table 997-18 Performance Characteristics, Vehicle Speed/Classification Unit	
Property	Requirements
Data Collection Requirement	Capable of obtaining and providing Classification by lane in vehicle type by axle class in 15 bins (minimum) in accordance with FHWA Classification Scheme "F" in Florida's Traffic Forecasting Handbook, Chapter 2, Figure 2.2 which can be accessed on the Department's website at the following URL address: https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/planning/systems/systems-management/document-repository/traffic-analysis/2019-project-traffic-forecasting-handbook.pdf?sfvrsn=e105e71d_2.
Data Collection Requirement	Capable of obtaining and providing a minimum of 95% accuracy of vehicle class, speed and volume.
Data Collection Requirement	Capable of providing real-time monitoring of volume data by lane or direction in user selected intervals of as little as 15 minutes, when required, without disrupting the above selected programs
Communications	Capable of communicating directly with a PC or through a modem at a minimum rate of 19,200 bps.
Configuration	At a minimum, the following parameters are programmable by direct connection to the vehicle speed/classification unit by Ethernet or via modem: 1. Six-digit site number. 2. Number of lanes and directions. 3. Date and time. 4. Data operating and transmission parameters. 5. Sensor spacing. 6. Recording interval. 7. Vehicle parameter table with axle spacing ranges for each type of vehicle. 8. Number and range of speed categories, axle and length classifications, and headway.
Sensor Failure	The vehicle speed/classification unit must continue to provide the speed and/or volume from the remaining functioning sensors.
Sensitivity	The sensitivity level for each axle sensor must be individually adjustable using software, by direct PC connection and remotely via
Loop Detector	Loop detectors must be internal and self-tuning. The sensitivity level and any additional parameters necessary to prevent "loop crosstalk" for each embedded inductive loop must be individually adjustable using software, both by direct PC connection and remotely via telemetry.
Time Delay	A time delay, or "de-bounce" value for ignoring spurious axle signals (ghost axles) in the vehicle speed/classification unit software must be provided.

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Table 997-18 Performance Characteristics, Vehicle Speed/Classification Unit	
Property	Requirements
Power	Provide a vehicle speed/classification unit that is field configurable to be powered 12 VDC and does not consume more than a total of 12 watts. If an internal battery is required, it must be capable of being recharged and shall be furnished and included with the vehicle speed/classification unit at no extra cost.
Mechanical	Provide a modular electronics unit which is completely enclosed in a durable housing of sheet metal or cast aluminum with a durable finish. When configured for operation the vehicle speed/classification unit including all cables must fit into a Type III cabinet.
Environmental (Ambient Temperature Range)	Provide an electronics unit which operates as specified when the ambient temperature and humidity inside the controller cabinet are within the following limits: The operating ambient temperature range must be between minus 0 to 140ºF. The rate of change in ambient temperature must not exceed 63ºF per hour, during which the relative humidity must not exceed 90%.
Environmental (Relative Humidity)	Provide an electronics unit which operates as specified when the ambient temperature and humidity inside the controller cabinet are within the following limits: The relative humidity must not exceed 90% over the temperature range of 40 to 109ºF. Above 109ºF, constant absolute humidity must be maintained as seen in Table 997-19. The relative humidity range shown in Table 997-19 is for dynamic testing.

Table 997-19 At 14.6 psi Barometric Pressure		
Dry Bulb ºF	Relative Humidity (%)	Wet Bulb ºF
40	75	37
50	80	46
60	83	57
70	86	66
80	87	77
90	89	88
100	89	97
109	90	108
120	70	109
130	50	109
140	38	109

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Table 997-19 At 14.6 psi Barometric Pressure		
Dry Bulb ºF	Relative Humidity (%)	Wet Bulb ºF
150	28	109
160	21	109
165	18	109

Table 997-20 Performance Characteristics, Vehicle Speed/Classification Unit Polling Software	
Property	Requirements
Operations	Real time polling software operates on a PC using the Department's recommended operating system.
Communications	Communicates with the traffic counter/classifier and downloads data via cellular modem and produces reports of 15 minute, hourly, weekly, monthly and annual volume and classification data.
Configuration	Displays and enters operating parameters into the vehicle class/counter and allowing the display of real-time traffic volumes in addition to routine data collection activities.
Data Storage	Processes and stores all vehicle data retrieved in routine mode, regardless of the selected parameters.

997-10 TMS Vehicle Weigh in Motion Unit.

Weigh in Motion Unit must meet the physical characteristics in Tables 997-21 and 997-22. Polling software must meet the requirements in Table 997-23.

Table 997-21 Performance Characteristics, Vehicle Weigh in Motion Unit	
Property	Requirements
Operations	Operates in an unattended mode, accumulating data and locally storing real-time data allowing for later retrieval by downloading via the polling computer system. Capable of downloading through direct connection with a PC, without deleting or marking the files.
Compatibility with software	Outputs data compatible with the Department's polling computer system. If non-compatible, then furnish a software module that converts the data into a format compatible with the Department's polling computer system.
Compatibility with sensors	Compatible with the weigh-in-motion sensors, embedded inductive loops, axle sensors, and non-intrusive vehicle sensors in place at the Traffic Monitoring Site.
Count and Classification	Capable of determining the count and classification by type and speed of all vehicles for both directions of traffic on the roadway.
Functional Requirements	Capable of receiving input from a 6-foot by 6-foot (or 6-foot by 8-foot) embedded inductive loop, with four single WIM axle sensors located outside the loop, in each WIM lane of a six lane (minimum) roadway.

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Table 997-21 Performance Characteristics, Vehicle Weigh in Motion Unit	
Property	Requirements
Functional Requirements	Capable of collecting data from each of the lanes of traffic in any combination of Weight, counts, classification, speed, or direction.
Electrical Components	Electrical components are designed to be solid-state so that they will not be damaged by jolts and vibrations encountered during shipping and everyday use.
Plug-In Modules	The vehicle Weigh in Motion unit may be constructed utilizing plug-in modules; however, when plug in modules are used, each vehicle Weigh in Motion unit must be identical except for the number and type of modules used. Ensure that modules of the same type are identical and interchangeable.
Multiple Vehicle Speed/Classification Units in One Cabinet	Ensure that each vehicle Weigh in Motion unit has a unique, individual unit number. The unit number must reside in non-volatile memory, so that it is not changed when a “cold or warm boot” is performed or by a power interruption.
Data Collection Requirement	Capable of obtaining and providing Weight, volume, speed, classification, and classification by speed data simultaneously.
Data Collection Requirement	Capable of obtaining and providing volume data by lane.
Data Collection Requirement	Capable of obtaining and providing speed data by lane in a minimum of 15 bins, programmable in 5 mph increments.
Data Collection Requirement	Capable of obtaining and providing Classification by lane in vehicle type by axle class in 15 bins (minimum) in accordance with FHWA Classification Scheme “F” in Florida’s Traffic Forecasting Handbook, Chapter 2, Figure 2.2 which can be accessed on the Department’s website at the following URL address: https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/planning/systems/systems-management/document-repository/traffic-analysis/2019-project-traffic-forecasting-handbook.pdf?sfvrsn=e105e71d_2.
Data Collection Requirement	Capable of obtaining and providing a minimum of 95% accuracy of vehicle weight, class, speed, and volume.
Data Collection Requirement	Capable of providing real-time monitoring of volume data by lane or direction in user selected intervals of as little as 15 minutes, when required, without disrupting the above selected programs
Communications	Capable of communicating directly with a PC or through a modem at a minimum rate of 19,200 bps.

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Table 997-21 Performance Characteristics, Vehicle Weigh in Motion Unit	
Property	Requirements
Configuration	At a minimum, the following parameters are programmable by direct connection to the Weigh in Motion unit by Ethernet or via modem: 1. Six-digit site number. 2. Number of lanes and directions. 3. Date and time. 4. Data operating and transmission parameters. 5. Sensor spacing. 6. Recording interval. 7. Vehicle parameter table with axle spacing ranges for each type of vehicle. 8. Number and range of speed categories, axle and length classifications, and headway.
Sensor Failure	The Weigh in Motion unit must continue to provide the speed and/or volume from the remaining functioning sensors.
Sensitivity	The sensitivity level for each axle sensor must be individually adjustable using software, by direct PC connection and remotely via telemetry.
Loop Detector	Loop detectors must be internal and self-tuning. The sensitivity level and any additional parameters necessary to prevent “loop crosstalk” for each embedded inductive loop must be individually adjustable using software, both by direct PC connection and remotely via telemetry.
Time Delay	A time delay, or “de-bounce” value for ignoring spurious axle signals (ghost axles) in the vehicle speed/classification unit software must be provided.
Power	Provide a vehicle Weigh in Motion unit that is field configurable to be powered 12 VDC and does not consume more than a total of 12 watts. If an internal battery is required, it must be capable of being recharged and shall be furnished and included with the vehicle Weigh in Motion unit at no extra cost.
Mechanical	Provide a modular electronics unit which is completely enclosed in a durable housing of sheet metal or cast aluminum with a durable finish. When configured for operation the Weigh in Motion unit including all cables must fit into a Type III cabinet.
Environmental (Ambient Temperature Range)	Provide a Weigh in Motion unit which operates as specified when the ambient temperature and humidity inside the controller cabinet are within the following limits: The operating ambient temperature range must be between minus 0 to 140ºF. The rate of change in ambient temperature must not exceed 63ºF per hour, during which the relative humidity must not exceed 90%.

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Table 997-21 Performance Characteristics, Vehicle Weigh in Motion Unit	
Property	Requirements
Environmental (Relative Humidity)	Provide a Weigh in Motion unit which operates as specified when the ambient temperature and humidity inside the controller cabinet are within the following limits: The relative humidity must not exceed 90% over the temperature range of 40 to 109ºF. Above 109ºF, constant absolute humidity must be maintained as seen in Table 997-22. The relative humidity range shown in Table 997-22 is for dynamic testing.

Table 997-22 At 14.6 psi Barometric Pressure		
Dry Bulb ºF	Relative Humidity (%)	Wet Bulb ºF
40	75	37
50	80	46
60	83	57
70	86	66
80	87	77
90	89	88
100	89	97
109	90	108
120	70	109
130	50	109
140	38	109
150	28	109
160	21	109
165	18	109

Table 997-23 Performance Characteristics, Department's Weigh in Motion Unit Polling Software	
Property	Requirements
Operations	Real time polling software operates on a PC using the Department's recommended operating system.
Communications	Communicates with the Weigh in Motion unit and downloading data via cellular modem and producing reports of 15 minute, hourly, weekly, monthly, and annual volume, weight, and classification data.

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Table 997-23 Performance Characteristics, Department's Weigh in Motion Unit Polling Software	
Property	Requirements
Configuration	Displays and enters operating parameters into the vehicle Weigh in Motion unit and allows the display of real-time traffic volumes in addition to routine data collection activities.
Data Storage	Processes and stores all vehicle data retrieved in routine mode, regardless of the selected parameters.

997-11 TMS Non-Motorized Data Collection Units.

Non-Motorized data collection units must meet the physical characteristics in Tables 997-24. Polling software must meet the requirements in Table 997-25.

Table 997-24 Performance Characteristics, Classification Unit	
Property	Requirements
Operations	Operates in an unattended mode, accumulating data for later retrieval by downloading via the polling computer system. Capable of downloading through direct connection with a PC, without deleting or marking the files.
Operations	Non-motorized unit operating procedures.
Compatibility with software	Outputs data compatible with the Department's polling computer system. If non-compatible, then furnish a software module that converts the data into a format compatible with the Department's polling computer system.
Compatibility with sensors	Compatible with the embedded inductive loops, axle sensors, and non-intrusive vehicle sensors in place at the Traffic Monitoring Site.
Count, Speed and Classification	Capable of determining the count and classification (bicycle and pedestrian) by type for all directions of traffic on the sidewalk, side path, bicycle lane, and shared use path.
Functional Requirements	Capable of receiving input from embedded inductive loops, axle sensors, and non-intrusive sensors on the sidewalk, side path, bicycle lane, and shared use path.
Functional Requirements	Capable of collecting data from each direction of bicycle and pedestrian traffic in any combination of counts, classification, or direction.
Electrical Components	Electrical components are designed to be solid-state so that they will not be damaged by jolts and vibrations encountered during shipping and everyday use.

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Table 997-24 Performance Characteristics, Classification Unit	
Property	Requirements
Plug-In Modules	The non-motorized data collection unit may be constructed utilizing plug-in modules; however, when plug in modules are used, each non-motorized data collection must be identical except for the number and type of modules used. Ensure that modules of the same type are identical and interchangeable.
Multiple Classification Units in One Cabinet	Ensure that each non-motorized data collection has a unique, individual unit number. The unit number must reside in non-volatile memory, so that it is not changed when a "cold or warm boot" is performed or by a power interruption.
Data Collection Requirement	Capable of obtaining and providing volume and classification data simultaneously.
Data Collection Requirement	Capable of obtaining and providing volume data by direction.
Data Collection Requirement	Capable of obtaining and providing a minimum of 80% accuracy of non-motorized classification and volume.
Communications	Capable of communicating directly with a PC or through a modem at a minimum rate of 115,200 bps.
Configuration	At a minimum, the following parameters are programmable by direct connection to the classification unit by Ethernet or via modem: 1. Six-digit alphanumeric site number. 2. Bicycle and pedestrian direction of travel. 3. Date and time. 4. Data operating and transmission parameters.
Sensor Failure	The non-motorized data collection unit must continue to provide the volume from the remaining functioning sensors.
Piezo Sensitivity	The sensitivity level for each axle sensor must be individually adjustable using software, by direct PC connection and remotely via telemetry.
Loop Detector	Loop detectors must be internal and self-tuning. The sensitivity level and any additional parameters necessary to prevent "loop crosstalk" for each embedded inductive loop must be individually adjustable using software, both by direct PC connection and remotely via telemetry.
Time Delay	A time delay, or "de-bounce" value for ignoring spurious axle signals (ghost axles) in the classification unit software must be provided.
Power	Provide a non-motorized data collection unit that is field configurable to be powered by 12 VDC and does not consume more than a total of 12 watts. If an internal battery is required, it must be capable of being recharged and shall be furnished and included with the non-motorized data collection unit at no extra cost.

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Table 997-24 Performance Characteristics, Classification Unit	
Property	Requirements
Mechanical	Provide a modular electronics unit which is completely enclosed in a durable housing with a durable finish. When configured for operation the classification unit including all cables must fit into a Type III cabinet or self-contained in the manufacture's housing.
Environmental	Provide an electronics unit which operates as specified when the ambient temperature and humidity inside the controller cabinet are within the following limits: The operating ambient temperature range must be between minus 0 to 140ºF.

Table 997-25 Performance Characteristics of Non-Motorized Data Collection Polling Software	
Property	Requirements
Operations	Polling software operates on a PC using the Department's recommended operating system.
Operations	Software operating procedures.
Communications	Capable of communicating with the non-motorized data collection unit and downloading data via cellular modem and producing reports of hourly, weekly, monthly and annual volume and classification data.
Configuration	Capable of displaying and entering operating parameters into the non-motorized data collection unit and allowing the display of traffic volumes in addition to routine data collection activities.
Data Storage	Capable of processing and storing all non-motorized data retrieved in routine mode, regardless of the selected parameters.

997-12 Adhesive Bonding Agent.

Meet the requirements in Table 997-26.

Table 997-26 Physical Characteristics, Adhesive Bonding Agent	
Property	Requirements
Agent	Flowable mortar-based methyl methacrylate resin
Application	Per manufacturer's instruction.
Curing Time	Less than 60 minutes.
Gel Time	At 77ºF, 13 to 17 minutes
Tensile Strength	Greater than 2,000 psi

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997-13 Loop Sealant for TMS.

Meet the requirements in Table 997-27.

Table 997-27 Physical Characteristics, Loop Sealant	
Property	Requirements
Agent	2-part unsaturated polyester resin utilizing a liquid methyl ethyl ketone peroxide (MEKP) hardener
Application	Per manufacturer's instruction. Hardener component amounts may be adjusted according to temperature and an accelerator is available for use in colder climates to further reduce drying time. Improper mixing may cause poor results.
Curing Time	Less than 60 minutes.
Gel Time	At 77°F, 10 to 25 minutes
Tensile Strength	Greater than 1,000 psi

997-14 TMS Cabinets.

Meet the requirements of Tables 997-28 and 997-29.

Table 997-28 Physical Characteristics, TMS Cabinet	
Property	Requirements
Cabinet Shell Material	0.125-inch-thick sheet aluminum Type 5052-H32
Weld Quality	Exterior seams are continuously welded, smooth, free of cracks, blow holes or other irregularities and the inside and outside edges are free of burrs.
Cabinet Finish	Outside surface of the cabinet has a smooth, uniform, and natural finish and the cabinet top has a sloped surface to prevent accumulation of water.
Cabinet Vent	Vent between the top of the door and the top of the cabinet, covered by screen material with a maximum opening of 0.125 inches.
Cabinet Door Hinge	Continuously hinged door constructed of 14-gauge stainless steel or 0.125 inches aluminum that occupies 80% of the front surface area of the cabinet and is rain and dust tight; hinged on the right side of the cabinet; hinge pin is stainless steel and capped at the top and bottom to deter tampering.
Cabinet Door	Double flanged on all four sides and equip it with a restraint that will hold the door open in the 90 degree and 120-degree position.

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Table 997-28 Physical Characteristics, TMS Cabinet	
Property	Requirements
Cabinet Door Lock	Three point latching system, consisting of the following latch points: (1) Center of the cabinet - latching handle with provisions for a padlock in the center position (2) Top of the cabinet - controlled by the door handle (3) Bottom of the cabinet - controlled by the door handle Ensure that latching points (2) and (3) remain in the locked position until the latching handle is rotated to the unlocked position.
Cabinet Door Vent	Louvered vents meeting the NEMA rod entry test for 3R enclosures. The louvers are covered by a replaceable air filter mounted inside the cabinet door with either brackets or clamps that will allow easy removal and replacement.
Cabinet Shelf	Adjustable shelf, constructed of 0.08 inches thick aluminum, that is adjustable to within 15 inches of the top of the cabinet and to within 26 inches of the bottom of the cabinet in 2 inches increments.

Table 997-29 TMS Cabinet Dimensions			
	Cabinet Dimensions in Inches		
Cabinet Type	Height	Width	Depth
Type III	38”	23”	18”
Type IV	48”	30”	16”
Type V	56”	38”	27”

997-15 TMS Suppression Devices.

997-15.1 Power Suppression Devices: Meet the requirements of Table 997-30.

Table 997-30 Physical Characteristics, Power Suppression Devices	
Property	Requirements
Connector Type	Terminal Strip - plug in or screw type
Voltage	12 – 24 V_{DC}

997-15.2 Sensor Suppression Devices: Meet the requirements of Table 997-31.

Table 997-31 Physical Characteristics, Sensor Suppression Devices	
Property	Requirements
Connector Type	Terminal Strip - plug in or screw type
Voltage	6 V_{DC}

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997-16 TMS Managed Field Ethernet Switch.

Meet the requirements of Table 997-32 and be compliant with the Code of Federal Regulations Section 200.216 Prohibition on certain telecommunications and video surveillance services or equipment.

Table 997-32
General Characteristics, Managed Field Ethernet Switch

Property	Requirements
Layer 2+ Capability	QoS, IGMP, rate limiting, security filtering
Transmission	Full Duplex, Half Duplex Ethernet communications
Error-free Operation	99.999%
Mean Time Between Failures	10 years or 87,600 hours, using Bellcore/Telcordia SR-332 standards
Networking Standards	IEEE 802.1Q, IEEE 802.1P, IEEE 802.3, IEEE 802.3u, IEEE 802.3x,
Optical Ports	Single Mode: 1,310 or 1,550 nanometers. Type ST or LC.
Optical Ports	1000 Base FX, with optical budget of at least 15dB. Minimum of four ports designed for use with two pair of fibers, two strands transmit, the other two strands receive.
Copper Ports	Minimum of four copper ports, Type RJ-45, auto-negotiate (10/100 Base), full duplex. IEEE 802.3 standard pinouts.
Operational Indicators	LEDs showing link, transmit, receive, and power.
Management Capability	Port-based VLAN, VLAN tagging, IEEE 802.1Q, 4-kilobit VLAN address table.
Management Capability	Forwarding/filtering rate at a minimum 14,880 packets per second for 10 megabits per second, and 148,800 packets per second for 100 megabits per second.
Management Capability	Minimum 4 kilobit MAC address table.
Management Capability	Support of, at a minimum, Version 2 of the Internet Group Management Protocol (IGMP).
Management Capability	Support of Secure Shell (SSH) and secure Web-based GUI.
Management Capability	Support of the Simple Network Management Protocol (SNMP) version 1/2/3. Accessible using the EIA-232 management port or telecommunication network.
Management Capability	Support of Remote Authentication Dial-In User Service (RADIUS) or Terminal Access Controller Access-Control System Plus (TACACS+).
Management Capability	Support of remote monitoring (RMON) of the Ethernet agent and the ability to switch monitoring (SMON).

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Table 997-32 General Characteristics, Managed Field Ethernet Switch	
Property	Requirements
Management Capability	Support of Secure Copy (SCP) or Secure File Transfer Protocol (SFTP) and either Network Tim Protocol (NTP) or Simple Network Time Protocol (SNTP).
Management Capability	Supports port mirroring when combined with a network analyzer.
Power Requirements	Compatible with the solar requirements in 997-5.
Power Requirements	Fiber port fail open feature.
Environmental Requirements	NEMA TS 2 2021, Sections 2.2.7, 2.2.8., and 2.2.9.
Data Interface Compatibility	Compatible with the Vehicle Speed/Classification Unit, Weigh-In-Motion Unit, and Non-motorized Data Collection Unit.
Data Interface Compatibility	Compatible with the Department's polling software (TPAS).