June 12, 2002

M E M O R A N D U M

TO: District Structures Design Engineers
(Gerard Moliere, Rod Nelson, Keith Shores, John Danielsen, Neil Kenis, Kim Saing, Jose Rodriguez, Agnes Spielmann)
Area Structures Engineers
(Robert Robertson, Tom Andres, Tony Mireles)

FROM: William N. Nickas, P.E., State Structures Design Engineer

COPIES: Secretary Tom Barry, Assistant Secretary Ken Morefield, District Secretaries (Chris Speer (Acting), Huey Hawkins, Edward Prescott, Rick Chesser, Mike Snyder, Jose Abreu, Ken Hartmann, Jim Ely), Freddie Simmons, Bill Domico, Jack Evans, Bob Nichols, Charles Boyd, Jeff Pouliotte, Andre Pavlov, FHWA, Dick Kane

SUBJECT: Temporary Design Bulletin C0-02-10
Summary of Post Tensioning Improvements
Effective: June 14, 2002

This memorandum effective June 14, 2002 provides a quick reference to proposed improvements discussed in the November 6, 2001 memo extending the Temporary Design Bulletins C00-5 and C01-01 (Post-Tensioning Issues) which review the use of post- tensioning on FDOT projects.

The information and direction contained in Corven's documents "New Directions for Florida Post-Tensioning Bridges, Vols. 1-5" are suggestions for the improvements to current post-tensioning practices. The attached matrix designates which improvements will be implemented by the FDOT and designates the documents where the specific requirements will be incorporated.

The schedule for implementing these modifications and improvements to Post-Tensioning design and construction is:

July 2002: Standards and Developmental Specifications effective and available.
Jan. 2003: Projects bid this date and after must include these post-tensioning requirements.

Jan-Jun 2003: B460 will be Developmental Specification.
July 2003: B460 will become Special Provision Section 462.

If you have any questions or need any additional information on this topic, please contact me at (850) 414-4260 or Larry Sessions at (850) 414-4273.

WNN/rn

Attachment

FDOT POST-TENSIONING POLICY IMPLEMENTATION MATRIX FOR DESIGN BULLETIN DB-C02-10 (DATE: 6/14/02)

	STRATEGIES AND DESCRIPTIONS	PREVIOUS REFERENCE *		Future Policy	SDG July 02	SDG Jan 03	Standards Jan 03	Construction Spec Jan 03	Construction Spec July 03	CPAM	Maintenance	Load Rating
Strategy 1	**Enhanced Post-Tensioning System**											
	Select system from Qualified Product List, etc.	1.A		DB-C02-11	X		X	X		X		
	- Pressure tested system	1.A 1.G						X				
	- mechanical or shrink wrap duct couplers	1.C 1.D					X	X				
	- duct coupler for precast joints	1.A	DB-C01-1									
	Use continuous 3-level corrosion protection system	1.B		DB-C02-11	X		X					
	- min slab thickness	1.B		DB-C02-11	X							
	- minimum duct spacing	1.B		DB-C02-11	X							
	Use plastic ducts per QPL (steel pipe in sharp curves)	1.C		DB-C02-11								
	-Thin members (Beam Webs)			TBD					X			
	-Thick members			DB-C02-11				X				
	Positively seal all duct connections, vents, ports, drains	1.D		DB-C02-11			X	X				
	Use only pre-approved grout to QPL	1.E	DB-C00-5					X				
	Use permanent, heavy duty grout caps	1.F		DB-C02-11			X	X				
	Pressure test ducts prior to grouting	1.G		DB-C02-11				X				
	Duct repair techniques during construction			TBD						X		
Strategy 2	**Fully Grouted Tendons**											
	Anchors accessible for grouting	2.A	DB-C01-1	DB-C02-12	X		X	X		X		
	-No embedded dead end anchors		DB-C02-09,B460		X			X				
	Low point injection / high point venting	2.B	DB-C00-5				X	X				
	Detail Contract Plans to be consistent with FDOT Standards	2.C		DB-C02-12	X		X					
	-Approved integrated shop drawings							X				
	-Contractor's grouting plan							X		X		
	Certified personnel	2.D						X		X		
	-General Contractor's supervisory personnel							X		X		
	-Installation personnel							X		X		
	-Grouting and inspection personnel							X		X		
	Staged grouting procedures		DB-C02-06						X	X		
	Control grouting rates and pressures	2.E		DB-C02-12				X		X		
	Testing of ejected grout (flow cone)	2.F		DB-C02-12				X		X		
	Probe and inspect anchorages and high points (vacuum inject)	2.G	DB-C01-1	DB-C02-12			X	X		X	X	
Strategy 3	**Multi-Layered Anchor Protection**											
	Detail Contract Plans to be consistent with FDOT Standards	3.A		DB-C02-13	X		X					
	-Four level corrosion protection system	3.B		DB-C02-13	X					X		
	-Epoxy grout pour-back						X	X				
	-Use permanent, heavy duty grout caps	1.F					X	X				
	-Use elastomeric coating						X	X				
	Transverse PT protection system	8.1.2		DB-C02-13			X	X				
	Tendons sealed at all times to prevent contamination	3.C	B460				X	X		X		
Strategy 4	**Watertight Bridges**											
	Two faced epoxy joints for segmental construction	4.A	DB-C01-1					X				
	-Deck treatment at precast joints containing shims			DB-C02-14				X		X		
	No permanent tensile stresses (SW, SDL, PT) across joints				X							
	Minimize block-outs and holes in deck	4.B		DB-C02-14	X		X	X				
	-No block-outs into deck for anchorages		SDG,DB-C01-1		X							
	-Seal external surfaces of secondary pours						X	X				
	-MAPC/Methyl Methacrylate						X	X				
	-Epoxy Grout						X	X				
	Crack repair techniques during/after construction			TBD						X	X	
	Deck overlays are not considered a protection barrier			DB-C02-14	X						X	X
	Expansion joint requirements											
	-Show drip notches and flanges on Contract Plans	4.C		DB-C02-14	X		X					
	-Deck drainage shall be addressed			TBD		X					X	
	Bridge Drainage										X	
	-Drainage for bottom slabs to prevent water accumulation	4.D		DB-C02-14	X		X	X		X	X	
	-Deck drainage details			TBD		X					X	
	Restriction on tendon locations in substructure		DB-C00-5		X							
Strategy 5	**Multiple Tendon Paths**											
	Maximize number of tendon paths	5.A										X
	-Maximum tendon sizes by structure type	5.A		TBD								
	-Minimum number of tendons across critical sections	5.A		DB-C02-15	X							
	Operating Rating > 1 with loss of most critical tendon	5.B		TBD								X
	Consideration how to compensate for loss of prestress due to corrosion	5.C		TBD							X	X
	Provisional Post-tensioning requirements for	5.C										
	-Construction adjustments	5.C		DB-C02-15	X							X
	-Future strengthening	5.C		DB-C02-15	X						X	X

* Previous references are provided for information only

Legend X = Document that will require revision as a result of strategy implementation
TBD = Final policy decision to be determined
DB-CXX-X References design bulletins
#.(abc) - References strategies contained in Corven's documents "New Directions for Florida Post-Tensioning Bridges, Vols. 1-5"

INDEX
OF
SPECIFICATIONS

1. **B460 POST-TENSIONING**
   (TO BE RENAMED 462)

2. **939 POST-TENSIONING SYSTEMS**
   (TO BE MERGER INTO 462)

3. **938 POST-TENSIONING GROUT**

4. **940 EPOXY GROUT FOR POST-TENSIONING TERMINI** (TO BE MERGED INTO 926)

5. **950 MAGNESIUM AMMONIUM PHOSPHATE CONCRETE** (TO BE MERGED INTO 930)

6. **956 ELASTOMERIC COATING SYSTEM**
   (CHANGED TO 975)

SECTION B460 Draft June 5, 2002
POST-TENSIONING (to be renamed **462**)

PAGE 468. The following new Section is added after Section 460:

SECTION B460
POST-TENSIONING

B460-1 Gereral.

B460-1.1 Discription

Submit shop and working drawings and manuals in accordance with instructions herein and section 5. The contractor's Speciality Engineer shall produce all shop drawings related to post-tensioning and these drawings shall bear the signature and seal of the responsible engineer.

Furnish and install all post-tensioning systems and any other pertinent items necessary for the particular prestressing system used, including but not limited to ducts, anchorage assemblies and supplementary reinforcement. Furnish all components of a post-tensioning system except strand and bars from one single supplier.

Install prestressing steel, which may be strands or bars, through ducts in the concrete. Stress to a predetermined load and anchor directly against the hardened concrete. Grout ducts to fill all voids and install protection of end anchorages

Conduct all stressing and grouting operations in the presence of the Engineer. Coordinate and schedule all post-tensioning activities to facilitate inspection by the Engineer.

B460-1.2 Technician and Supervisor Qualifications.

B460-1.2.1 Technician Qualifications and Engineer's Inspections

B460-1.2.1Qualifications: *Perform all post-tensioning field operations under the direct supervision (crew foreman) of qualified post-tensioning and grouting technicians that are qualified through the Department's Construction Training Qualification Program (CTQP). For information about how to become qualified, consult the following CTQP website: http://ctqp.ce.ufl.edu. 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. All personnel involved in grouting must attend a grouting training session provided by the Department not less then seven days prior to the start of the first stressing or grouting operation of the project.*

B460-1.2.2 Qualification Requirements for Supervisory Personnel In Charge of Post-tensioning Related (PTR) Operations

B460-1.2.2.1 General: *These qualification provisions are only required for longitudinal superstructure PTR operations and are not required for substructure or transverse superstructure PTR operations. Supervisory personnel must possess experience and licensing that substantiates proficiency in engineering and management of PTR operations. Proof of*

qualifications must be submitted to the Department at the pre-construction conference and PTR operations will not be permitted to begin until the qualifications of supervisory personnel, as set forth herein, have been approved by the Engineer.

B460-1.2.2.2 Failure to comply with Qualification Requirements: *After the project is underway, the Contractor may fail to be in compliance with the provisions of this article due to normal employee turnover. Under this circumstance, the Contractor must make an immediate "Good Faith" effort to reestablish compliance. If a Good Faith effort is not put forth, as determined by the Engineer, payment for the PTR operations that require supervisors to be qualified under this provision will be withheld up to 90 days. If the Contractor is not in compliance after 90 days, regardless of how much Good Faith effort is put forth, PTR operations must cease entirely until compliance is reestablished.*

B460-1.2.2.3 Proof of License: *Contractor personnel that are required to be registered as professional engineers as required herein, must submit a copy of the license renewal notice/card issued by the licensing agency of the state from which they hold registration. The renewal notice/card, or some other official document, must display the license number and must indicate that the license is in force and is current. If not shown on the renewal notice, the telephone number and address of the licensing agency that issued the renewal notice shall be included with the copy of the renewal notice.*

B460-1.2.2.4 Experience Record: *For each bridge project experience period, the following information must be submitted for supervisory personnel in order to substantiate their experience record. The supervisor (engineer, superintendent/manager or foreman) seeking approval must provide a notarized certification statement attesting to the completeness and accuracy of the information submitted.*

(1) Project Identification and Location: *Project owner's name – such as State of Florida -- and identification number for the project as well as the following project location information: state, city, county, highway number and feature intersected such as the St. Johns River. In addition, provide the name and telephone number of an owner's representative.*

(2) **Work Description and Level of Authority:** Article B460-1.2.2.5, describes the specific type of PTR experience, and the level of supervisory authority during that experience, that is required for approval by the Department. Describe the specific type of experience so that the duration of that type of experience can be determined by the Department reviewer. The requirements call for categories of experience and these must be addressed individually as to duration and authority. For example: I supervised the design and erection of falsework or I assisted the foreman with erection, stressing and grouting of girders.

(3) **Duration of Experience:** Report the duration in weeks, as well as begin and end dates, for each experience period that is to be addressed as described under the Work Description and Level of Authority section above.

(4) Certification of Experience: *Provide a notarized certification statement from an individual that can verify that the experience covered by 1.2.2.4 (1), (2) and (3) above, for each experience period, is accurate. This may require certification statements from more then one individual. 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. The certification should state that the project work experience being reported is accurate to the best of the certifier's knowledge and the certification must be notarized. The name, address and telephone number of the certifier must be shown on the certification statement.*

B460-1.2.2.5 Qualification Requirements: *Submit written documentation per Article B460-1.2.2.3 and 1.2.2.4, substantiating that Project Engineers, Project*

Superintendents / Managers and Foremen involved with PTR operations, meet the minimum qualifications and experience that follow.

(1) Project Engineer: *Must be a registered professional engineer per Article B460-1.2.2.3 and have a minimum of 5 years of general bridge construction experience of which 3 years must have been in engineering of PTR operations. The 3 PTR years must have included experience in girder erection, including safe use of cranes and stabilization of girders; design of falsework for temporary girder support; and supervision of PT and grouting operations. Also required, is a minimum of 1 year of experience as the Project Engineer in responsible charge of the engineering of PTR operations.*

(2) Project Superintendent/Manager: *Must have a minimum of 5 years of general bridge construction experience as a registered professional engineer or 10 years without registration, and with or without registration, 3 years must have been in PTR operations. The 3 PTR years must have included experience in girder erection, including safe use of cranes and stabilization of girders; design of falsework for temporary girder support; and supervision of PT and grouting operations. Also required, is a minimum of 1 year of experience as the Project Superintendent/Manager in responsible charge of PTR operations.*

(3) Foreman of a PTR Operations: *Must have a minimum of 5 years of general bridge construction experience of which 2 years must have been in PTR operations. Also required, is a minimum of 1 year of experience as the foreman in responsible charge of a PTR operation.*

B460-1.3 Penalties

All provisions of this section are particularly important; therefore, the provisions in subarticle 8-6 "Temporary Suspension of Contractor's Operations" will be vigorously enforced.

The Department will withhold payment for any defective work or material in accordance with subarticle 9-6.3.

B460-1.4 Shop Drawings

Prepare shop drawings to address all requirements stated in the plans and the requirements stated herein. Indicate the QPL post-tensioning systems to be used. Show tendon geometry and locations complying with the plans and the limitations of the selected post-tensioning system. Show all inlets, outlets, high point outlet inspection details, anchorage inspection details and permanent grout caps.

B460-2 Terminology.

Anchorage Assembly: An assembly of various hardware components which secure a tendon at its ends after it has been stressed imparting the tendon force into the concrete.

Anticipated Set: Anticipated set is that set which was assumed to occur in the design calculation of the post-tensioning forces immediately after load transfer.

Bar: Post-tensioning bars are high strength steel bars, normally available from 5/8 to 1 3/4 inch (15 to 46 mm) diameter and usually threaded with very coarse thread.

Bearing Plate: Any hardware that transfers the tendon force into a structure or the ground.

Bleed: The autogenous flow of mixing water within or its emergence from, newly placed grout, caused by the settlement of the solid materials within the mass.

Coupler: The means by which the prestressing force may be transmitted from one partial length prestressing tendon to another.

Duct: Material forming a conduit to accommodate prestressing steel installation.

Fluidity: Is a measure of time, expressed in seconds necessary for a stated quantity of grout to pass through the orifice of a flow cone. Grout: A mixture of cementitious materials and

water with or without mineral additives or admixtures, proportioned to produce a pumpable consistency without segregation of the constituents *when* injected into the duct to fill the space around the prestressing steel.

Grout Cap: A device which contains the grout and forms a protective cover sealing the post-tensioning steel at the anchorage.

Inlet: Tubing or duct used for injection of the grout into the duct.

Outlet: Tubing or duct to allow the escape of air, water, grout and bleed water from the duct.

Post-tensioning: A method of prestressing in which the tendons are tensioned after the concrete has reached a specified strength.

Prestressing Steel: The steel element of a post-tensioning tendon, which is elongated and anchored to provide the necessary permanent prestressing force.

Post-Tensioning Scheme or Layout: The pattern, size and locations of post-tensioning tendons provided by the Designer on the Contract Plans.

Post-Tensioning tendon : A particular size tendon including prestressing material, anchors, local zone reinforcement, duct, *duct connections* and stressing equipment supplied by a particular manufacturer.

Post-tensioning System: A post-tensioned system is a particular size and type of a family of similar systems with its associated hardware including but not limited to anchorage assembly, local zone reinforcement, wedge plate, wedges, inlet, outlet, couplers, duct, duct connections and grout cap. The post-tensioning system is selected from a family of similar type products. The entire assembly must meet the system pressure testing requirement.

Set (Also Anchor Set or Wedge Set): Set is the total movement of a point on the strand just behind the anchoring wedges during load transfer from the jack to the permanent anchorages. Set movement is the sum of slippage of the wedges with respect to the anchorage head and the elastic deformation of the anchor components. For bars, set is the total movement of a point on the bar just behind the anchor nut at transfer and is the sum of slippage of the bar and the elastic deformation of the anchorage components.

Strand: An assembly of several high strength steel wires wound together. Strands usually have six outer wires helically wound around a single straight wire of a similar diameter.

Tendon: A single or group of prestressing *steel* elements and their anchorage assemblies which imparts prestress to a structural member or the ground. Also, included are ducts, grouting attachments, grout and corrosion protection filler materials or coatings.

Thixotropic - The property of a material that enables it to stiffen in a short time while at rest, but to acquire a lower viscosity when mechanically agitated.

Wedge Plate: The hardware that holds the wedges of a multi-strand tendon and transfers the tendon force to the *anchorage assembly*.

Wedge: A conically shaped device which anchors the strand in the wedge plate.

B460-3 Alternate Post-Tensioning Designs.

Alternate designs using a post-tensioning scheme other than that shown on the plans may be submitted for the Engineer's approval provided that the proposed alternate scheme fulfills the following requirements:

(1) The prestress system is a type described in B460-4.

(2) The net compressive stress in the concrete after all losses is at least as large as that provided by the post-tensioning shown on the Plans.

(3) The distribution of individual tendons at each cross section generally conforms to the distribution shown on the Plans.

(4) The ultimate strength of the structure with the proposed post-tensioning scheme meets the requirements of Section 5 of the "AASHTO LRFD Bridge Design Standard Specifications" and shall be equivalent to or greater than the ultimate strength provided by the original design.

(5) Stresses in the concrete and prestressing steel at all sections and at all stages of construction meet the requirements of the Design Criteria noted on the Plans.

(6) All provisions of the Design Criteria noted on the Plans shall be satisfied.

(7) The Contractor fully ~~re~~design~~s~~ and details, the elements where the alternate post-tensioning scheme is proposed to be used.

(8) The Contractor submits complete shop drawings including post-tensioning scheme and system, reinforcing steel, and concrete cover; and design calculations (including short and long term prestress losses) for the Engineer's approval.

(9) Any alternate post-tensioning system approved by the Engineer, which results in a change in quantity from that shown on the *contract documents*, will be paid based on the quantity actually used and accepted or the plan quantity, whichever is less, and at the unit bid price. If the approved alternate post-tensioning scheme or system is under a VECP (Value Engineering Change Proposal), the method of payment will be in compliance with the VECP agreement.

(10) Alternative post-tensioning shall be designed and sealed by the responsible Specialty Engineer.

B460-4 Materials.

Meet the requirements of following:

Wire Strand*……ASTM A 416
Bar**……ASTM A 722
Water……Section 923
Grout……Section 938
Epoxy Compounds……Section 926
Magnesium Ammonium Phosphate Concrete……..Section 950
Elastomeric Coating System…….Section 956
Post-Tensioning System……..Section 939
Epoxy Grout for Post-Tensioning Termini……...Section 940

*Unless otherwise noted on the plans, use uncoated, Grade 270 [1860 MPa], low relaxation 7-wire strand meeting the requirements of ASTM A 416.

**Unless otherwise noted on the plans, use uncoated bar, Grade 150 [1035 MPa], high strength, coarse thread bar meeting the requirements of ASTM A 722, Type II.

B460-4.1 Prestressing Steel:

(a) Strand: Unless otherwise noted on the plans, use uncoated strand meeting requirements of Section 933 (Grade 270 (1860 MPa), low relaxation 7-wire strand meeting the requirements of ASTM A 416).

(b) Bar: Unless otherwise noted on the plans, bar shall be uncoated, Grade 150 (1035 MPa), high strength, thread bar meeting the requirements of ASTM A 722, Type II.

The proper use of strand, and bars is predicated upon the use of suitable accessory materials. Furnish details from the manufacturer for the use of these materials in connection with shop and working drawing submittals.

B460-4.1.2 Post-Tensioning System: *Meet the requirements of Section 939, Post-Tensioning System. Use only complete post-tensioning system listed on the Department's Qualified Product List (QPL). Use size and type shown on the contract documents. For permanent applications, the use and location of bar couplers is subject to approval by the Engineer.*

B460-4.1.3 Protection of Ducts: *Protect ducts against ultraviolet degradation, crushing, excessive bending, dirt contamination and corrosive elements during transportation, storage and handling. End caps supplied with the duct shall remain in place until the duct is incorporated into the bridge. Store duct in a location that is dry and protected from the sun. Storage must be on a raised platform and completely covered to prevent contamination. If necessary, wash duct before use to remove any contamination.*

B460-4.1.4 Grout Inlets and Outlets:

All grout inlets and outlets will be equipped with mechanical shut-off valves or plugs. The inner diameter of these inlets/outlets will be at least 3/4 inch (20 mm) for strand and 3/8 inch (10 mm) for single bar tendons and four-strand duct. The length shall extend sufficiently out of the concrete member to allow proper closing of the valves and provide a vertical stand-pipe for visual inspection. Grout inlets and outlets will be bonded to the duct by use of mechanical connections, adhesives or welding.

When performing vertical grouting, increase the minimum diameter to 2 inches (50 mm) and use dual mechanical shut-off valves. One inch diameter inlets and outlets on vertical bar tendons less than 50 feet (15m) in height may be used.

B460-4.1.*5* Grout:

Use only grouts on the Department's Qualified Products List (QPL) meeting the requirements of Section 938. Select the post-tensioning grout for use by the proper application either repair, horizontal or vertical. Grout will be mixed with potable water meeting the requirements of Section 923. Grout fluidity will be tested with a flow cone. Fluidity will be in strict compliance with the grout manufacturer's recommendations.

B460-4.1.5.1 Grout Production Test: *During grouting operations the fluidity of the grout shall be strictly maintained within the limits established by the grout manufacturer. A target flow rate shall be established by the manufacturer's representative based on ambient weather conditions. Determine grout fluidity by use of either test method found in Section 938. Perform fluidity test and maintain the correct water to cementitious ratio. Do not use grout which tests outside the allowable flow rates. Perform a wick induced bleed test in accordance with Section 938, during each grouting operation with a frequency of one test every 24 hours. If zero bleed is not achieved, adjust operations and test fluidity until no bleed is achieved.*

B460-4-1.5.2 Grout Storage: *Store grout in a location that is both dry and convenient to the work. Storage in the open must be on a raised platform and with adequate waterproof covering. On site storage of grout is limited to a maximum period of one month.*

B460-4.2 Samples for Testing and Identification:

B460-4.2.1 General: Testing shall conform to the applicable ASTM Specifications for the prestressing material used.

Furnish all material samples for testing at no cost to the Department.

Consider the job site or site referred to herein as the location where the prestressing steel is to be installed, whether at the bridge site or *at the* casting yard.

B460-4.2.2 Prestressing Steel: Furnish samples for testing as described below for each manufacturer of prestressing strand *and* bar to be used on the project.

With each sample of prestressing steel strand *or* bar ~~or wires~~ furnished for testing, submit a certification stating the manufacturer's minimum guaranteed ultimate tensile strength of the sample furnished.

The Engineer shall sample the following materials, at the plant or jobsite, from the prestressing steel used for post-tensioning operations:

(a) For strand: 3 randomly selected samples, 5 feet (1.5 m) long, per manufacturer, per size of strand, per shipment, with a minimum of 1 sample for every 10 reels delivered.

(b) For bars: 3 randomly selected samples, 5 feet (1.5 m) long, per manufacturer, per size of bar, per heat of steel, with a minimum of 1 sample per shipment.

One of each of the samples furnished to represent a lot will be tested. The remaining sample(s), properly identified and tagged, will be stored by the Engineer for future testing. *In* the event of loss or failure of the component *the stored sample will be utilized to evaluate for* minimum strength requirements. For acceptance of the lot represented, test results must show that 100% of the guaranteed ultimate tensile strength.

B460-4.2.3 Lots and Identification: A lot is that parcel of components as described herein. All bars, of each size from each mill heat of steel, and all strand from each manufactured reel to be shipped to the site shall be assigned an individual lot number and shall be tagged in such a manner that each such lot can be accurately identified at the job site. Submit records to the Engineer identifying assigned lot numbers with the heat, or reel of material represented. All unidentified prestressing steel, or bars received at the site will be rejected. Also, loss of positive identification of these items at any time will be cause for rejection.

Provide a copy of the grout Quality Control Data Sheet from the manufacturer for each lot number and shipment sent to the job site to the Engineer. Materials with a total time from manufacture in excess of six months shall be retested and certified by the supplier before use or removed and replaced.

B460-4.3 Approval of Materials: The *approval* of any material by the Engineer shall not preclude subsequent rejection if the material is damaged in transit or later damaged or found to be defective.

B460-5 Testing by the Contractor: (Not Required on Post-tensioned, Precast Flat Slab Bridges and Double Tee Bridges)

B460-5.1 Tendon Modulus of Elasticity Test: *The test for the determination of the tendon modulus of elasticity is not normally required. If specifically called for in the plans or ordered by the Engineer, perform a tendon modulus of elasticity test in accordance with the following procedure.*

For the purpose of accurately determining the tendon elongations while stressing, bench test 2 samples of each size and type of tendon to determine the modulus of elasticity prior to stressing the initial tendon.

For the purpose of this test, the bench length between anchorages shall be at least 40 feet (12 m) and the tendon duct shall be at least 2 inches (50 mm) clear of the tendon all around. The test procedure shall consist of stressing the tendon at an anchor assembly with a load cell at the dead end. Tension the test specimen to 80% of ultimate in 10 increments and then detention from 80% of ultimate to zero in 10 decrements. For each increment and decrement, record the gauge pressure, elongations and load cell force. Note elongations of the tendon for both ends and the central 30 feet (9 m), measured to an accuracy of ± 1/32 inch (±1 mm). Correct the elongations for the actual anchorage set of the dead end.

Calculate the modulus as follows:

$E = PL/Adl$

where;

P= force in tendon,

L= distance between pulling wedges and dead end wedges or exact length in center 30 feet (9 m) of the tendon.

A= cross sectional area of the tendon based on nominal area.
dl= strand elongation for load P.

If the bench test varies from the modulus of elasticity used for the shop or working drawings by more than 1%, submit revisions to the theoretical elongations to the Engineer for approval.

When the observed elongations of the tendons in the erected structure fall outside the acceptable tolerances or to otherwise settle disputes, additional Tendon Modulus of Elasticity Tests may be required to the satisfaction of the Engineer.

If the source of prestressing steel changes during the project, additional test series or substantiation from previous projects, not to exceed 2 per source shall be required.

The apparatus and methods used to perform the test must be submitted to the Engineer for approval. Tests shall be conducted in the Engineer's presence.

B460-5.2 In Place Friction Test:

For tendons in excess of 100 feet [15m] long, the Contractor shall test in place a minimum of one tendon in a group of tendons performing the same function. Functional tendon groups are cantilever tendons, continuity tendons, draped external tendons or continuous profiled tendons passing through one or more spans, etc. The selected tendon shall represent the size and length of the group of tendons being tested. The in-place friction test is not required on projects with straight tendons used in flat slabs or precast voided slabs.

The test procedure shall consist of stressing the tendon at an anchor assembly with a load cell at the dead end. Tension the test specimen to 80% of ultimate tendon strength in eight equal increments. For each increment, record the gauge pressure, elongations and load cell force. Take into account any wedge seating in both the live end (i.e., back of jack) and the dead end (i.e., back of load cell) and any friction within the anchorages, wedge plates and jack as a result of slight deviations of the strands through these assemblies. For long tendons requiring multiple jack pulls with intermediate temporary anchoring, keep an accurate account of the elongation at the jacking end allowing for intermediate wedge seating and slip of the jack's wedges.

If the elongation's fall outside the ±7% range of the expected friction coefficients, investigate the reason and make detailed calculations confirming the final tendon forces are in agreement with the approved Plans.

In reconciling theoretical and actual elongations, do not vary the value of the expected friction and wobble coefficients by more than ±10%. Significant shortfall in elongations is indicative of poor duct alignments and/or obstructions. Correct or compensate for such elongations in a manner proposed by the Contractor and reviewed and approved by the Engineer at no additional cost to the Department.

The Engineer will require 1 successful friction test for each tendon group for the project.

If there are irreconcilable differences between forces and elongations, or other difficulties during the course of routine stressing operations, the Engineer may require additional in place friction tests.

The apparatus and methods used to perform the test must be submitted to the Engineer for approval. Tests shall be conducted in the Engineer's presence.

B460-5.3 Tests Reports Required: *If required,* submit 2 test reports of the "Tendon Modulus of Elasticity Test" to the Engineer at least 30 days prior to installing the tendon.

Submit 2 test reports of the "In Place Friction Test" to the Engineer within 2 weeks after successful installation of the tested tendon.

B460-5.6 4 Payment for Testing: Testing by the Contractor will not be paid for separately but shall be incidental to the price paid for the post-tensioning.

B460-5. 5 Application of Test Results: Reevaluate the theoretical elongations shown on the post-tensioning shop or working drawings using the results of the tests for Tendon Modulus of Elasticity and In Place Friction as appropriate and correct as necessary. Submit revisions to the theoretical elongations to the Engineer for approval.

B460-6 Protection of Prestressing Steel.

B460-6.1 Shipping, Handling and Storage: Protect all prestressing steel against physical damage and corrosion at all times from manufacturer to final grouting or encasing in the concrete. The Engineer will reject prestressing steel that has sustained physical damage at any time. Carefully inspect any reel that is found to contain broken wires during use and remove and discard lengths of strand containing broken wires. The wire shall be bright and uniformly colored, having no foreign matter or pitting on its surface.

Prestressing steel shall be packaged in containers for protection of the steel against physical damage and corrosion during shipping and storage. A corrosion inhibitor, which prevents rust, shall be placed in the package, or shall be incorporated in a corrosion inhibitor carrier type packaging material, or when permitted by the Engineer, may be applied directly to the steel. The corrosion inhibitor shall have no deleterious effect on the steel or the concrete or bond strength of steel to concrete. Inhibitor carrier type packaging material shall conform to the provisions of Federal Specification MIL-P-3420. Immediately replace or restore packaging damaged from any cause to the original condition.

The shipping package shall be clearly marked with a statement that the package contains high-strength prestressing steel, the care to be used in handling, and the type, kind and amount of corrosion inhibitor used, including the date when placed, safety orders and instructions for use. Specifically designate low relaxation (stabilized) strand per requirements of ASTM A 416. Strands not so designated will be rejected.

B460-6.2 During Installation in the Structure: *The time between the first installation of the prestressing steel in the duct and the completion of the stressing and grouting operations will not exceed 7 calendar days. Any light surface corrosion forming during this period of time will not be cause for rejection of the prestressing steel.*

If duct requires flushing, use flush water containing slack lime (calcium hydroxide) or quicklime (calcium oxide) in the amount of 0.17lb/gal (0.2 kg/L).

Except when approved by the Engineer in writing, failure to grout tendons within the 7 calendar days specified will result in stoppage of the effected work as defined in subarticle 8-6.

B460-7 Fabrication.

B460-7.1 General: Accurately and securely fasten all post-tensioning anchorages, ducts, inlet and outlet pipes, miscellaneous hardware, reinforcing bars, and other embedments at the locations shown on the Plans or on the approved Shop or Working Drawings or as otherwise approved the Engineer. *Use corrugated plastic ducts meeting the requirements of Section 939 for internal tendons or smooth plastic ducts meeting the requirements of Section 939 for external tendons.*

B460-7.2 Ducts: Accurately align ducts and position at the locations shown on the Plans or according to the approved Shop or Working Drawings or as otherwise approved by the Engineer. Securely fasten all internal ducts in position at regular intervals not exceeding 30 inches (0.75 m) for steel *pipes and 24 inches (0.61 m) for plastic duct* to prevent movement, displacement or damage from concrete placement and consolidation operations. Show the method and spacing of duct supports on appropriate Shop Drawings. Ensure that ducts for external tendons are straight between connections to internal ducts at anchorages, diaphragms and

deviation saddles and are supported at intermediate locations according to the plans or approved shop drawings.

Ensure that 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.

Carefully check and repair all ducts as necessary before placing any concrete.

After installing the ducts and until grouting is complete, ensure that all ends of ducts, connections to anchorages, splices, *inlets and outlets* are sealed at all times. *Provide an absolute seal of anchorage and duct termination locations by using plumber's plugs or equal. Grout inlets and outlets will be installed with valves or positive plugs in the closed position. Low point outlets will be left open. The use of duct tape is not acceptable.*

B460-7.3 Splices and Joints*: All splices, joints, couplings and connections (inlet and outlet) shall be part of the approved post-tensioning system. Approved shrink-wrap material may be used to repair duct. The use of duct tape to repair or seal duct is not permitted.*

B460-7.4 Location of Grout Inlets and Outlets: *Place grout inlets and outlets at locations as shown on the plans and shop drawings. Equip all grout inlets and outlets with positive shut-off devices. At a minimum, grout inlets and outlets will be placed in the following positions:*

(a) Top of the tendon anchorage;
(b) Top of the grout cap;
(c) At the high points of the duct when the vertical distance between the highest and lowest point is more than 20 in. (0.5m);
(d) At a location 3 ft. (1m) past high points of the duct on the down stream side opposite the direction of grouting;
(e) At all low points;
(f) At major changes in the cross section of the duct;
(g) At other locations required by the Engineer.

The locations of grout inlets and outlets will be detailed on the shop drawings.

B460-7.5 Tolerances: Ensure that post-tensioning ducts *in their final position* are within the following tolerances:

Table of Duct Position Tolerances		
Tolerances	Vertical position Inches (mm)	Lateral position Inches (mm)
Horizontal tendons in slabs or in slab regions of larger members:	±1/4 (±6)	± ½ (±13)
Longitudinal draped super-Structure tendons in webs: Tendon over supports or in middle third of span	±1/4 (±6)	±1/4 (±6)
Tendon in middle half of web depth	±*1* (±25)	±1/4 (±6)
Longitudinal, generally horizontal, superstructure tendons usually in top or bottom of member:	±1/4 (±6)	±1/4 (± 6)
Horizontal tendons in substructures and foundations:	± 1/2 (±13)	± 1/2 (±13)
Vertical tendons in webs	Longitudinal position ±1 (±25)	Transverse position ±1/4 (±6)
Vertical tendons in pier shafts	±1/2(±13)	±1/4 (±6)

In all other cases, ensure that tendons are not out of position by more than ±1/4 inch (±6 mm) in any direction.

Ensure entrance and exit angles of tendon paths at anchorages and/or at faces of concrete are within ±3^{o} (±5%) of desired angle measured in any direction.

Angle changes at duct joints shall not be greater than ±3^{o} (±5%) in any direction.

Locate anchorages within ±1/4 inch (±6 mm) of desired position laterally and ±1 inch (±25 mm) along the tendon except that minimum cover requirements must be maintained.

Position anchorage confinement reinforcement in the form of spirals, multiple U shaped bars or links, to be properly centered around the duct and to start within 1/2 inch (13 mm) of the back of the main anchor plate.

If conflicts exist between the reinforcement and post-tensioning duct, , the position of the post-tensioning duct shall prevail and the reinforcement shall be adjusted locally with the Engineer's approval.

B460-7.6 Internal (Bonded) Duct Pressure Test: *For all structures using internal duct, except segmental box girders, pressure test the duct prior to casting concrete. Seal the duct at the termini and test with compressed air to determine if duct connections require repair. Pressurize the duct to 5 psi (34.5 kPa) and lock-off the outside air source. Record the pressure loss for 5 minutes. A pressure loss of 40% is acceptable. If pressure loss exceeds the allowable, repair leaking duct connections using methods approved by the Engineer.*

For segmental box girders utilize an continuous duct (no joints) spanning from bulkhead to bulkhead.

B460-8 Placing Concrete.

B460-8.1 Precautions: Exercise great care when placing and consolidating concrete so as not to displace or damage any of the post-tensioning ducts, anchorage assemblies, splices and connections, reinforcement or other embedments. *Fabricate all duct splices to prevent duct kinks during concrete placement. Use mandrels as needed to maintain duct alignment and shape.*

B460-8.2 Proving of Post-Tensioning Ducts: Upon completion of concrete placement prove that the post-tensioning ducts are free and clear of any obstructions or damage and are able to accept the intended post-tensioning tendons by passing a torpedo through the ducts. Use a torpedo having the same cross-sectional shape as the duct and that is a 1/4 inch (6 mm) smaller all around than the clear, nominal inside dimensions of the duct. Make no deductions to the torpedo section dimensions for tolerances allowed in the manufacture or fixing of the ducts. For straight ducts, use a torpedo at least 2 feet (0.6 m) long. For curved ducts, determine the length so that when both ends touch the outermost wall of the duct, the torpedo is 1/4 inch (6 mm) clear of the innermost wall. If the torpedo will not travel completely through the duct, the Engineer will reject the member, unless a workable repair can be made to clear the duct ~~all to the satisfaction of the Engineer~~. ~~Pass~~ The torpedo *shall pass* through the duct easily, by hand, without resorting to excessive effort or mechanical assistance.

B460-8.3 Problems and Remedies: The Engineer will reject ducts or any part of the work found to be deficient. Perform no remedial or repair work without the Engineer's approval.

B460-9 Installing Tendons.

Push or pull post-tensioning strands through the ducts to make up a tendon. Push with care to avoid snagging on any lips or joints in the ducts. Take precautions by rounding off the end of the strand or fitting it with a smooth protective cap.

Alternatively, strands may be assembled into the tendon and pulled through the duct together using a special steel wire sock ("Chinese finger") or other device attached to the end. Also, the ends of the strands may be welded together for this purpose. If so, then round the end of the bundle for smooth passage and cut off and waste the entire welded end together with at least 20 inches (0.51 m) of tendon beyond the end of the last weld. Cut using an abrasive saw or *equal*. Flame cutting is not allowed.

Do not install permanent tendons before the completion of testing as required by these Specifications or Plans. As a sole exception, the tendon to be tested in the "In Place Friction Test" may be installed for the test.

B460-10 Post-Tensioning Operations.

B460-10.1 General: Do not apply post-tensioning forces until the concrete has attained the specified compressive strength as determined by cylinder tests.

B460-10.2 Stressing Tendons: Tension all post-tensioning steel with hydraulic jacks so that the post-tensioning force is not less than that required by the plans or approved shop drawings, or as otherwise approved by the Engineer. Do not utilize monostrand jacks to stress tendons with 5 or more strands.

B460-10.2.1 Maximum Stress at Jacking: The maximum temporary stress (jacking stress) in the post-tensioning steel shall not exceed 80% of its specified minimum ultimate tensile strength. Do not overstress tendons to achieve the expected elongation.

B460-10.2.2 Initial and Permanent Stresses: The post-tensioning steel shall be anchored at initial stresses that will result in the long term retention of permanent stresses or

forces of no less than those shown on the Plans or the approved shop drawings. Unless otherwise approved by the Engineer, the initial stress after anchor set shall not exceed 70% of the specified ultimate tensile strength of the post-tensioning steel.

Permanent stress and permanent force are the stress and force remaining in the post-tensioning steel after all losses, including long term creep and shrinkage of concrete, elastic shortening of concrete, relaxation of steel, losses in the post-tensioning steel from the sequence of stressing, friction and unintentional wobble of the ducts, anchor set, friction in the anchorages and all other losses peculiar to the post-tensioning system.

B460-10.2.3 Stressing Sequence: Except as noted on the Plans, the approved shop drawings or as approved by the Engineer, permanent post-tensioning tendons must be stressed from both ends. The required force may be applied at one end and subsequently at the other end or simultaneously at both ends.

Single end stressing is permitted when the following are satisfied:

(a) Space limitations prohibit 2 end stressing.

(b) The calculated elongation of the post-tensioning steel at the second end is 1/2 inch (13 mm) or less.

(c) Single end stressing applied at alternate ends of paired adjacent post-tensioning tendons is required to produce a symmetrical force distribution in agreement with the Plan design.

For construction in stages where some tendons are required to be stressed before others, install and stress in accordance with the Plans or approved Shop Drawings or as otherwise approved by the Engineer.

B460-10.3 Stressing Equipment: Only use equipment furnished by the *supplier* of the post-tensioning system (tendons, hardware, anchorages, etc.).

B460-10.3.1 Stressing Jacks and Gauges: Each jack shall be equipped with a pressure gauge for determining the jacking pressure. The pressure gauge shall have an accurately reading *gage with a* dial at least 6 inches (150 mm) in diameter.

B460-10.3.2 Calibration of Jacks and Gauges*: Each jack and its gauge(s) shall be calibrated as a unit. The calibration shall consist of three test cycles with the cylinder extension of the jack in various positions (i.e. 2", 4", 8" stroke). At each pressure increment the forces from each test cycle shall be averaged to obtain an average force. Calibration shall be performed with the equipment (jack, pump, hoses, etc.) setup in the same configuration that is intended to be used at the job site. The post-tensioning supplier or an independent laboratory shall perform initial calibration of jacks and gauge(s). Calibration of the load cell(s) used for equipment calibration shall not exceed 1 year. For each jack and gauge unit used on the project, furnish certified calibration charts to the Engineer prior to stressing. Documentation revealing the load cell(s) calibration date and tractability to NIST (National Institute of Standards & Technology) shall be submitted with the jack/gauge calibration.*

Certified calibration shall be made at the start of the work and at every 6 months thereafter, or as requested by the Engineer. Calibrations subsequent to the initial calibration with a load cell may be accomplished by the use of a master gauge. Supply the master gauge to the Engineer in a protective waterproof container capable of protecting the calibration of the master gauge during shipment to a laboratory. Provide a quick-attach hydraulic manifold to enable quick and easy installation of the master gauge to verify the permanent gauge readings. The master gauge will be calibrated and provided to the Engineer. The master gauge will remain in the possession of the Engineer for the duration of the project.

Any jack repair, such as replacing seals or changing the length of the hydraulic lines, is cause for recalibration using a load cell.

No extra compensation will be allowed for the initial or subsequent calibrations or for the use and required calibrations of the master gauge.

B460-10.4 Elongations and Agreement with Forces: Ensure that the forces being applied to the tendon and the elongation of the post-tensioning tendon can be measured at all times.

Elongations shall be measured to the nearest 1/16 inch (1.5 mm).

For the required tendon force, the observed elongation shall agree within 7% of the theoretical elongation or the entire operation shall be checked and the source of error determined and remedied to the satisfaction of the Engineer before proceeding further. Do not overstress the tendon to achieve the theoretical elongation.

In the event that agreement between the observed and theoretical elongations at the required force falls outside the acceptable tolerances, the Engineer may, at his discretion and without additional compensation to the Contractor, require additional tests for "Tendon Modulus of Elasticity" and/or "In-Place Friction" in accordance with B460-5.1 and B460-5.2.

B460-10.5 Friction: The Contract Plans were prepared based on the assumed friction and wobble coefficients and anchor set noted on the Plans. Submit calculations and show a typical tendon force diagram, after friction, wobble and anchor set losses, on the Shop Drawings based upon the expected actual coefficients and values for the post-tensioning system to be used. Show these coefficients and values on the Shop Drawings.

If, in the opinion of the Engineer, the actual friction significantly varies from the expected friction, revise post-tensioning operations so the final tendon force is in agreement with the Plans.

When friction must be reduced, graphite may be used as a lubricant, subject to the approval of the Engineer. Flush lubricants from the duct as soon as possible after stressing is completed by use of lime treated potable water. After ducts are flushed, immediately blow dry with oil-free air.

B460-10.6 Wire Failures in Post-Tensioning Tendons: Multi-strand post-tensioning tendons, having wires which fail, by breaking or slippage during stressing, may be accepted provided the following conditions are met:

(a) The completed structure must have a final post-tensioning force of at least 98% of the design total post-tensioning force.

(b) For precast or cast-in-place segmental construction and for any similar construction that has members post-tensioned together across a common joint face, at any stage of erection, the post-tensioning force across a mating joint must be at least 98% of the post-tensioning required for that mating joint for that stage of erection.

(c) Any single tendon must have no more than a 5% reduction in cross-sectional area of post-tensioning steel due to wire failure.

Any of the above conditions may be waived *with* approval *of* the Engineer, when conditions permit the Contractor to propose acceptable alternative means of restoring the post-tensioning force lost due to wire failure.

B460-10.7 Cutting of Post-Tensioning Steel: Cut post-tensioning steel by an abrasive saw within 3/4 to 1-1/2 inches (20 to 40 mm) away from the anchoring device. Flame cutting of post-tensioning steel is not allowed.

B460-10.8 Record of Stressing Operations: Keep a record of the following post-tensioning operations for each tendon installed:

(a) Project name, number;

(b) Contractor and/or subcontractor;

(c) Tendon location, size and type;

(d) Date tendon was first installed in ducts;
(e) Reel number for strands and heat number for bars;
(f) Tendon cross-sectional area;
(g) Modulus of elasticity;
(h) Date Stressed;
(e) Jack and Gauge numbers per end of tendon;
(f) Required jacking force;
(g) Gauge pressures;
(h) Elongations (theoretical and actual);
(i) Anchor sets (actual);
(j) Stressing sequence (i.e. tendons *to be stressed* before and after;
(k) Stressing mode (1 end/ 2 ends/ simultaneous);
(l) Witnesses to stressing operation (Contractor and inspector);
(m) Date grouted

Record any other relevant information. Provide the Engineer with a complete copy of all stressing and grouting operations.

B460-10.9 Duct Pressure Field Test: *After stressing and prior to grouting internal or external tendons, install all grout caps, inlets and outlets and test with compressed air to determine if duct connections require repair. Pressurize the duct to 100 psi and lock-off the outside air source. Record pressure loss for 5 min. A pressure loss of 10% is acceptable. If pressure loss exceeds the allowable, repair leaking duct connections using methods approved by the Engineer..*

B460-10.11 Tendon Protection: *Within 4 hours after stressing install grout caps and seal all other tendon openings. If tendon contamination occurs, the tendon is to be removed and replaced.*

B460-11 Grouting Operations.

B460-11.1 Grouting Operations Plan: *Submit a grouting operations plan for approval at least 6 weeks in advance of any scheduled grouting operations. Written approval of the grouting operations plan by the Engineer is required before any grouting of the permanent structure takes place.*

At a minimum, the plan will address and provide procedures for the following items:

(a) Provide names and proof of training for the grouting crew and the crew supervisor in conformance with this specification;

(b) Type, quantity, and brand of materials used in grouting including all certifications required;

(c) Type of equipment furnished, including capacity in relation to demand and working condition, as well as back-up equipment and spare parts;

(d) General grouting procedure;
(e) Duct pressure test and repair procedures;
(f) Method to be used to control the rate of flow within ducts;
(g) Theoretical grout volume calculations;
(h) Duct cleaning methods prior to grouting;
(i) Mixing and pumping procedures;
(j) Direction of grouting;
(k) Sequence of use of the inlets and outlet pipes;
(l) Procedures for handling blockages;
(m) Procedures for possible post grouting repair.

Before grouting operations begin, a joint meeting of the contractor, subcontractors grouting crew and the Engineer will be conducted. At the meeting the grouting operation plan, required testing, corrective procedures and any other relevant issues will be discussed.

B460-11.2 Ducts: *Perform an in-place duct pressure test at each tendon location as defined in Article B460-7.6.*

Repair all tendon communication (grout crossover to non-grouted tendon), blockages or leaks to the satisfaction of the Engineer.

For tendons subject to contamination with chlorides (construction location in an aggressive environment), flush the duct with lime treated potable water (see B460-6.2) and test for presence of chlorides and oils. Chlorides in the water must be less than 600 ppm. The use of single parameter test strip by HACH Company is acceptable for this measurement. If chloride levels are in excess of 600 ppm, continue to flush the duct until acceptable levels of chloride are achieved (250 ppm). Blow oil-free compressed air through the duct to remove any excess water in the duct. Unless immediately grouted, seal the tendon to exclude water and debris.

B460-11.3 Grout Inlets and Outlets: *Connections from the grout pump hose to inlets shall be free of dirt and be air- tight. Inspect outlets to be sure that they can be opened and closed properly.*

B460-11.4 Supplies: *Before grouting operations start, provide an adequate supply of water and compressed air for clearing and testing the ducts, mixing and pumping the grout. All necessary materials shall be checked and made conveniently available for mixing.*

B460-11.5 Material Storage: *Store grout as specified in Article 460-4.1.5.2.*

B460-11.6 Equipment:

B460-11.6.1 General: *Provide grouting equipment consisting of measuring devices for water, a high-speed shear colloidal mixer, a storage hopper (holding reservoir) and a pump with all the necessary connecting hoses, valves, and pressure gauge. Provide pumping equipment with sufficient capacity to ensure that the post-tensioning ducts to be grouted can be filled and vented without interruption at the required rate of injection in not more than 30 minutes.*

Provide an air compressor and hoses with sufficient output to perform the required functions.

Provide vacuum grouting equipment (volumetric measuring type) on the job during the entire duration of time grouting is being conducted.

B460-11.6.2 Mixer, Storage Hopper: *Provide a high speed shear colloidal mixer capable of continuous mechanical mixing producing a homogeneous and stable grout free of lumps and undispersed cement. The colloidal grout machinery will have a charging tank for blending and a holding tank. The blending tank must be equipped with a high shear colloidal mixer. The holding tank must be kept agitated and at least partially full at all times during the pumping operation to prevent air from being drawn into the post-tensioning duct.*

Add water during the initial mixing by use of a flow meter or calibrated water reservoir with measuring accuracy of ± 1.0 ounces (30 ml) or better.

B460-11.6.3 Grout Pumping Equipment: *Provide pumping equipment capable of continuous operation which will include a system for circulating the grout when actual grouting is not in progress.*

The equipment will be capable of maintaining pressure on completely grouted ducts and will be fitted with a valve that can be closed off without loss of pressure in the duct.

Grout pumps will be positive displacement type, will provide a continuous flow of grout and will be able to maintain a discharge pressure of at least 145 psi (1MPa).

Pumps will be constructed to have seals adequate to prevent oil, air or other foreign substances entering the grout and to prevent loss of grout or water. The capacity will be such that an optimal rate of grouting can be achieved.

A pressure gauge having a full scale reading of no more than 300 psi (2 MPa) will be placed at the duct inlet. If long hoses (in excess of 100 ft (30m)) are used, place 2 gauges, one at the pump and one at the inlet.

The diameter and rated pressure capacity of the grout hoses must be compatible with the pump output.

B460-11.6.4 Vacuum Grouting Equipment: *Provide vacuum grouting equipment at the job site concurrently with all pressure grouting operations. Grouting of transverse tendons having a length of less than 100 feet (30m) are an exception to the above stated rule. Vacuum grouting equipment shall be the volumetric measuring type with the ability to measure a void and supply a measured volume of grout to fill the void.*

B460-11.6.5 Stand-by Equipment: *During grouting operations, provide a stand-by grout mixer and pump. Where water is not supplied through the public water supply system, a water storage tank of sufficient capacity must be provided.*

B460-11.7 Grouting:

B460-11.7.1 General: *Grout tendons in accordance with the procedures set forth in the approved grouting operation plan.*

B460-11.7.2 Temperature Considerations*: Maximum grout temperature will not exceed 90 Degrees F (32E C). Use chilled water and/or pre-cooling of the bagged material to maintain mixed grout temperature below the maximum allowed temperature. Grouting operations are prohibited when the ambient temperature is below 40° F (4° C) or is 40° F (4° C) and falling. Remove any standing water from ducts using compressed air, if freezing temperatures are forecast.*

B460-11.7-3 Mixing and Pumping*: Mix the grout with a metered amount of water.*

The materials will be mixed to produce a homogeneous grout. Continuously agitate the grout until it is pumped.

Check the fluidity of the grout and perform wick induced bleed test..

B460-11.7.4 Grout Operations*: Open all grout outlets before starting the grouting operation. Grout tendons in accordance with the Grouting Operations Plan.*

Unless approved otherwise by the Engineer, pump grout at a rate of between 16 linear feet (5 m) and 50 linear feet (15 m) of duct per minute. Conduct normal grouting operations at a pressure range of 10 psi (.07 MPa) to 50 psi (.34 MPa) measured at the grout inlet. Do not exceed the maximum pumping pressure of 145 psi (1.0 MPa) at the grout inlet.

Use grout pumping methods which will ensure complete filling of the ducts and complete encasement of the steel. Grout must flow from the first and subsequent outlets until any residual water or entrapped air has been removed then close the outlet.

Pump grout through the duct and continuously discharge it at the anchorage and grout cap outlets until all free water and air are discharged and the consistency of the grout is equivalent to that of the grout being pumped into the inlet. Close the anchorage outlet and discharge a minimum of 2 gallons (7.5 liters) of grout from the grout cap into a clean receptacle. Close the grout cap outlet.

For each tendon, immediately after uncontaminated uniform discharge begins, perform a fluidity test using the flow cone on the grout discharged from the anchorage outlet. The measured grout efflux time will not be less than the efflux time measured at the pump or minimum acceptable efflux time as established in Section 938. If the grout efflux time is not acceptable, discharge additional grout from the anchorage outlet and test the grout efflux time. Continue this

cycle until an acceptable grout fluidity is achieved. Discard grout used for testing fluidity. After all outlets have been bled and sealed, terminate grouting by the following procedure. Elevate the grout pressure to ± 75 psi (0.5 MPa) seal the inlet valve and wait 2 minutes to determine if any leaks exist. If leaks are present, fix the leaks using methods approved by the Engineer. Repeat the above stated process until no leaks are present. If no leaks are present, bleed the pressure to 5 psi (0.034MPa) and wait 10 minutes for any entrapped air to flow to the high points. After the 10 min. period has expired, increase the pressure as needed and discharge grout at each high point outlet to eliminate any entrapped air or water. Complete the process by locking a pressure of 30 PSI (0.21 MPa) into the tendon.

If the actual grouting pressure exceeds the maximum allowed, the inlet will be closed and the grout will be pumped at the next outlet, which has just been, or is ready to be closed as long as a one-way flow is maintained. Grout will not be pumped into a succeeding outlet from which grout has not yet flowed. If this procedure is used, the outlet/inlet which is to be used for pumping will be fitted with a positive shut-off and pressure gage.

When complete grouting of the tendon cannot be achieved by the steps stated herein, stop the grouting operation. After waiting the 48 hours, fill the tendon with grout in accordance with the procedure outlined in Article B460-11.7.6.

***B460-11.7.5 Vertical Grouting**: Grouting of cable stays is not covered by this specification. For all vertical tendons, provide a standpipe at the upper end of the tendon to store bleed water and grout, maintain the grout level above the level of the prestressing plate and anchorage. This device will be designed so that the level of the grout can be brought to an elevation which will assure that bleeding will at no time cause the level of the grout to drop below the highest point of the upper anchorage device. Provision will be made to assure that bleed water rises into the standpipe, not into the uppermost part of the tendon and anchorage device.*

Discharge grout and check grout fluidity as described in B460-11.7.4. As grouting is completed, the standpipe will be filled with grout to a level which assures that, as settlement of the grout occurs, the level of the grout will not drop below the highest point in the upper anchorage device. If the level of the grout drops below the highest point in the anchorage device, immediately add grout to the standpipe. After the grout has hardened, the standpipe will be removed.

For vertical tendons in excess of 100 ft. (30m) or if the grouting pressure exceeds the maximum recommended pumping pressure, then grout will be pumped at increasingly higher outlets which have been or are ready to be closed as long as a one-way flow of grout is maintained. Grout will be allowed to flow from each outlet until all air and water have been purged prior to using that outlet for pumping.

***B460-11.7.6 Post-Grouting Operations and Inspection:** Grouted tendons will not be subjected to construction loading causing shock vibration within 48 hours of grouting or an inspection is performed to insure the grout has achieved its final set.*

Inlets and outlets will not be removed or opened until the grout has cured for 24 to 48 hours. After the grout has cured, drill into all outlets located at anchorages and high points along the tendon. Unless grout caps are determined to have voids by sounding, do not removed or drill the cap. Jointly with the Engineer, visually inspect for voids in the grout using an endoscope or probe. If voids are found, fill the void with grout using the volumetric metering vacuum grouting process. If no voids are found clean and backfill the drilled hole with Type E orF-1 epoxy selected from the QPL. Use an injection tube to extend to the bottom of the drill hole. During drilling operations use equipment that will automatically cut-off when steel is encountered.

Post grouting inspection of tendons having a length of less than 150 feet (46 m) may utilize the following statistical frequency for inspection.

1. For the first 20 tendons inspect all outlets located at anchors and tendon high points by drilling and probing with an endoscope or probe. If one or more of the inspection locations are found to contain a defect (void), repeat this step (100% inspection) until no defects are detected.

2. When no defects are detected as defined in No. 1 above, then the frequency of inspection can be reduced to inspect every other tendon (50%). If a defect is located, inspect 100% of the last five tendons grouted. Return to step 1 above and renew the cycle of 100% tendon inspection.

If tendon grouting operations were terminated without completely filling the tendon, drill into the duct and explore the voided areas with an endoscope or probe. Determine the location, length and ends of all voided areas. Install grout inlets as needed and fill the voids using the volumetric metering vacuum grouting.

***B460-11.7.7 Grouting Report:** Provide a grouting report signed by the Contractor and/or the Subcontractor for review by the Engineer. These records will be supplied to the Engineer within 72 hours of each grouting operation.*

Report the theoretical quantity of grout anticipated as compared to the actual quantity of grout used to fill the duct. Notify the Engineer immediately of shortages or overages.

Information to be noted in the records shall include but shall not necessarily be limited to the following: identification of the tendon; date grouted; number of days from stressing to grouting; type of grout; tendon(s) grouted; injection end and applied grouting pressure, ratio of actual to theoretical grout quantity; summary of any problems encountered and corrective action taken.

B460-*12 Forming and Repairs of Holes and Block-Outs.*

***B460-12.1 Repair of Lifting Holes and Equipment Block-Out:** Form and repair all these holes and block-outs as shown in the plans. After use, repair all holes and block-outs with magnesium ammonium phosphate concrete meeting the requirements of Section 950. Immediately before casting the concrete (within 24 hrs.), mechanically clean and roughen the mating concrete surfaces to remove any laitance and expose the small aggregate. Grit blasting or water blasting using a minimum 10,000 psi (69 Mpa) nozzle pressure is required. Flush surface with water and blow dry. Mix, place and cure the material in strict compliance with the manufacture's recommendations.*

Upon completion of the deck grooving, coat the repaired holes and block-outs and surrounding areas with methyl methacrylate. Apply and remove any excess material as per manufacturer's instructions.

Alternately, epoxy grout meeting the requirements of Section 940 may be used for the repair material. See article B460-13 for specific requirements for the use of epoxy grout.

***B460-12.2 Repair of Grout Inlets and Outlets:** Repair these inlets/outlets as shown on the plans. Use epoxy grout meeting the requirements of Section 940 for the repair. Prepare the surface to receive the epoxy grout in strict compliance with the manufacture's recommendations.*

B460- 13 Protection of Post-Tensioning Anchorage Termini.

Within 7 days upon completion of the grouting, protect the anchorage termini of post-tensioning bars, tendons and grout inlet/outlet as indicated in the plans. Use an epoxy grout

meeting the requirements of Section 940 to construct and fill all pour-backs located at the anchorage termini.

The epoxy grout material shall be factory pre-proportioned including factory suppplied aggregate. Deliver products in original, unopened bags with manufacturer's name, label, product identification and batch numbers. Store and condition the product in full compliance with the manufacturer's recommendations. Material must be used within manufacturer's recommended shelf life.

Remove all laitance, grease, curing compounds, surface treatments, coatings and oils by grit blasting or water blasting using a minimum 10,000 psi (69 Mpa) nozzle pressure. Flush surface with water and blow dry. Surfaces must be clean, sound and without any standing water. In case of dispute, use ACI 503 for substrate testing and develop a minimum of 175 psi. (1.2 Mpa) tension (pull-off value).

Mix and apply epoxy as per manufacturer's current standard technical guidelines. All pour-backs shall be constructed in leak proof forms creating neat lines. The epoxy grout may require pumping for proper installation. Construct forms to maintain a liquid head to insure intimate contact with the substructure. Use vents as needed to provide for the escape of air to insure complete filling of the cavities in the forms.

Coat the exposed surfaces of pour-backs or grout caps with an elastomeric coating system meeting the requirements of Section 956 and having a thickness of 30 t0 40 mils. Concrete, plastic or other substrate must be 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 10,000 psi (69 Mpa) nozzle pressure to establish the anchor pattern. Blow the surface with compressed air to remove the dust or water.

In order to determine the number of coats required to build a coating thickness between 30 to 45 mils a vertical mock-up of ((2 x 4 ft)(0.61 x 1.2 m)) will be constructed and coated. The final coating must be uniform without runs and drips.

Mix and apply elastomeric coating as per manufacturer's current standard technical specifications. Spray or roller application is permitted (spray application preferred). Coatings will be applied by approved and experienced applicators. Apply coatings using approved and experienced personnel with three years experience applying similar polyurethane systems. Submit applicator's credentials to the Engineer for review and consideration for approval.

B460-14 Method of Measurement.

The quantity of post-tensioning tendons to be paid for under this Section will be the computed weight, in pounds (kilograms), of permanent post-tensioning steel tendons entered into the completed structure and accepted. Measurement will be the theoretical plan length measured from anchorage to anchorage (measured from front face of the bearing plate) with no allowance made for waste or extension past the bearing faces. No measurement will be made for temporary post-tensioning which will be considered incidental to the item "Post-Tensioning Tendons". For quantity determination, the following unit weights will be used:

Prestressing System	Weight per Unit Length lb/ft (kg/m)
½ inch (12.7 mm) diameter 7 wire strand	0.52 (0.77)
0.6 inch (15.2 mm) diameter 7 wire strand	0.74 (1.1)

1 inch (26 mm) high strength deformed bar	3.01 (4.48)
1-1/4 inch (32 mm) high strength deformed bar	4.39 (6.54)
1-3/8 inch (36 mm) high strength deformed bar	5.56 (8.28)
1-3/4 inch (46) mm high strength deformed bar	*9.23 (13.74)*

B460-15 Basis of Payment.

B460-15.1 General: Post-tensioning tendons will be paid for at the Contract unit price per pound (kilogram) of steel tendon, complete and in place. Payment will be full compensation for furnishing, installing, stressing and grouting all temporary and permanent post-tensioning tendons. Payment also includes anchorage assemblies and post-tensioning system hardware which is not embedded in concrete, ducts, grout and grouting, all testing, protection of post-tensioning terminuses and all labor, materials, tools, equipment and incidentals necessary for completing the work in accordance with these specifications and the Plans. This payment also includes lubricants in the tendon ducts for friction control and flushing the lubricant from the tendon ducts after stressing. No separate measurement and payment will be made for anchorage components, local anchorage zone reinforcement supplied as an integral part of a proprietary anchorage system, nor ducts for similar post-tensioning system hardware. Anchorage components, ducts and similar items of post-tensioning system hardware embedded within precast components or cast-in-place concrete will be deemed to be included in the cost of the precast components or cast-in-place concrete.

B460-~~14~~ 15-2 Payment Items:

Payment will be made under:

Item No. 460-111 - Post-tensioning Tendons - per pound

Item No. 2460-111- Post-tensioning Tendons - per kilogram

If the Contractor constructs the structure with an accepted alternate not detailed on the Plans, payment will be based on the unit price bid extended by either the quantities shown on the Plans or the actual quantities used and accepted, whichever is less.

Permanent post-tensioning strand 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 the cost of those precast concrete segments or units.

Payment for post-tensioning will be made following successful placement, stressing, grouting, inspection and approval by the Engineer. Full payment for post-tensioning tendons, within precast segmental concrete structure units, may occur prior to erection of the segments into their final position when ducts have been grouted and the segmental unit otherwise approved for placement by the Engineer.

Draft 5/7/02
(**to be merged into 462**)

Section 939
Post-Tensioning Systems

939-1 General Requirements.

Manufacture and test post-tensioning system hardware to comply with the requirements of this section. Provisions herein apply equally to post-tensioning consisting of either bars or strands. Use post-tensioning systems that are listed on the Department's Qualified Products List (QPL).

All components of a system shall be stamped with the suppliers name, trademark and size corresponding to catalog designation. Post-tensioning systems consist of an assembly of components for various sizes of strand or bars assembled and pressure tested. Post-tensioning systems will have to be developed and tested for both internal (corrugated) and external (smooth) applications. At a minimum, the following post-tensioning systems will be provided: 1 through 1 ¾ inch bar sizes; 3 and 4 strand flat duct sizes; 4 through 32 strand round duct sizes.

939-2 Terminology.

Anchorage Assembly: An assembly of various hardware components which secure a tendon at its ends after it has been stressed imparting the tendon force into the concrete.

Bearing Plate: Any hardware that transfers the tendon force into a structure or the ground.

Coupler: The means by which the prestressing force may be transmitted from one partial-length prestressing bar to another (strand coupled is not allowed).

Duct: Material forming a conduit to accommodate prestressing steel installation and provide an annular space for the grout which protects the prestressing steel.

Grout Cap: A device which contains the grout and forms a protective cover sealing the post-tensioning steel at the anchorage.

Inlet: Tubing or duct used for injection of the grout into the duct.

Outlet: Tubing or duct to allow the escape of air, water, grout and bleed water from the duct.

Post-tensioning System: A post-tensioned system is a particular size and type of a family of similar systems with its associated hardware including but not limited to anchorage assembly, local zone reinforcement, wedge plate, wedges, inlet, outlet, couplers, duct, duct connections and grout cap. The post-tensioning system is selected from a family of similar type products. The entire assembly must meet the system pressure testing requirement.

Pressure Rating: The estimated maximum pressure that water in a duct or in a duct component can exert continuously with a high degree of certainty that failure of the duct or duct component will not occur (sometimes referred to as working pressure).

Wedge Plate: The hardware that holds the wedges of a multi-strand tendon and transfers the tendon force to the anchorage assembly.

Wedge: A conically shaped device which anchors the strand in the wedge plate.

939-3 Qualified Products List.

Use only post-tensioning system that is on the Department's Qualified Products List. Manufacturers of post-tensioning systems seeking evaluation of post-tensioning systems shall submit an application in accordance with Section 6 and include certified test reports from an independent laboratory audited by AASHTO Materials Research Laboratory (AMRL) which shows the material meets all the requirements specified herein. If any component of the system is changed, the QPL qualification will have to be reviewed and repeated if required.

Certification test for the plastic duct shall be performed on the finished product. The plastic from the duct shall be certified to comply with all requirements of the specified cell class and the specified amount of the ultraviolet light stabilizer. Certification of the post-tensioning system along with plastic material certification will be supplied with the system when delivered to the job.

939-4 Materials.

939-4.1 Post-Tensioning Anchorages: The anchorages shall develop at least 95% of the actual ultimate tensile strength of the prestressing steel, when tested in an unbonded state, without exceeding the anticipated set.

Design anchorages so that the average concrete bearing stress is in compliance with the "AASHTO LRFD Bridge Design Specifications". Test and provide written certification that anchorages meet or exceed the testing requirements in the AASHTO LRFD Bridge Construction Specifications.

The body of the anchorage will be galvanized. Other components of the anchorage including wedges, wedge plate and local zone reinforcement are not required to be galvanized. The bearing and wedge plate must be constructed from ferrous metal. Anchorages will be equipped with a permanent fiber reinforced plastic grout cap that is vented and bolted to the anchorage.

Cast anchors with grout outlets suitable for inspection from either the top or front of the anchorage. The grout outlet will serve a dual function of grout outlet and post-grouting endoscope inspection. The grout outlet must be drillable from either direction using a straight bit to facilitate endoscope inspection directly behind the anchor plate. Two castings of the same type each providing singular inspection entry location are acceptable.

939-4.2 Bar Couplers: Design couplers to be in compliance with the "AASHTO LRFD Bridge Design Specifications". Test and provide written certification that couplers meet or exceed the testing requirements in the AASHTO LRFD Bridge Construction Specifications.

939-4.3 Inlets and Outlets: Fabricate grout inlets, outlets and plugs from polypropylene meeting the requirements in article 939-4.5.3.1. All inlets and outlets will be equipped with pressure rated mechanical shut-off valves or plugs. Inlets, outlets, valves and plugs will be rated for a minimum pressure rating of 150 psi (0.69 MPa).

939-4.4 Permanent Grout Caps: Fabricate permanent grout caps from fiber reinforced plastic. Provide a grout vent on the cap with orientation at the top of the cap. Grout caps shall be sealed with neoprene "O" ring seals and shall completely cover and seal all metal parts of the anchorage exposed at the block-out. Grout caps shall be bolted to the anchor using 316 stainless steel bolts. Design the permanent grout caps with sufficient anti-oxidant additives for a maintenance free life of 75 years. Cap material will be tested for environmental stress cracking as per ASTM D 1693, Condition C, and will have an endurance of not be less than192 hours. Caps will be pressure rated at 150 psi.

939-4.5 Duct and Pipe.

939-4.5.1 General: Use only plastic duct, steel pipe or combination of plastic duct and steel pipe. All connectors, connections and components of post-tensioning system shall be air and water tight and pass the pressure test requirements herein.

939-4.5.2 Steel Pipes: Schedule 40 galvanized steel pipes as required, which conform to ASTM A53 "Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-coated, Welded and Seamless." Steel pipes used in the tendon anchorage zones will be equipped with shear transfer devices to achieve 100% of the maximum tendon force for the largest tendon that can be used for the pipe in a length equal to 25 pipe diameters.

939-4.5.3 Plastic Duct: Post-tensioning duct material for corrugated bonded and smooth duct shall meet the requirements herein. Do not use recycled material. Manufacture duct using seamless fabrication methods.

939-4.5.3.1 Material Properties: Corrugated duct shall be made of unfilled polypropylene meeting the requirements of ASTM D 4101 "Standard Specification for Polypropylene Plastic Injection and Extrusion Materials", cell classification range PP0346B44544 to PP0346B65884. In addition to the above stated requirements, the polypropylene plastic will meet these additional requirements: 0.2 % hindered amine light stabilizer non-yellowing type; environmental stress cracking as determined by ASTM D 1693, Condition C, will not be less than 192 hours.

Smooth duct shall be made of one hundred percent virgin polyethylene material meeting the requirements of ASTM D 3350 with a minimum cell class of 344464C.

939-4.5.3.2 Minimum Thickness: Corrugated duct will have a minimum thickness of 0.08 in (2.0 mm).

Smooth duct will have a dimension ratio (DR) of 17.0 as established by either ASTM D 3055 or ASTM F 714 used for manufacturing.

939-4.5.3.3 Minimum Bending Radius for Corrugated Duct:

Through testing, the manufacturer will establish the minimum bending radius for the duct. The test consists of a 1/2" diameter (270 ksi (1860 MPa)) strand stressed to 0.75 % GUTS bearing on an un-grouted duct for a length of not more than 4 feet (1.22 m). The test will have a duration of seven days. Upon completion of the test period, the duct will be removed and the minimum thickness along the strand path must not be less than 0.06 in (1.5 mm).

939-4.5.3.4 Manufacturing of Smooth Duct:

The minimum pressure rating of the duct is 100 psi (0.69 Mpa). Use a polyethylene material which meets the requirements of 939-4 herein and manufacture duct to either of the following specifications ASTM D 3035 "Standard Specifications for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter" or ASTM F 714 "Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter".

939-4-5.3.5 Manufacturing and Component Testing

Test components for corrugated duct to comply with the requirements of Chapter 4 Articles 4.1 through 4.1.8 of FIB Technical Report, Bulletin 7, titled "Corrugated Plastic Duct for Internal Bonded Post-Tensioning". To order the technical report, contact the International Federation for Structural Concrete (FIB) at e-Mail fib@epfl.ch.

939-5 Duct or Pipe Minimum Diameter.

Use duct for bar and monostrand that have a minimum internal diameter of at least 0.5 in (13 mm) larger than the outside diameter (maximum dimension) of the prestressing bar, strand or coupler.

Use ducts for tendons (composed of strand) that have a minimum empty cross-sectional area 2.5 times the cross-sectional area of the prestressing steel.

939-6 Connection Tolerance Between Pipe and Duct.

When a steel pipe and plastic duct are connected to each other, the outside diameters will vary not more than ± 0.12 in (3.0 mm) in order to achieve a leak tight connection.

939-7 External Duct Connections (Smooth Duct).

Make all connections between the steel pipe duct embedded in concrete and a plastic duct by using a neoprene sleeve. The connecting neoprene sleeve will have a minimum pressure rating of 100 psi (0.69 MPa). Use a circular neoprene sleeve with a minimum wall thickness of 1/2 inch reinforced with a minimum of 1 layer of fabric reinforcement of 100 percent glass fibers of "E" type yarn. Use a 1 inch (25.4 mm) wide power seated band on each end of the boot to seal against leakage of grout. The band

will be installed with an 80 to 120 lb (356 to 534 N) seating force. Clamps and the seating band assembly will be constructed from 316 stainless steel.

All other connections shall be mechanical and have a minimum pressure rating of 100 psi. (0.69MPa).

939-8 Internal Duct connections (Corrugated Duct).

All splices, joints, joints between segments (segmental construction), couplings and connections to anchorages shall be made with mechanical or shrink wrap connections producing a smooth interior alignment and a sealed connection with no lips or kinks. Duct tape is not permitted to join or repair duct connections.

939-9 Shipping and Storage of Ducts.

Furnish duct with end caps to seal the duct interior from contamination. Ship in bundles which are capped and covered during shipping and storage.

939-10 System Test Requirements.

939-10.1 Smooth Duct Systems (External Tendons): For each family of sizes and types of post-tensioning systems test three assemblies which represent the range of sizes for that system. Assemble the unit and perform the pressure test defined herein. The post-tensioning assembly includes all components necessary to construct the tendon excluding prestressing steel. After maintaining a pressure of 150 psi (0.69Mpa) in the system for 3 hours, the assembly shall sustain a 150 psi (0.69 MPa) internal pressure for five minutes with no more than 10.0 % reduction in pressure to be approved.

939-10.2 Corrugated Duct Systems (Internal Tendons): For each family of sizes and types of post-tensioning systems test three assemblies which represent the range of sizes for that system. Assemble the system units and perform the pressure test defined herein. The post-tensioning assembly includes all components necessary to construct the tendon excluding prestressing steel. Modify this test to include one duct segment coupler (for segmental construction) with the system test. Cast the coupler into a two part concrete test block joined by epoxy or restrain the joint by other means. Test the assembly for compliance with the requirements of FIB Technical Report, Bulletin 7, Chapter 4, Article 4.2 through 4.2.2 titled "Corrugated Plastic Duct for Internal Bonded Post-tensioning".

POST-TENSIONING GROUT.
(REV 7-30-01) (1-02) (DRAFT5/7/02)

PAGE 875. The following new Section is added after Section 937.

SECTION 938
POST-TENSIONING GROUT

938-1 General Requirements.

This section covers grouts to be used to protect post-tensioning steel. Grout applications are differentiated into three applications horizontal, vertical and repair.

Grouts shall be prepackaged in plastic lined or coated bags. Grout bags shall indicate application, date of manufacture, LOT number and mixing instructions. Any change of materials or material sources requires new testing and certification of the conformance of the grout with this Specification. A copy of the Quality Control Data Sheet for each lot number and shipment sent to the job site shall be provided to the Contractor by the grout supplier and furnished to the Engineer. Materials with a total time from manufacture to usage in excess of six months shall be retested and certified by the supplier before use or the material shall be removed and replaced.

938-2 Qualified Products List.

Use only post-tensioning grouts that are listed on the Department's Qualified Products List (QPL). Manufacturers of post-tensioning grout seeking evaluation of their product shall submit an application in accordance with Section 6 and include certified test reports from an independent laboratory, audited by Cement Concrete Reference Laboratory (CCRL), which shows the material meets all the requirements specified herein. Provide a written certification from the manufacturer that the product meets the requirements of this section.

938-3 Mixing.

The material shall be mixed in accordance with the manufacturer’s recommendations.

938-4 Grout Physical Properties.

938-4.1 Gas Generation.

The grout shall not contain aluminum powder or components which jk produce hydrogen, carbon dioxide or oxygen gas.

938-4.2 Laboratory Test.

The grout shall meet or exceed the specified physical properties stated herein as determined by the following standard and modified ASTM test methods.

Property	Test Value	Test Method
Total Chloride Ions	Max. 0.08% by weight of cementitious material	ASTM C 1152
Fine Aggregate (if utilized)	Max Size $\leq$ No. 50 Sieve (300 micron)	ASTM C 33
Hardened Height Change @ 24 hours and 28 days	0.0% to 0.2%	ASTM C 1090*
Expansion	$\leq$ 2.0% for up to 3 hours	ASTM C 940
Compressive Strength 28 day (Average of 3 cubes)	$\geq$ 7,000 psi [48.3 MPa]	ASTM C 942
Initial Set of Grout	Min. 3 hours Max. 12 hours	ASTM C 953
Fluidity Test** Efflux Time from Flow Cone		
(a) Immediately after mixing	Min. 20 Sec. Max. 30 Sec.	ASTM C 939
	or Min. 9 Sec. Max. 20 Sec.	ASTM C 939***
(b) 30 minutes after mixing with remixing for 30 sec	Max. 30 Sec.	ASTM C 939
	or Max. 30 Sec.	ASTM C 939***
Bleeding @ 3 hours	Max. 0.0 percent	ASTM C 940****
Permeability @ 28 days	Max. 2500 coulombs at 30 V for 6 hours	ASTM C 1202

*Modify ASTM C 1090 to include verification at both 24 hours and 28 days.
**Adjustments to flow rates will be achieved by strict compliance with the manufacturer's recommendations.
***Grout fluidity shall meet either the standard ASTM C 939 flow cone test or the modified test described herein. Modify the ASTM C 939 test by filling the cone to the top instead of to the standard level. The efflux time is the time to fill a one liter container placed directly under the flow cone.
****Modify ASTM C 940 to conform with the wick induced bleed test as follows:

(a) Use a wick made of a 20 inch [0.5 m] length of ASTM A 416 seven wire 0.5 inch [12.7 mm] diameter strand. Wrap the strand with 2 inch [50 mm] wide duct or electrical tape at each end prior to cutting to avoid splaying of the wires when it is cut. Degrease (with acetone or hexane solvent) and wire brush to remove any surface rust on the strand before temperature conditioning.

(b) Condition the dry ingredients, mixing water, prestressing strand and test apparatus overnight at 65 to 75^0F [18 to 24^0C].

(c) Mix the conditioned dry ingredients with the conditioned mixing water and place 800 ml of the resulting grout into the 1,000 ml graduate cylinder. Measure and record the level of the top of the grout.

(d) Completely insert the strand into the graduated cylinder. Center and fasten the strand so it remains essentially parallel to the vertical axis of the cylinder. Measure and record the level of the top of the grout.

(e) Store the mixed grout at the temperature range listed above in (b).

(f) Measure the level of the bleed water every 15 minutes for the first hour and hourly for two successive readings thereafter.

(g) Calculate the bleed water, if any, at the end of the three hour test period and the resulting expansion per the procedures outlined in ASTM C 940, with the quantity of bleed water expressed as a percent of the initial grout volume. Note if the bleed water remains above or below the top of the original grout height. Note if any bleed water is absorbed into the specimen during the test.

938-5 Simulated Field High Temperature Fluidity Test.

Perform a conditioned laboratory high temperature grout fluidity test as described below using production grouting equipment having both mixing and storage tanks. Grouts to be tested must conform with the requirements of Article 938-4 including initial fluidity test. For the test to be successful, the grout must have an efflux time of not greater than 30 seconds at the end of the one hour test period. Efflux time may be determined by either ASTM C 939 or the modified ASTM C 939 described herein.

(a) Perform the test in a temperature conditioned laboratory. Condition the room, grout, water, duct, pump, mixer and all other equipment to be used to temperature of 90^{o}F [32.5^{o}C] for a minimum of 12 hours prior to the test.

(b) Use 400 feet [122 m] ($\pm$10 feet [3.0 m]) of duct (tube) for the test. Use a duct with an inside diameter of 1 inch [25 mm]

(c) Mix the grout to the specified water content. Pump the grout through the duct until the grout discharges from the outlet end of the duct and is returned to the pump.

(d) Start the one hour test period after the duct is completely filled with grout. Record the time to circulate the grout through the duct. Constantly pump and recirculate the grout into the commercial grout mixer storage tank.

(e) Pump and recirculate the grout for a minimum of one hour.

(f) Record, 10 minute intervals throughout the test period, the pumping pressure at the inlet, the grout temperature and fluidity at the discharge outlet.

938-6 Accelerated Corrosion Test Method (ACTM).

Perform the ACTM as outlined in Appendix B of the "Specification for Grouting of Post-Tensioned Structures" published by the Post-Tensioning Institute. Report the time to corrosion both for the grout being tested and the control sample using a 0.45 water-cement ratio neat grout. To order the guide specification contact the Post-Tensioning Institute at http://www.post-tensioning.org.

A grout that shows a longer average time to corrosion in the ACTM than the control sample and the time to corrosion exceeds 1000 hours is considered satisfactory.

938-7 Variation in Testing for Specific Applications.

938-7.1 Horizontal Applications.

Horizontal grout applications are defined as tendon grouting where the maximum vertical elevation gain from the low to the high points along the tendon being grouted is less than 20 feet (6.1m). All requirements defined in Articles 938-4, 938-5 and 938-6 are applicable for grouts used in horizontal applications.

938-7.2 Vertical Applications.

Vertical grout applications are defined as tendon grouting where the maximum vertical elevation gain from the low to the high points along the tendon being grouted is equal to or greater than 20 feet (6.1m). All requirements defined in Articles 938-4, 938-5 and 938-6 are applicable for grouts used in vertical applications. In addition, perform the Schupack Pressure Bleed Test Procedure for Cement Grouts for Post-Tensioned Structures as outlined in Appendix C of the "Specification for Grouting of Post-Tensioned Structures" published by the Post-Tensioning Institute. Report the percent bleed for the grout tested. Test grout at the specified pressure of 100 psi (689 kPa). An acceptable test will result in no bleed water (0.0 percent).

938-7.3 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 grout approved for use in the tendon as long as the volume of the void is less 0.5 gal. (2.0 l). In all other cases, use a non-sanded grout meeting the requirements of 938-4 and 938-6 with a modified maximum permeability of 2800 coulombs (ASTM C 1202 at 30 volts).

Section 940 **(to be merger into 926)**

Epoxy Grout for Post-Tensioning Termini

940-1 General Requirements

This section covers epoxy material to be used to protect the termini (anchorages) of post-tensioning tendons or bars and other uses indicated in the plans. The material shall produce a low exotherm reaction and have flow and fill characteristics suitable for machine base plate applications. The material will be extended with the aggregate supplied by the manufacturer. Mix with the full aggregate loading unless the use of less aggregate is approved by the Engineer.

940-2 Qualified Products List

Use only epoxy materials that are listed on the Department's Qualified Products List (QPL). Manufacturer seeking evaluation of their products shall submit an application in accordance with Section 6 and include independently certified test reports. Provide a written certification from the manufacturer that the product meets the requirements of this section. The manufacturer must submit written documentation that the plant which manufactures the epoxy grout meets ISO 9901 & 9002 Standards or a recognized equivalent Quality Assurance Program, such as 10CFR50 Appendix B, Quality Assurance Criteria for Nuclear Power Plants.

940-3 Physical Properties

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.

Property	Test Value	Test Method
Compressive Strength Cubes 7 day Cure @ 77ºF (25ºC)	> 10,000 psi (82.7 MPa)	ASTM C 579B
Tensile Strength @ 7 day	> 2100 psi (14.5 MPa)	ASTM C 307
Flexural Strength @ 7day Cure @ 77ºF (25ºC)	> 4000 psi (27.6 MPa)	ASTM C 580
Modulus of Elasticity 7 day Cure @ 77ºF (25ºC)	< 2,100,000 psi (14.5 GPa)	ASTM C 580
Coefficient of Thermal Expansion @ 74 to 210^{o}F (23 to 99 ^{o}C)	< 19 x 10 $^{-6}$ in/in/ºF (10.6 x 10 $^{-6}$ mm/mm/^{o}C	ASTM C 531

Peak Exotherm, Specimen 12 x 12 x 3 in. (305 x 305 x 76 mm)	< 150ºF (66ºC)	ASTM D 2471
Slant Shear @ 7 days (Bond Strength to Concrete)	> 3200 psi (21.1 MPa)	ASTM C 882
Thermal Compatibility	≥ 5 Cycles Passed	ASTM C 844
Linear Shrinkage @ 7 days	≤ 0.025%	ASTM C 531
Flowability and Bearing Area	≥ 90% Contact area	ASTM C 1339
Gel Time, Specimen 12 x 12 x 3 in. (305 x 305 x 76 mm)	< 4:00 (hr.)	ASTM C 2471

940-4 Material Supply and Storage

The material shall be factory pre-proportioned including factory supplied aggregate. Deliver products in original containers with manufacturer's name, date of manufacture, product identification label and batch numbers. Materials must be within the manufacturer's recommended shelf life. Store and condition the product in full compliance with the manufacture’s recommendations.

Draft 5-7-02
(to be merged into 930)

Section 950
Magnesium Ammonium Phosphate Concrete

950-1 General Requirements

This section covers magnesium ammonium phosphate concrete (MAPC) to be used to repair block-outs and holes in post-tensioned boxes and girders. Good surface preparation is essential and air curing is required. The manufacturer's representative will be consulted to confirm satisfactory mixing methods and water content. Accurate control of the quantity of water used for mixing this material is required.

950-2 Qualified Products List

Use only MAPC that is listed on the Department's Qualified Products List (QPL). Manufacturers seeking evaluation of products shall submit an application in accordance with Section 6 and include independently certified test reports. Provide a written certification from the manufacturer that the product meets the requirements of this section.

950-3 Material Supply and Storage

The material shall be pre-proportioned including aggregate. Deliver products in original, unopened bags with manufacturer's name, date of manufacturer, product identification label and batch numbers. 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.

950-4 Physical Properties

The MAPC material shall meet or exceed the specified physical properties stated herein as determined by the following standard ASTM test methods.

Property	Test Value	Test Method
Compressive Strength @ 28 days	> 8500 psi (58.6 MPa)	ASTM C 109*
Flexural Strength @ 28 days, Specimen 1 9/16 x 1 9/16 x 6 5/16 in. (40 x 40 x 160 mm)	> 600 psi (4.1 MPa)	ASTM C 348*
Slant Shear Bond @ 14 days	> 2500 psi (17.2 MPa)	ASTM C 882*
Freeze Thaw Resistance	RDF 80%	ASTM C 666**
Initial Set Time	15 min @ 95ºF (35ºC) min.	ASTM C 266

Scaling Resistance	No scaling	ASTM C 672***
Shrinkage @ 28 days	$\leq$ 0.03%	ASTM C 596
Sulfate Resistance after 52 week of immersion	$\leq$ 0.1%	ASTM C 1012
Chloride Absorption, Weight Change At 21 days, Specimen 4 in cubes (102 mm)	$\leq$ 1.5 %	NCHRP T-244

* Modified test methods for air curing instead of moist curing.
** 300 Cycles
*** 25 Cycles

Draft 5-7-02
(changed to 975)

Section 956

Elastomeric Coating System

956-1 General Requirements

This section defines the requirements for an elastomeric polyurethane waterproof coating system (prime and subsequent coats). This system is to be used to provide an elastomeric coating providing a waterproof barrier over the termini (anchorage) of post-tensioning or other areas designated in the plans. The coating system must be supplied by a single manufacturer and sold as a waterproof coating system. The surface preparation and application of the coating system must be applied in strict accordance with the manufacturer's specifications.

956-2 Qualified Products List

Use only elastomeric coating systems that are listed on the Department's Qualified Products List (QPL). Manufacturer seeking evaluation of products shall submit an application in accordance with Section 6 and shall include independently certified test reports. Provide a written certification from the manufacturer that the product meets the requirements of this section. The manufacturer must have quality control standards conforming to ISO 9000 Standards.

956-3 Physical Properties

The elastomeric coating system is composed of several coats. The use of an epoxy prime coat is dependant upon the requirements of the manufacture’s waterproofing system. The polyurethane chemistry may be either waterborne aromatic (moisture-curing) or aromatic (moisture-sensitive). The total thickness of the system is not less than 30 mils. The minimum properties for the cured coating system are defined below.

Property	Test Value	Test Method
Hardness, Shore A	Between 60 and 90	ASTM D 2240
Tensile Strength	$\geq$ 750 psi (5.2 MPa)	ASTM D 412
Elongation	$\geq$ 400 %	ASTM D 412
Tear Strength	> 70 pli	ASTM C 957
Abrasion Resistance H-18 wheels 1000 gm/wheel	$\leq$ 350 mg loss / 1000 revs.	ASTM C 957
Crack Bridging 1000 Cycles	System Passes	ASTM C 957
Elongation Recovery	$\geq$ 94%	ASTM C 957

956-4 System Modifications for Use on Bridge Substructure

Supply the elastomeric coating system with a aliphatic polyurethane top coating with a matching color to the color scheme shown in the plans when applied to bridge substructures. If no color scheme is shown on the plans utilize a color similar to Federal Color Standard No. 595B, Table VIII, Shade No. 36622.

POST-TENSIONING INSTRUCTIONAL SHEET

PLAN REQUIREMENTS FOR PROJECTS THAT UTILIZE POST-TENSIONING

1. Grouting and Anchor Protection: In addition to providing post tensioning quantity and stressing information on the plans, the designer shall provide general grouting information for each tendon type and anchor protection information for all tendons on the project. See the example post-tensioning schedules shown below for both PT Bar and strand type tendons, respectively. Also refer to the Post-Tensioning Vertical Profiles Index and Post-Tensioning Anchorage Protection Index, Index Nos. 1801 and 1802, respectively.
2. The plan details should be consistent with the Post-Tensioning Structural Standards and the Post-Tensioning Specifications.
3. Details shown in the Post-Tensioning Anchorage and Grouting Details - Index No. 1803 shall be incorporated into the Contract Documents.
4. In cases where the tendon types and anchor protection details are not sufficient for specific project requirements, the designer shall supplement the drawings as necessary. Deviation from Standard Drawings, however require the Department's approval.
5. Detail to the following FDOT Standard tendon anchorage capacities: 4k6, 7k6, 12k6, 19k6, 27k6.
6. Any deviations from these standards shall be apporved by the Department.

PT BAR QUANTITY / STRESSING / GROUTING / ANCHOR PROTECTION SCHEDULE

BAR DESIGNATION	NO. REQUIRED	BAR QUANTITY & SIZE	BAR LENGTH (ft-in)	BAR WEIGHT (lbs)	TOTAL WEIGHT (lbs)	STRESSING FORCE (kips)	ELONGATION (in)	* TENDON PROFILE	** ANCHOR PROTECTION TYPE	
									UP STA.	DOWN STA.
T1	8	1-1 3/8"Ø	17-0	56.2	449.6	170.6	5/8	12	5	7

* See Post-Tensioning Vertical Profiles, Index No. 1801.
** See Post-Tensioning Anchorage Protection, Index No. 1802. For transverse tendons, up station denotes left anchor, down station denotes right anchor (looking up station). For vertical bars, up station denotes top anchor, down station denotes bottom anchor.

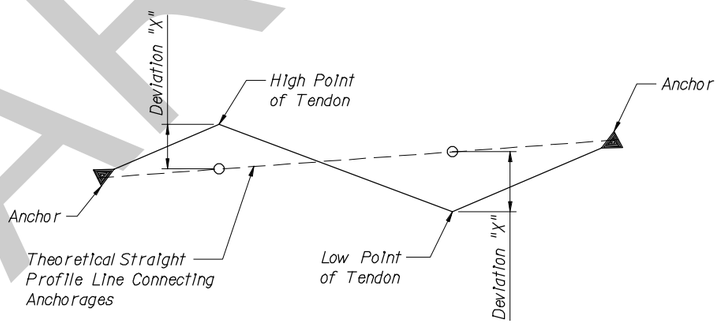
TENDON QUANTITY / STRESSING / GROUTING / ANCHOR PROTECTION SCHEDULE

TENDON DESIGNATION	NO. REQUIRED	TENDON QUANTITY & SIZE	TENDON LENGTH (ft-in)	TENDON WEIGHT (lbs)	TOTAL WEIGHT (lbs)	STRESSING FORCE (kips)	STRESSING END	ELONGATION (in)		* TENDON PROFILE	** ANCHOR PROTECTION TYPE	
								BEFORE ANCHOR SET	AFTER ANCHOR SET		UP STA.	DOWN STA.
2C1	4	12X0.6"Ø	30-0	466.2	1864.8	951	UPSTATION	2.71	2.47	9	1A	3

* See Post-Tensioning Vertical Profiles, Index No. 1801.
** See Post-Tensioning Anchorage Protection, Index No. 1802. For transverse tendons, up station denotes left anchor, down station denotes right anchor (looking up station). For vertical tendons, up station denotes top anchor, down station denotes bottom anchor

Notes: Tendon Profiles - Index No. 1801

1. Top slab transverse tendons with Deviation "X" less than or equal to 18" shall be treated as a Profile 12 tendon for grouting procedures (see sketch).
2. Top slab cantilever tendons with Deviation "X" less than or equal to 18" shall be treated as a Profile 12 tendon for grouting procedures (see sketch).
3. Bottom slab continuity tendons with Deviation "X" less than or equal to 18" shall be treated as a Profile 12 tendon for grouting procedures (see sketch).



TENDON PROFILE DEVIATION

SHOP DRAWING REVIEW AND REVIEW OF CONTRACTOR'S GROUTING PLAN

1. Shop Drawings
   a. Shop Drawings shall conform to the requirements of Section 462.
   A partial list of essential elements are as follows:
      i. Post-tensioning systems to be used.
      ii. Layout showing locations and geometry.
      iii. Duct spacing and supports
      iv. Inlet and outlet locations.
      v. Stressing sequence and friction
      vi. Inspection details
   b. Verify that PT systems are consistent with Contractor's Grouting Plan.
   c. Layout for post-tensioning systems shall at a minimum include the following:
      i. Anchor access after grouting for inspection.
      ii. Anchor access for vacuum grouting of voids.
      iii. Injection ports at all low point and at all anchor locations consistent with indices.
      iv. Grout outlets and inspection access at all high points and at all locations consistent with indices.
      v. All individual concrete element shop drawings shall clearly cross-reference the necessary PT systems components by type and name.

2. Contractor's Grouting Plan: The Engineer of Record should work with the Project Engineer and review the Contractor's Grouting Plan submittal along with construction personnel. The Contractor's Grouting Plan shall include, but is not limited to the following items for each tendon on the project.
   a. Type, quantity, and brand of materials used in grouting including all certifications required.
   b. Type of equipment furnished, including capacity in relation to demand and working condition, as well as back-up equipment and spare parts.
   c. General grouting procedure.
   d. Duct pressure test and repair procedures.
   e. Method to be used to control the rate of flow within ducts.
   f. Theoretical grout volume calculations.
   g. Types and locations of inlet and outlet pipes consistent with plan requirements.
   h. Duct cleaning methods prior to grouting.
   i. Mixing and pumping procedures.
   j. Direction of grouting.
   k. Grouting process for each tendon on project including injection locations (low points), vent closure sequence, and time delayed grout phasing.
   l. Sequence of use of the inlets and outlet pipes.
   m. Procedures for handling blockages.
   n. Procedures for possible post grouting repair.

REVISIONS					
DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION

	NAMES	DATES
DRAWN BY	JVH	.
CHECKED BY	TAA/LMS	.
DESIGNED BY	JVH/TAA	.
CHECKED BY	RVR/LMS	.
APPROVED BY	WNN	

ENGINEER OF RECORD.
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FLORIDA DEPARTMENT OF TRANSPORTATION

ROAD NO.	COUNTY	FINANCIAL PROJECT ID
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SHEET TITLE.
INSTRUCTIONAL NOTES POST-TENSIONING
INDEX NO. 1-1800

PROJECT NAME.
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SHEET NO.
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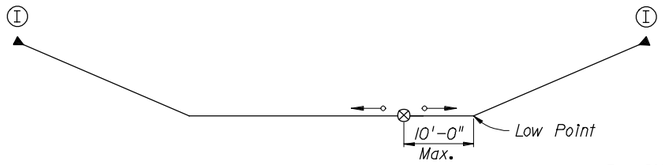

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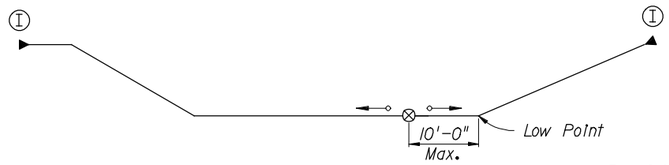

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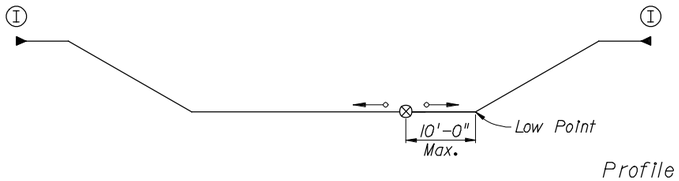

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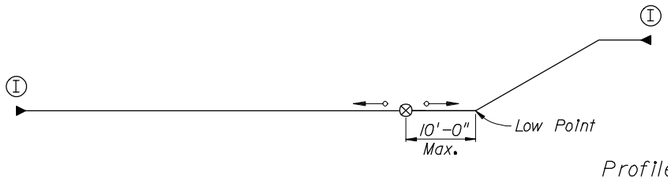

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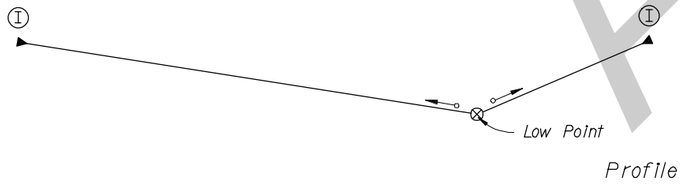
Profile 5



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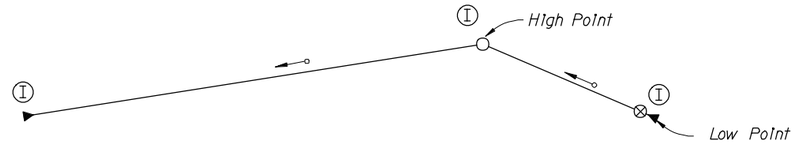

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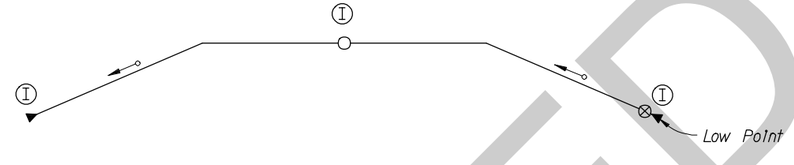

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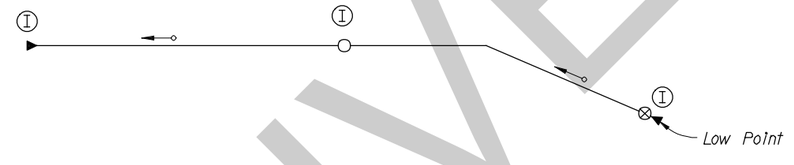

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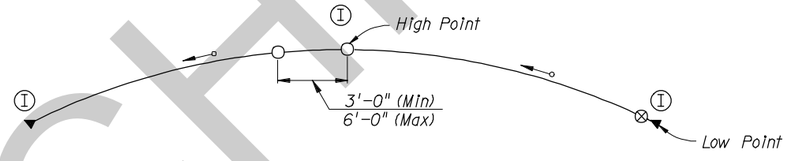

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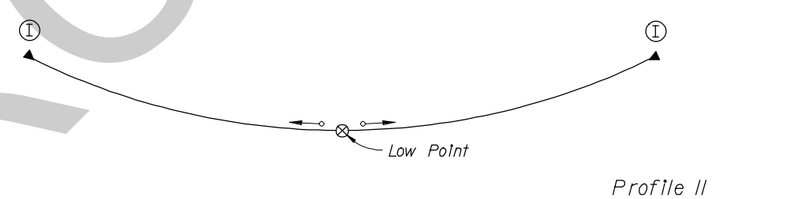

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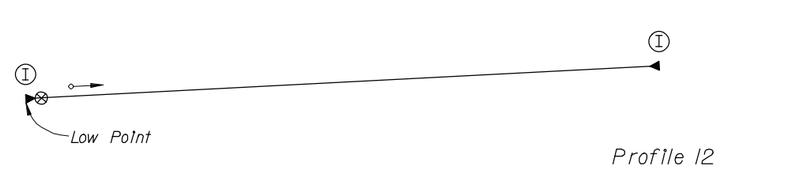

Profile 12

General Notes:

1. The details shown on Standards Indices No. 1801, 1802, and 1803 depcit the final condition of the post-tensioning system. The standards assume certain methods to obtain the required final condition. The Contractor may elect to modify these methods with the approval of the Engineer of Record provided the post-tensioning system is protected from contamination during all intermediate steps and the final condition conforms with the requirements of the Contract Documents.
2. For specifications regarding grouting procedures, and post-tensioning systems, see Section 462 (Post-Tensioning).
3. For surface preparation and other details of the epoxy grout pour-backs, see Specifications Section 926 (Epoxy Grout for Post-Tensioning Terminl).
4. For surface preparation and other details of the elastomeric coating, see Specifications Section 975 (Elastomeric Coating System).
5. For surface preparation and other details of the Magnesium Ammonium Phosphate Concrete, see Specifications Section 930 (Magnesium Ammonium Phosphate Concrete) (MAPC).
6. If deviations from these standard methods are proposed The Contractor shall demonstrate through a mock-up or other methods that his proposed grouting plan adequately fulfills the requirement of fully grouted tendons.
7. The Contractor shall attach pressure gages to all grout inlets during the grouting operation. Locations of all pressure gages shall be noted on the grouting operations plan.
8. The grout outlets shown shall be adjusted to accomodate the true high point of the tendon in the completed structure.
9. All grout inlets / outlets are to be sealed using threaded plugs with the exception of inlets / outlets exiting to a vertical face or exiting from the bottom of the bottom soffit.
10. All grout inlets / outlets exiting on vertical surfaces shall be directed toward the inside face of exterior girders or toward the interior of cellular boxes.
11. See "POST-TENSIONING VERTICAL PROFILES (1 OF 2)" for General Notes and Notes on Grouting Procedures.
12. See Index No. 1802 for "POST-TENSIONING ANCHORAGE PROTECTION"
13. See Index No. 1803 for "POST-TENSIONING ANCHORAGE AND GROUTING DETAILS"

Legend:

- Strand Tendon
- End Anchor with Grout Outlet
- Grout Inlet
- Grout Outlet
- Optional Grout Outlet
- Drain / Grout Inlet
- Direction of Grout Flow
- Inspection Location

PRELIMINARY

REVISIONS					
DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION

	NAMES	DATES
DRAWN BY	JVH	.
CHECKED BY	TAA/LMS	.
DESIGNED BY	JVH/TAA	.
CHECKED BY	RVR/LMS	.
APPROVED BY	WNN	

ENGINEER OF RECORD.

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FLORIDA DEPARTMENT OF TRANSPORTATION

ROAD NO.	COUNTY	FINANCIAL PROJECT ID
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SHEET TITLE.

POST-TENSIONING VERTICAL PROFILES
INDEX NO. 1801, DRAWING 1 OF 2

PROJECT NAME.

SHEET NO.

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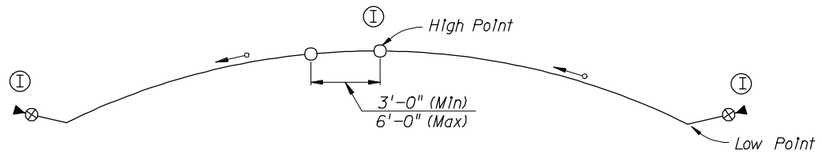
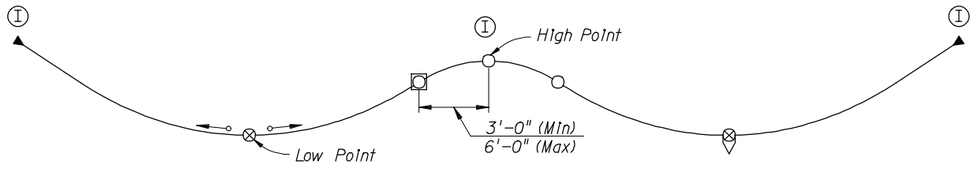
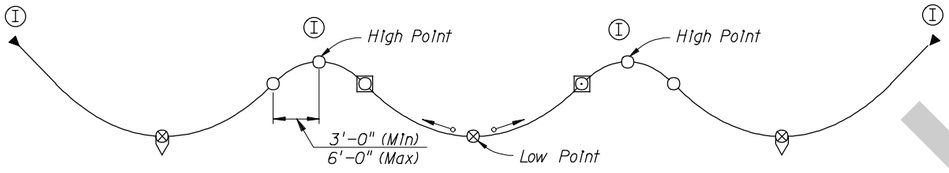


Profile 13

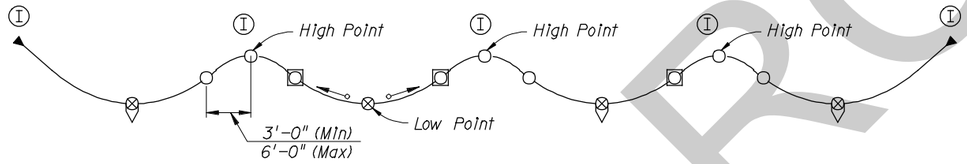
Post-Tensioning Vertical Profiles for Staged Grouting



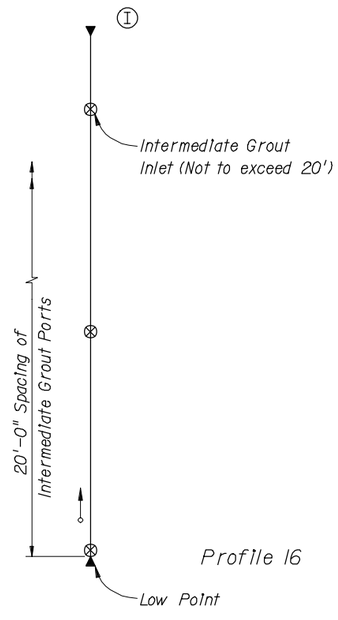
Profile 14



Profile 15



Profile 16



Profile 16

NOTES: Grouting Procedures

1. Take into account longitudinal grade, if any, and establish direction of grouting.
2. Orient end anchors so that grout outlet is at the top.
3. Provide grout outlets at all anchors.
4. Provide grout inlet at low point of all tendon profiles.
5. For tendons longer than 150 feet, additional grout outlets are required.
6. Incorporate the information on these drawings into the grouting operations plan.
7. In the grouting plan, show
   a. Direction of grouting
   b. Locations of grout inlets & outlets
   c. Staged grouting operations
   d. Sequence of opening & closing vents
   e. Procedures for time delayed grout phasing of the tendons.
8. After grouting, inspect all anchors and high points for voids.
9. Vacuum grout voids and seal post-tensioning system in accordance with the specifications.

Legend:

- Strand Tendon
- End Anchor with Grout Outlet
- Grout Inlet
- Grout Outlet
- Optional Grout Outlet
- Drain / Grout Inlet
- Direction of Grout Flow
- Inspection Location

REVISIONS					
DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION

	NAMES	DATES
DRAWN BY	JVH	.
CHECKED BY	TAA/LMS	.
DESIGNED BY	JVH/TAA	.
CHECKED BY	RVR/LMS	.
APPROVED BY	WNN	

ENGINEER OF RECORD:
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FLORIDA DEPARTMENT OF TRANSPORTATION

ROAD NO.	COUNTY	FINANCIAL PROJECT ID
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SHEET TITLE:
POST-TENSIONING VERTICAL PROFILES
INDEX NO. 1801, DRAWING 2 OF 2

PROJECT NAME:
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SHEET NO.
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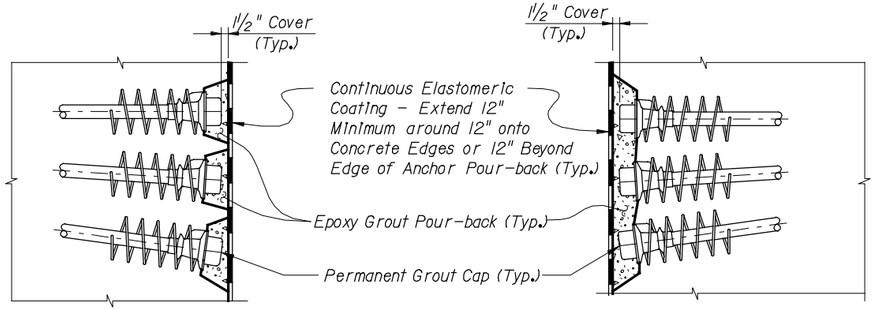
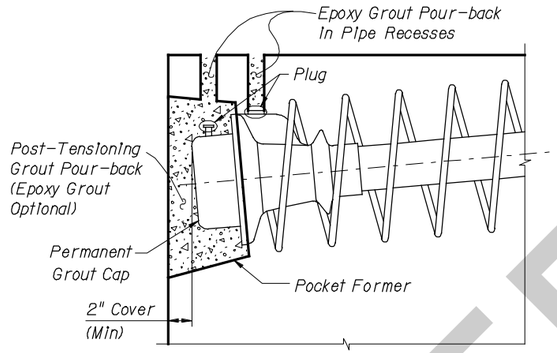


TYPE 1A TYPE 1B



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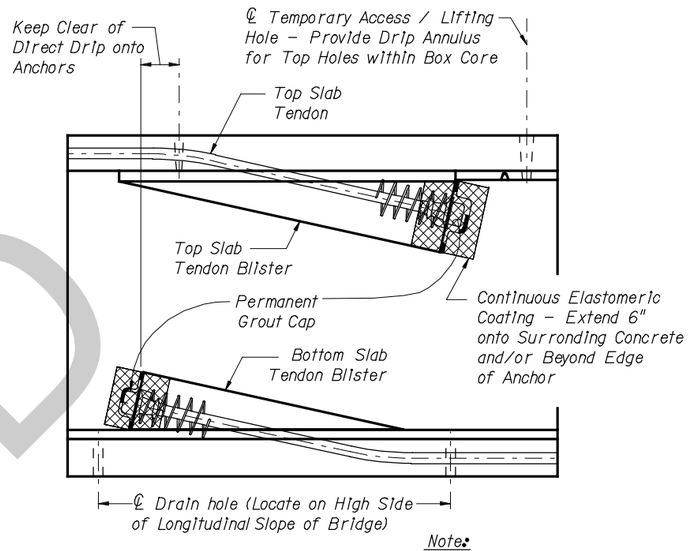
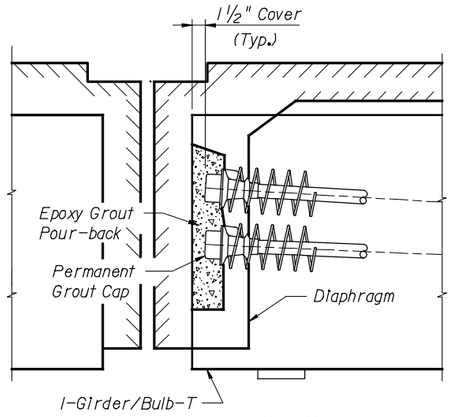


TYPE 3

Note:
Pour-backs not Required for Interior Anchors on Blisters or Pier Segments

DETAIL - TYPICAL ALTERNATE POUR-BACK TREATMENTS FOR ANCHOR PROTECTION ON EXPOSED SURFACES AND EXPANSION JOINTS

DETAIL - ANCHOR PROTECTION FOR INTERIOR ANCHORS IN CELLULAR BOXES ON BLISTERS OR PIER SEGMENTS (NOT FOR USE IN EXPANSION JOINTS)



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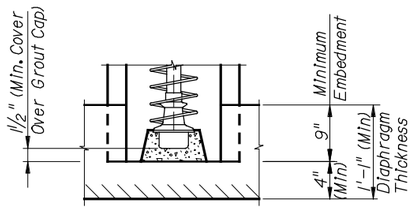
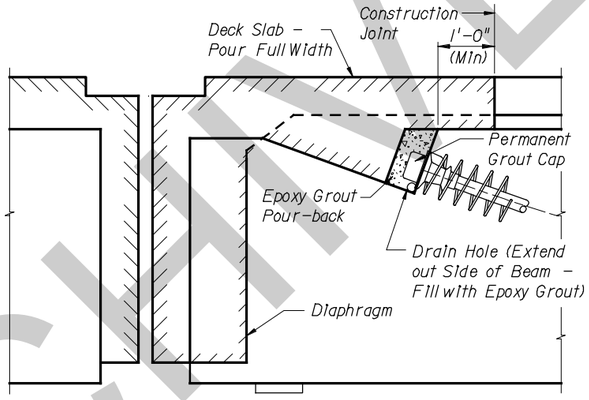


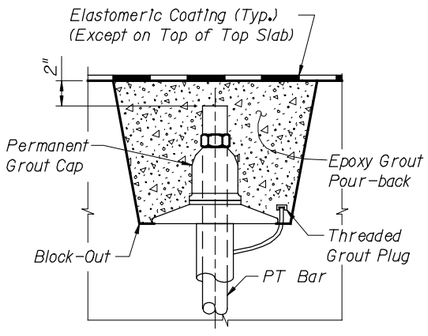
TYPE 4A

DETAIL - ANCHOR PROTECTION FOR POST-TENSIONED I-GIRDERS & BULB-T's



TYPE 4B

DETAIL - FLAT SLAB ANCHOR PROTECTION



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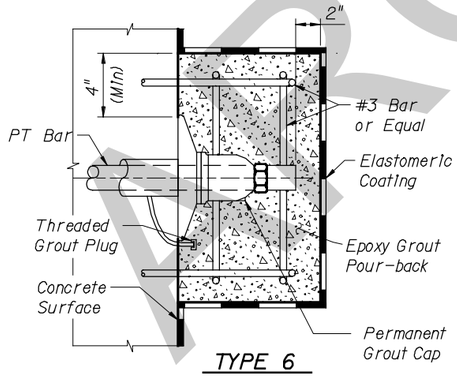
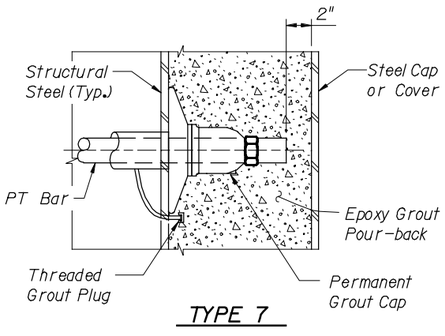


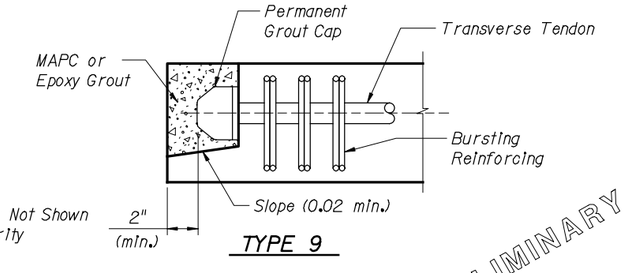
TYPE 6

DETAIL - ANCHOR PROTECTION FOR PT BARS



TYPE 7

Note:
Extend elastomeric coating 12" onto concrete edges or 12" beyond edge of anchor pour-back



Note:
Barrier Not Shown for Clarity

TYPE 9

DETAIL - TRANSVERSE TENDON ANCHOR PROTECTION

PRELIMINARY

REVISIONS					
DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION

	NAMES	DATES
DRAWN BY	JVH	.
CHECKED BY	TAA/LMS	.
DESIGNED BY	JVH/TAA	.
CHECKED BY	RVR/LMS	.
APPROVED BY	WNN	

ENGINEER OF RECORD:
.

FLORIDA DEPARTMENT OF TRANSPORTATION

ROAD NO.	COUNTY	FINANCIAL PROJECT ID
.	.	.

SHEET TITLE:
POST-TENSIONING ANCHORAGE PROTECTION
INDEX NO. 1802

PROJECT NAME:
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SHEET NO.
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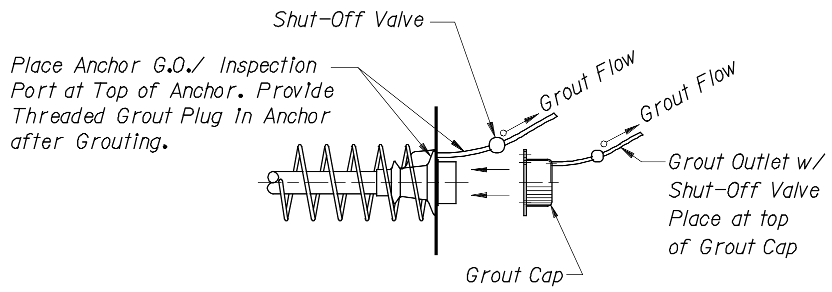
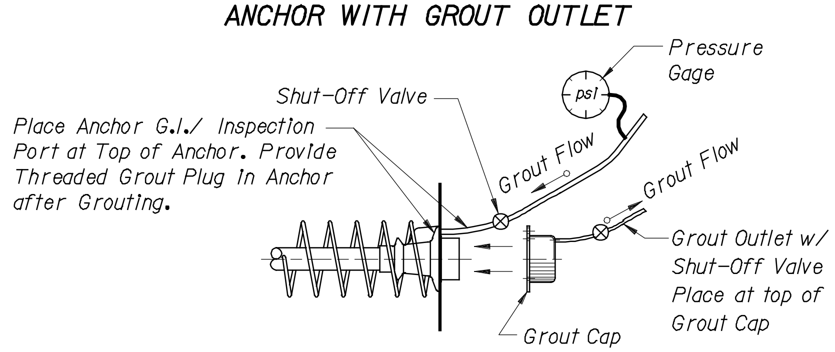
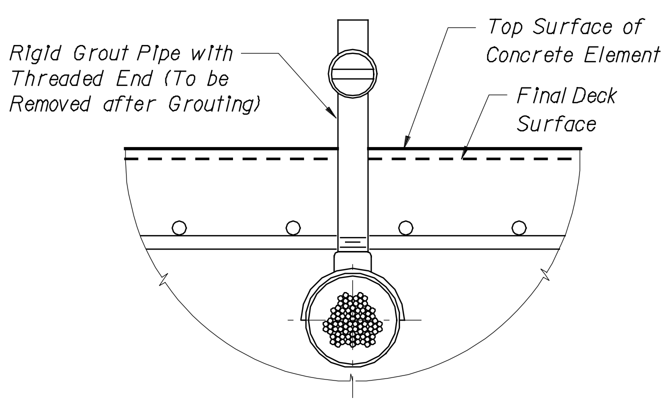


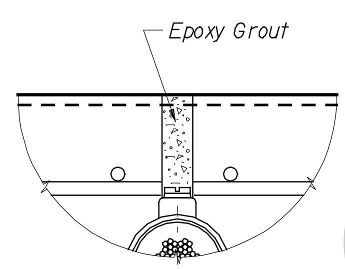
DETAIL A - FACE INSPECTED ANCHOR WITH GROUT OUTLET



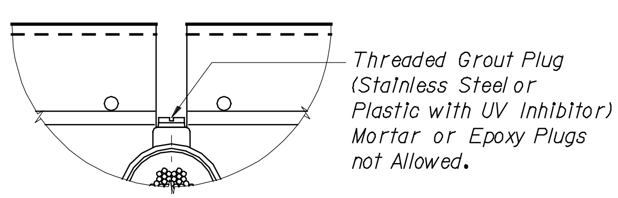
DETAIL B - FACE INSPECTED ANCHOR WITH GROUT INLET



(1) GROUT OUTLET CONNECTION TO TENDON



(3) FILLING POCKET

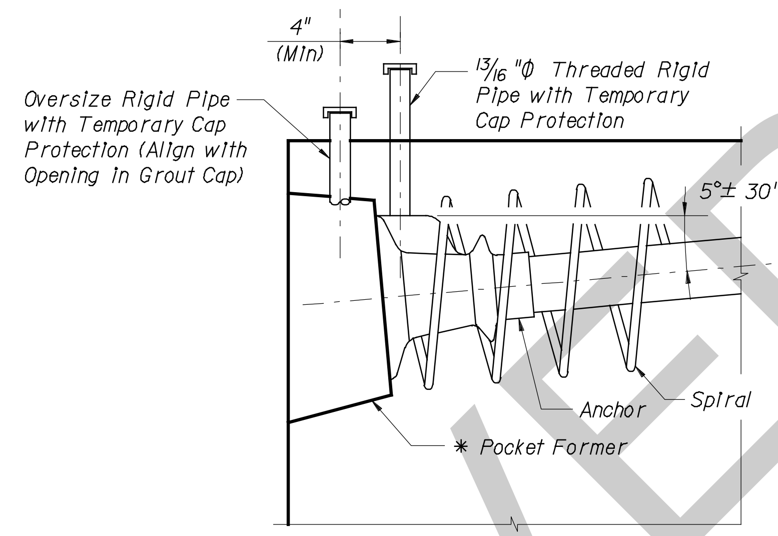


(2) POCKET PREPARATION

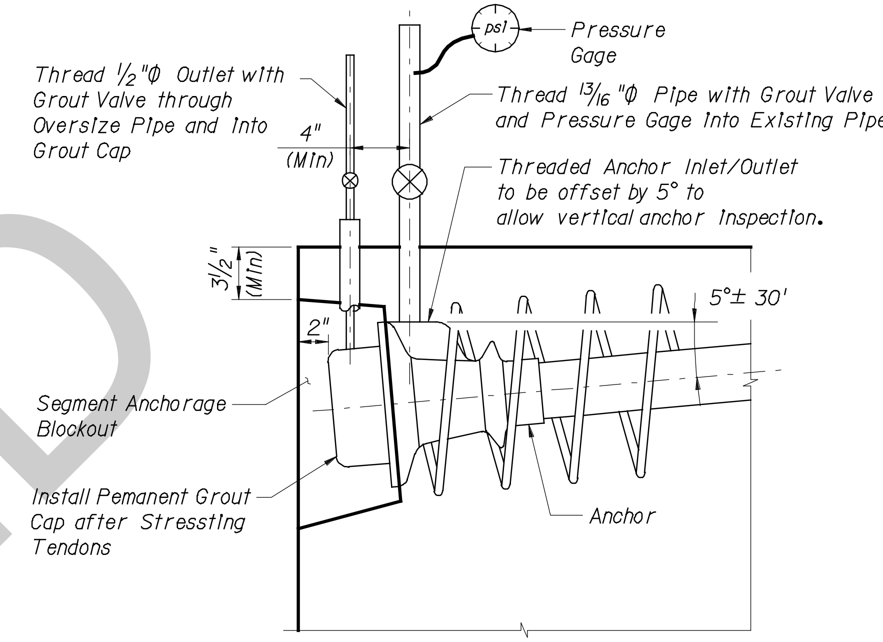
PROCEDURE

1. Remove Rigid Grout Pipe.
2. Inspect Tendon for Voids as Necessary.
3. Vacuum Grout as Required and Allow Grout to Cure for 24 hr.(min.). Remove Pipe used for Vacuum Grouting.
4. Clean Threads and Re-thread as Required.
5. Install Grout Plug and Screw Plug Into Outlet to Form a Tight Fit.
6. Over-Ream Hole (1/4"Ø Over-Ream) Clean and Roughen Sides.
7. Fill Pocket with Epoxy Grout.

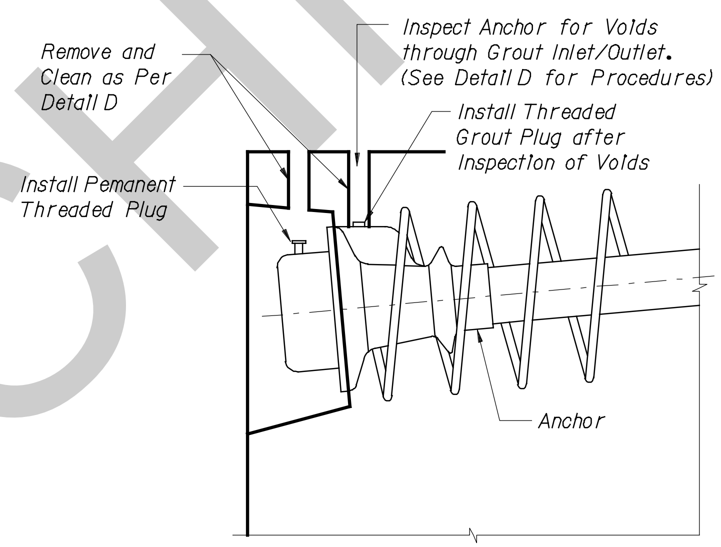
DETAIL D - HORIZONTAL SURFACES



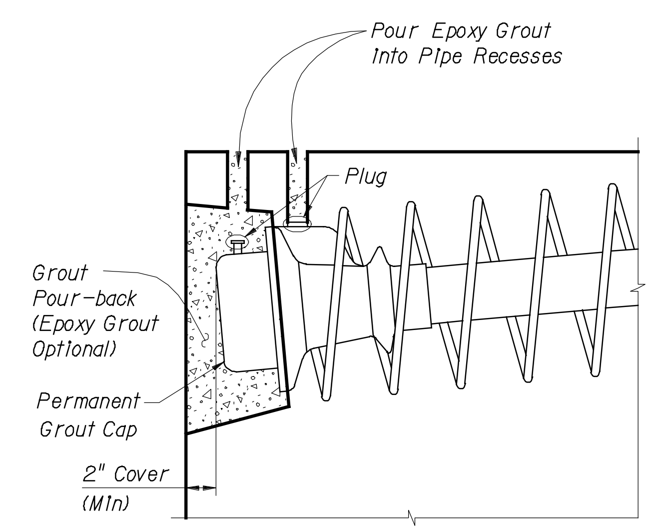
(1) INSTALLATION & SHIPPING



(2) GROUTING



(3) INSPECTION



(4) PROTECTION

DETAIL C - TOP INSPECTED ANCHOR WITH GROUT INLET
INSTALLATION, GROUTING, INSPECTION & PROTECTION

∗ Round ◯ Pocket Former - Gravity Fed Placement of Grout Acceptable
Modified Square Pocket Former - Gravity Fed Placement of Grout Acceptable
Square ☐ Pocket Former - Vacuum Grouting Required

REVISIONS					
DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION

	NAMES	DATES
DRAWN BY	JVH	.
CHECKED BY	TAA/LMS	.
DESIGNED BY	JVH/TAA	.
CHECKED BY	RVR/LMS	.
APPROVED BY	WNN	

ENGINEER OF RECORD:

FLORIDA DEPARTMENT OF TRANSPORTATION

ROAD NO.	COUNTY	FINANCIAL PROJECT ID
.	.	.

SHEET TITLE: POST-TENSIONING ANCHORAGE AND GROUTING DETAILS INDEX NO. 1803, DRAWING 1 OF 3

PROJECT NAME:

SHEET NO.

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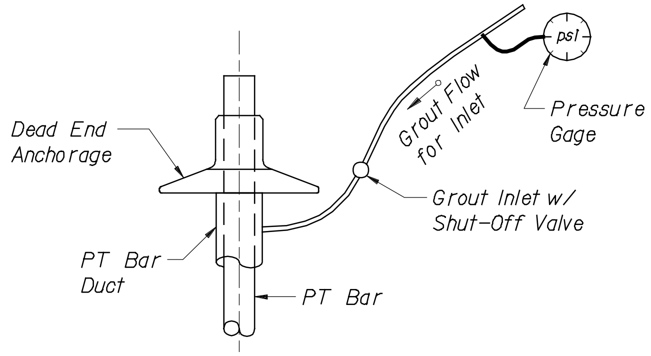
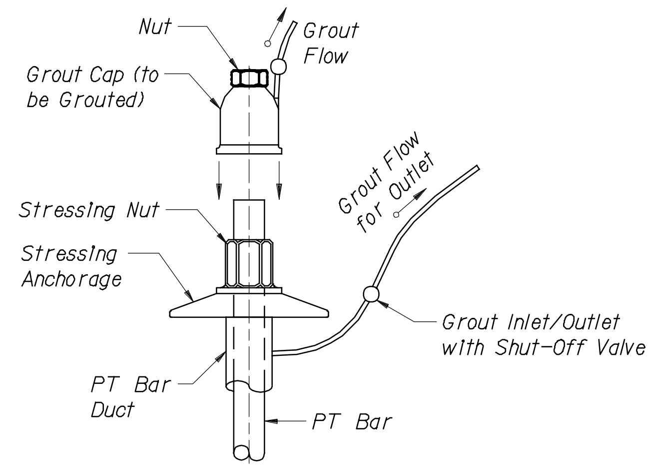
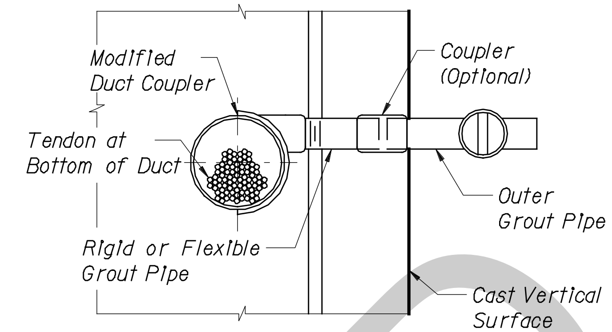


DETAIL E - PT BAR ANCHORAGE NON-STRESSING END

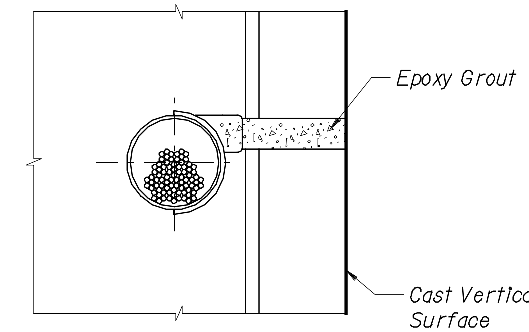


NOTE:
Stressing Anchorage or Nut to allow for Flow of Grout into Cap.

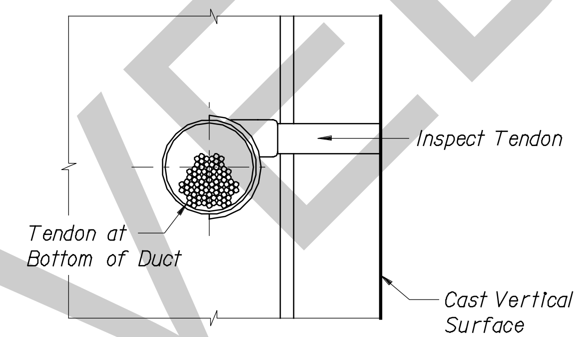
DETAIL F - PT BAR ANCHORAGE STRESSING END



(1) GROUT OUTLET CONNECTION TO TENDON



(3) FILLING POCKET

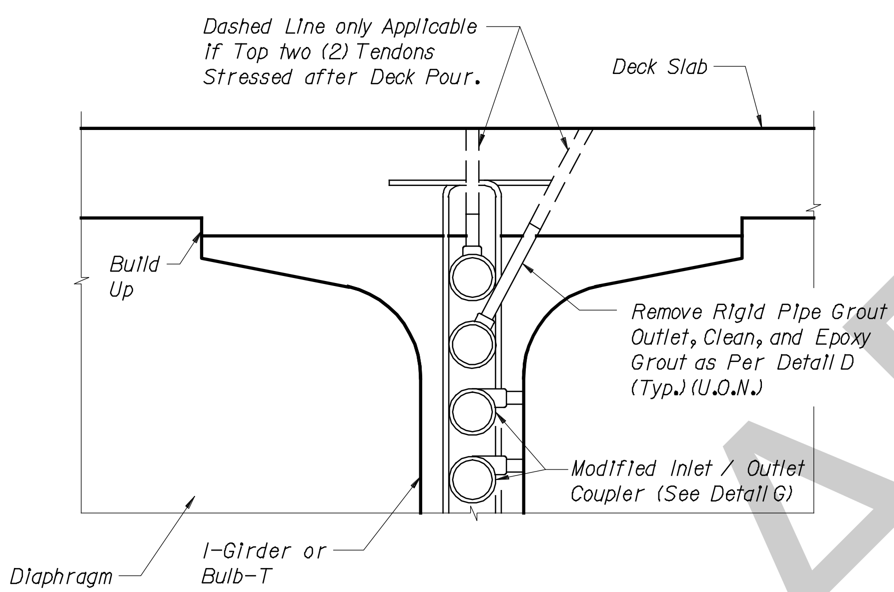


(2) POCKET PREPARATION

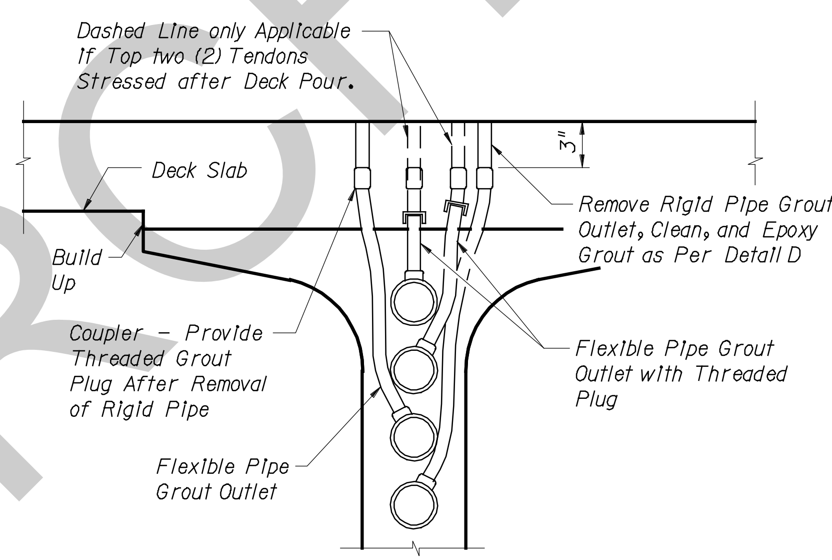
PROCEDURE

1. Remove Rigid Grout Pipe. or Drill Grout in Flexible Pipe.
2. Inspect Tendon for Voids as Necessary.
3. Vacuum Grout as Required and Allow Grout to Cure for 24 hr.(min.). Remove Pipe used for Vacuum Grouting.
4. Over-Ream Hole (1/4"Ø Over-Ream) Clean and Roughen Sides.
5. Fill Pocket with Epoxy Grout.

DETAIL G - VERTICAL SURFACES

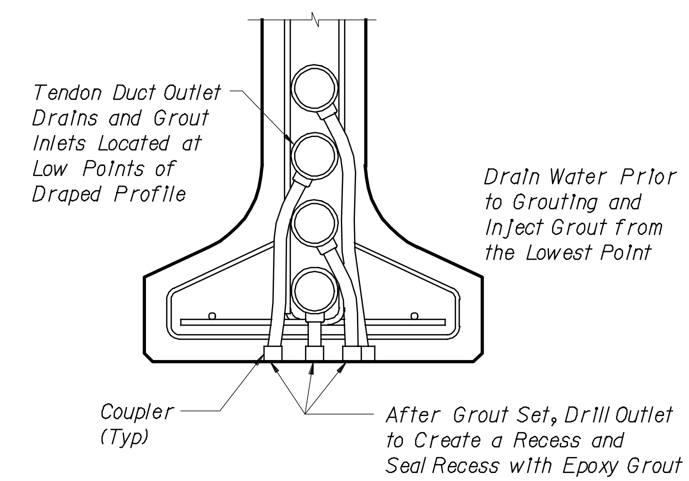


DETAIL H- HIGH POINT INSPECTION LOCATION AT GROUT OUTLET



Web Reinforcing not Shown for Clarity

DETAIL I- TENDONS AT 3' TO 6' FROM HIGH POINTS (GROUT OUTLET)



DETAIL J- TENDONS AT LOW POINTS (GROUT INLET / DRAIN)

Details H, I, & J Shown for I-Girders/Bulb-T's - Details for C.I.P. Boxes with Internal Tendons Similar

REVISIONS							NAMES	DATES	ENGINEER OF RECORD:
DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION	DRAWN BY	JVH	.	.
						CHECKED BY	TAA/LMS	.	
						DESIGNED BY	JVH/TAA	.	
						CHECKED BY	RVR/LMS	.	
						APPROVED BY	WNN		

FLORIDA DEPARTMENT OF TRANSPORTATION		
ROAD NO.	COUNTY	FINANCIAL PROJECT ID
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SHEET TITLE: POST-TENSIONING ANCHORAGE AND GROUTING DETAILS INDEX NO. 1803, DRAWING 2 OF 3

PROJECT NAME: .

SHEET NO. .

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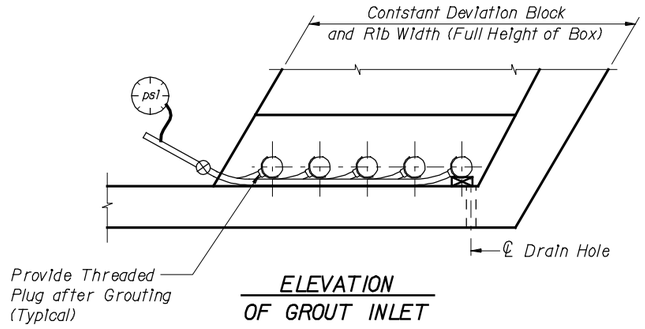
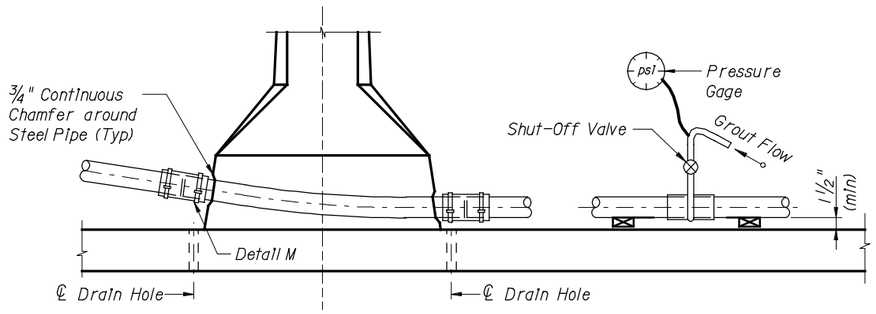


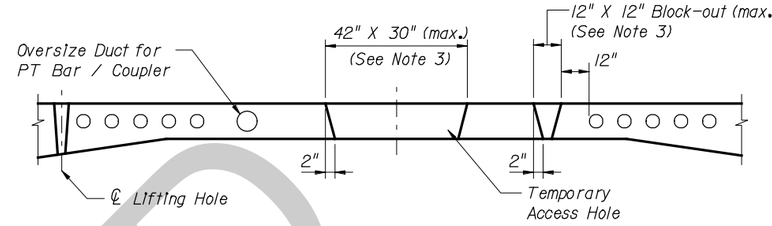
ELEVATION
OF GROUT INLET

NOTES:
Place Tapered Blocks Under Each Tendon to be Grouted to Raise Duct off Tendon Strands. Center Strands within Duct before Grouting Blocks Shall be Removed after Grout has Set. Blocks Shall not Damage or Permanantly Deform Duct.



SECTION

DETAIL K - GROUTING FOR SPAN BY SPAN CONSTRUCTION



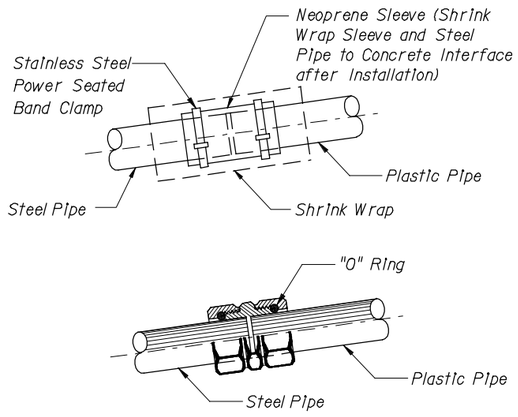
Notes: Temporary Access Holes

1. Temporary access holes to facilitate access for erection, jacking and grouting operations inside the box during construction. The access holes shall limited to a maximum size of 42" wide x 30" long.
2. Slab block-outs for temporary / permanent longitudinal post-tensioning bars are not allowed. Temporary / permanent PT bars in the top slab shall be placed in oversized ducts in the slab to accomodate both the bar and coupler.
3. In lieu of (1) 42" x 30" temporary access hole, a maximum of 2 top slab blockouts (12" x 12" (max.)) between the webs is allowed for construction per span. Block-outs shall be a minimum of 12" from the nearest duct or anchor and shall be located as to prevent direct drip onto bottom slab anchors.

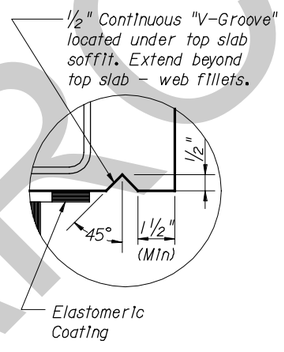
Notes: Repair of Temporary Access Holes, Block-outs, and Lifting Holes

1. Form all large blockouts with tapered sides.
2. Immediately before casting the concrete, mechanically clean the mating concrete surfaces to remove any laitance and to expose small aggregate.
3. Repair all holes and blockouts with Magnesium Ammonium Phosphate Concrete within 24 hours of cleaning concrete.
4. After completion of the deck grooving, coat the repaired and surrounding concrete surfaces with Methyl Methacrylate.
5. Alternately, epoxy grout may be used to repair holes. Methyl Methacrylate is not required with epoxy grout.

DETAIL L - TEMPORARY ACCESS HOLES



DETAIL M
Use Approved Duct Couplers with Post-Tensioned System



DETAIL N - DETAIL OF DRIP LEDGE AT ABUTMENTS AND EXPANSION JOINTS FOR SEGMENTAL AND CAST-IN-PLACE BOX CONSTRUCTION

REVISIONS					
DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION

	NAMES	DATES
DRAWN BY	JVH	.
CHECKED BY	TAA/LMS	.
DESIGNED BY	JVH/TAA	.
CHECKED BY	RVR/LMS	.
APPROVED BY	WNN	

ENGINEER OF RECORD.
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FLORIDA DEPARTMENT OF TRANSPORTATION

ROAD NO.	COUNTY	FINANCIAL PROJECT ID
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SHEET TITLE:
POST-TENSIONING ANCHORAGE AND GROUTING DETAILS
INDEX NO. 1803, DRAWING 3 OF 3

PROJECT NAME.
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SHEET NO.
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