Florida Department of Transportation

CHARLIE CRIST
GOVERNOR

605 Suwannee Street
Tallahassee, FL 32399-0450

STEPHANIE KOPELOUSOS
SECRETARY

December 11, 2007

Dr. Leslie McCarthy, PhD, P.E.
Program Operations Engineer
Federal Highway Administration
545 John Knox Road, Suite 200
Tallahassee, Florida 32303

Re: Office of Design, Specifications
Section 407
Proposed Specification: **4070000.D01**

Dear Dr. McCarthy:

We are submitting, for your approval, two copies of a proposed Supplemental Specification for Three-Sided Precast Culvert.

This change was proposed by Tom Malerk of the State Materials Office to notify Contractors that three-sided precast culverts are to be obtained from producers with accepted Quality Control Programs, and to notify producers that the requirements of 105-3 shall be met..

Please review and transmit your comments, if any, within two weeks. Comments should be sent via Email to SP965DB or duane.brautigam@dot.state.fl.us.

If you have any questions relating to this specification change, please call Duane F. Brautigam, State Specifications Engineer at 414-4110.

Sincerely,

Duane F. Brautigam, P.E.
State Specifications Engineer

DFB/dr
Attachment
cc: Gregory Jones, General Counsel
Florida Transportation Builders' Assoc.
State Construction Engineer

THREE-SIDED PRECAST CULVERT.
(REV 12-07-07)

SECTION 407 (of the Supplemental Specifications) is deleted and the following substituted:

SECTION 407
THREE-SIDED PRECAST CONCRETE CULVERT

407-1 Description.

Design and construct a three-sided precast concrete culvert for the three-sided concrete culvert structure shown in the Contract Documents. Three-sided precast concrete culverts are defined as monolithic arched segments, frame segments with vertical walls and either horizontal or arched top slabs, or three-sided proprietary precast concrete bridge systems.

Obtain the three-sided precast culvert from a plant that is currently on the Department's list of *Producers with accepted Quality Control Programs. Producers seeking inclusion on the list shall meet the requirements of 105-3.*
~~qualified precast drainage structures plants and meet the requirement of Section 6.3 of the Materials Manual, which is available at the following URL:~~
~~www.dot.state.fl.us/specificationsoffice/materialsmanual/section63.pdf~~ .

At the beginning of each project, provide a notarized statement to the Engineer from a company designated representative certifying that the plant will manufacture the products in accordance with the requirements set forth in the Contract Documents and plant's ~~approved q~~*Q*uality ~~c~~*C*ontrol ~~p~~*P*lan. The ~~q~~*Q*uality ~~c~~*C*ontrol ~~m~~*M*anager's stamp on each product indicates certification that the product was fabricated in conformance with the Contractor's ~~q~~*Q*uality ~~c~~*C*ontrol ~~p~~*P*lan, the Contract, and this Section. Ensure that each shipment of precast concrete products to the project site is accompanied with a *Quality Control* signed or stamped delivery ticket providing the description and the list of the products.

407-2 Materials.

Ensure that the materials used for the construction of precast culverts have certification statements from each source, showing that they meet the applicable requirements of the following:

Portland Cement Concrete	Section 346
Reinforcing Steel	Section 415
Precast Concrete Drainage Products	*Section 449*
Riprap	Section 530
Coarse Aggregate	Section 901
Fine Aggregate	Section 902
Curing Materials	Section 925
Materials for Concrete Repair	Section 930
Non-Shrink Grout	Section 934
Filter Fabric	Section 985

407-3 Limitations on Use.

Do not use three-sided precast culverts in lieu of four-sided culverts described in Section 410, however they may be considered as a VECP in accordance with Section 4. Provide the required Section 346 concrete class and concrete cover in accordance with the Structures Design Guideline for the environmental classification shown in the plans for the culvert location. Do not use a three-sided precast culvert to extend the inlets of existing multi-cell culverts due to the potential for clogging with debris.

407-4 Materials Acceptance and Testing.

407-4.1 General: Meet concrete materials, testing, inspection, and acceptance requirements of Section 346, as modified herein:

Precast culverts are produced using certification-acceptance criteria; therefore, assume responsibility for performance of all quality control testing and inspections in accordance with Sections 346.

Prepare, cure, and test the test cylinders in accordance with ASTM C 31 and ASTM C 39 test methods. The use of 4 x 8 inch test cylinders is allowed for the testing of precast culverts, provided that it meets the requirements of 450-4.1. Follow the alternative method of compaction, in accordance with ASTM C 497, if the consistency of concrete is too stiff for compaction by rodding or internal vibrations. Expose shipping strength test cylinders to the same curing conditions as the precast concrete sections. 28-day test cylinders shall be cured in accordance with Section 346.

Perform all concrete quality control testing and inspections in accordance with 346-9.2.

For training and other qualifications meet the requirements of Article105-5. Test all QC samples for compressive strength in a laboratory meeting the requirements of Article 6-9.

407-4.2 Quality Assurance Inspection and Testing: The Engineer will perform periodic inspections, sampling, and testing to ensure of the quality and acceptability of the materials, methods, techniques, procedures and processes being utilized by the manufacturing facility in the fabrication of precast concrete culverts.

407-5 Design Requirements.

Provide a design that complies with the requirements of the AASHTO LRFD Bridge Design Specifications and the Structures Design Guidelines, current at the time of letting. Perform a bridge load rating in accordance with the Structures Design Guidelines, for any design with a total span equal to or greater than 20 feet, when measured between the inside face of end supports, along the centerline of the roadway crossing. Submit design calculations, shop drawings and loading rating for approval in accordance with Section 5. Ensure that the Contractor’s Engineer of Record performs the design of the precast culvert and signs and seals the design plans, calculations and load rating. When the channel lining design is not provided in the Contract Documents or must be redesigned, ensure that a hydraulic analysis and scour evaluation is completed, signed, and sealed by the Contractor’s Engineer of Record, and submitted to the Engineer.

Line the channel between footings with either a cast-in-place reinforced concrete slab with a toe wall at the inlet and outlet end of the structure or a blanket of revetment designed in accordance with the Department Drainage Manual. Use a concrete slab with a minimum thickness of 6 inches and with toe walls that have a minimum depth of

30 inches. Use lining designed to withstand the hydraulic forces and extend the lining beyond the ends of the structure a minimum of 10 feet. A riprap rubble ditch lining with a minimum thickness of 18 inches will be permitted if the flow velocity corresponding to the Design Flood Scour Event does not exceed five feet per second. Filter fabric must be used in conjunction with any revetment and should be sized in accordance with Design Standards Index No. 199. Design and construct the connection between the revetment or concrete slab and the culvert footing, to prevent the migration of soil through the connection.

Ensure that the bottom of spread footings are a minimum of 30 inches below the bottom of the channel lining.

407-6 Other Elements of a Precast Culvert System.

Extend reinforcing from precast sections to provide adequate splice lengths or utilize a mechanical rebar splicing system listed on the Department's Qualified Products List (QPL) for securing reinforcing dowels for cast-in-place headwalls and wingwalls. Precast headwalls, wingwalls and culvert footings are permitted. Precast culvert footings must span a minimum of three culvert units and provide shear connections between adjacent units with keyed joints or cast-in-place closure sections. Precast footings under wingwalls are not permitted.

Submit all connection details for precast elements to the Engineer for approval. All mechanical connections must be galvanized in accordance with 962-7 or Type 316 (UNS S31600) stainless steel, except in extremely aggressive environments only Type 316L (UNS 31603) stainless steel is permitted for welded connections and Type 316 stainless steel for non-welded shapes and fasteners.

Unless otherwise addressed in the plans, bedding material and compaction requirements for wingwalls and toe walls shall be the same as required for the footing in 407-12, except that the granular material may be placed to the inside edge of the toe wall. All requirements of Section 400 and Section 415 apply to the fabrication of cast-in-place elements. Backfill the locations behind the walls in accordance with the requirements of Section 125.

407-7 Fabrication.

407-7.1 Casting: Cast precast elements in unyielding beds and forms. Ensure bearing surfaces in casting forms are level and straight, and vertical surfaces are plumb prior to casting. Ensure surfaces within the forms against which concrete will be cast, are clean and free from rust and hardened residual concrete. Provide full concrete cover clearance to all form wires and other miscellaneous pieces of metal, except as permitted by Section 415. Bend all tie wires away from the form surface to provide maximum concrete cover. Embedded metal lifting devices may be positioned 1/2 inch below the concrete surface, provided blockouts are backfilled with an epoxy mortar within a distance of 1 1/2 inches of the perimeter of the metal device located within the concrete cover.

407-7.2 Surface Finish: Finish the precast elements in accordance with 400-15.1.

407-7.3 Curing: Perform the curing by any method prescribed in Sections 400 and 450, or by any other Department approved alternate curing method included in the manufacturer's ~~approved q~~*Q*uality ~~c~~*C*ontrol ~~p~~*P*lan ~~(QCP)~~, or combinations thereof that have provided satisfactory results.

407-7.4 Fabrication Tolerances:

407-7.4.1 Internal Dimensions: Ensure the internal dimensions do not vary more than 1 percent from the design dimensions, with a maximum of 3/4 inch. The haunch dimensions shall not vary from the design dimensions more than 1/4 inch for straight haunches or 1 inch for radial haunches.

407-7.4.2 Slab and Wall Thickness: Ensure the slab and wall thickness are not less than that shown in the design plans or approved shop drawings by more than 5 percent or 3/16 inch, whichever is greater. A thickness more than that required in the design will not be a cause for rejection.

407-7.4.3 Length of Opposite Surfaces: Ensure the variations in laying lengths of two opposite surfaces of the culvert segments are not more than 1/8 inch/foot of clear span, with a maximum of 1 inch. The exception to this shall be when beveled ends, for the purpose of laying curves, or skewed ends are specified by the Engineer.

407-7.4.4 Length of Section: Ensure the underrun in length of segments is not more than 1/8 inch/foot of length with a maximum of 1/2 inch in any culvert segment. The total under run in length of the in-place precast culvert must not be less than 3 inches from the design length.

407-7.4.5 Tongue and Groove Joints or Ends: Ensure the planes formed by the ends of precast culvert sections do not vary perpendicular from the joint axis by more than 3/8 inch for internal spans or heights less than 15 feet, or more than 1/2 inch for internal spans or heights of 15 feet or greater.

407-7.4.6 Position of Reinforcement: Meet the requirements of 415-5.10.2 for the maximum variation in the position of slab steel. Meet the requirements of 415-5.8.2 for the maximum variation of the wall steel, except that the concrete cover must not be less than 1/4 inch nor more than 1/2 inch from the design dimensions.

407-7.4.7 Area of Reinforcement: Provide the area of reinforcement as indicated in the plans or approved shop drawings as a minimum. If welded wire reinforcement is utilized in lieu of mild steel reinforcement, the provisions of 415-6 shall apply. Reinforcing steel areas greater than specified in the shop drawings will be acceptable when the reinforcing spacing is equal or less than specified in the shop drawings.

407-7.5 Removal of Forms: Remove forms after the concrete has attained the minimum compressive strength requirements included as part of the *Quality Control Plan*~~QCP~~, but not less than 2500 psi. Products manufactured with dry-cast concrete, are exempt from these requirements.

407-7.6 Lifting and Removal From Casting Area: Handled all products, including those manufactured by the dry-cast process, upon the concrete attaining sufficient compressive strength as determined by the manufacturer and included as part of the *Quality Control Plan*~~QCP~~, but not less than 2500 psi.

407-8 Joints.

Produce the precast units with keyways at the adjoining surfaces or with butt joints between adjacent units. In the keyways, use a non-shrink grout listed on the Qualified Products List. Design and construct the adjoining surfaces so that when placed together, they make a continuous line of units with a smooth interior free of appreciable irregularities within the tolerance permitted. Seal all joints between precast units with a bituminous seal or low modulus silicone sealant listed on the Qualified Products List, and

provide an external sealing band in accordance with ASTM C 877 along the outside of the joint. Determine the minimum width of sealing bands by substituting the larger of the clear rise or span of the precast concrete box section, for the equivalent pipe diameter in ASTM C 877 Tables 1 and 2. Install external sealing band wrap in accordance with the manufacturer's instructions. Cover the external sealing band with a strip of filter fabric adhered to the precast unit. Ensure that the filter fabric strip is a minimum of 24 inches wide and meets the requirements of Section 985. Obtain the Engineer's approval of the adhesive used. Exercise care during backfilling to prevent damage to the filter fabric.

Construct headwalls, wingwalls, and other special features in place or as detailed on the shop drawings. Leave sufficient steel exposed or utilize a mechanical rebar splicing system listed on the Qualified Products List, in end units for connection of headwalls, wingwalls and other cast-in-place sections.

407-9 Handling, Storage, and Shipping.

Handle, store, and ship precast culverts in a manner that prevents chipping, cracks, fractures, and excessive bending stress. Do not ship precast culverts before the concrete attains the required 28-day strength.

The manufacturer is permitted to verify the shipping strength test, before 28 days, by testing compressive strength cylinders that are cured under the conditions similar to the product or by testing temperature match cured cylinders. The manufacturer may use the maturity method, ASTM C 1074, pulse velocity method in accordance with ASTM C 597, or any other approved nondestructive test method to estimate the strength of concrete for determining form removal and handling strengths or before verification of shipping strength by test cylinders. Curing temperature and cycle must be monitored on a minimum of one precast culvert curing cell from each day of production when nondestructive test methods or temperature match cured cylinders are used to determine concrete strengths.

The shipping strength test is the average compressive strength of two test cylinders. Do not ship any products until the Quality Control Manager's (QCM) stamp is affixed to the product. ~~The QCM's stamp indicates certification that the product was fabricated in conformance with the manufacturer's QCP and Contract Documents.~~

407-10 Repairs and Rejection.

Evaluate cracks, spalls and other deficiencies in accordance with 450-12, except that cracks will be classified in accordance with 400-21. Classify fractures and cracks passing through the wall or slab, except for a single end crack that does not exceed the depth of the joint, as structural cracks. Repair nonstructural cracks in accordance with 400-21 (substructure requirements), and all other deficiencies in accordance with 450-13 or the plant's approved repair methods that are included as part of the *Quality Control Plan*~~QCP~~. Ensure that the original performance and durability of the repaired precast culverts are maintained. Use materials for concrete repair that will meet or exceed the strength requirement of the class of concrete used. Materials meeting the requirements of Section 930 may be substituted for non-shrink grout when required by 450-13. Precast culvert elements are subject to rejection if they fail to conform to any of the specification requirements after repair or when damaged ends would prevent making a satisfactory joint.

407-11 Marking.

Clearly mark indelibly the following information on the interior of each precast unit by indention, water proof paint, or other approved method: span, rise, skew angle, date of manufacture, serial number, project number, name or trademark of manufacturer, and design earth cover.

407-12 Construction Requirements.

Prior to constructing the footing, prepare the bearing soil in accordance with Section 455 for spread footings. If a precast concrete footing is used, prepare a 4 inch thick layer of compacted granular bedding material to a minimum width of 12 inches outside the footing width and meet the density requirements of 125-9.2. Provide bedding material in accordance with Design Standards Index No. 505 select material, with not more than 15% fines passing the No. 200 U.S. Standard sieve, or other granular material approved by the Engineer.

Accomplish all footing construction in dry or dewatered excavations, as defined in 455-29. When coarse aggregate is approved for use as an alternate bedding or foundation backfill material, fully wrap the coarse aggregate with a layer of Type D-4 geotextile filter fabric, as specified in Design Standards Index No. 199. At each end of any concrete slab channel lining, substitute the coarse aggregate with select material within four feet of toe walls.

Form a 3 inch deep key in the top surface of the footing 4 inches wider than the wall thickness. Ensure that footings reach a compressive strength of 3,000 psi before placing precast units.

Place the units as shown in the shop drawings. Carefully set the structure to the true line and grade. Set the units in a bed of mortar placed in the keyway in the top of the footing. Fill the keyway with mortar, and float the mortar flush with the top of the footing or use shims between the footer and culvert during setting, then inject non-shrink grout under the culvert walls.

Carefully place backfill against the filter fabric and joint seal to avoid damage to the material. Use mechanical tampers or approved compacting equipment to compact all backfill and embankment immediately adjacent to each side of the structure. Place the backfill within 4 feet of each side of the structure in lifts of 8 inches or less (loose depth). Do not operate heavy compaction equipment within 4 feet of the structure. Ensure that the backfill elevation differential between both sides of the structure does not exceed 24 inches. Carry backfill in front of wingwalls to ground lines shown in the plans.

407-13 Shop Drawings.

Submit details of all precast culvert elements and modifications to cast-in-place elements for approval to the Engineer prior to manufacturing in accordance with 5-1.4. These shop drawings must include the proposed layout, full reinforcing details, lifting devices, a note describing the casting method for the precast culverts and full details of any modifications to cast-in-place elements. All details must be submitted as a complete package including modifications to cast-in-place elements.

407-14 Method of Measurement.

The quantity to be paid for will be the plan quantity at the price bid for the sum of the items shown in the Contract Documents. The length of precast culvert is measured

along the centerline of the structure, from the outside face of the headwalls at each end. No increase in length will be permitted for multiple barrel precast culvert installations or extension of precast culverts ends to avoid skewed end conditions.

407-15 Basis of Payment.

Price and payment will be full compensation for all work and materials specified in this Section necessary to complete the structure, including dewatering, excavation, channel excavation, channel lining, backfilling, footings, headwalls, wingwalls, toe walls and other miscellaneous items.

Payment will be made under:

Item No. 407-1- Precast Three-Sided Culvert – per foot.

THREE-SIDED PRECAST CULVERT.
(REV 12-07-07)

SECTION 407 (of the Supplemental Specifications) is deleted and the following substituted:

SECTION 407
THREE-SIDED PRECAST CONCRETE CULVERT

407-1 Description.

Design and construct a three-sided precast concrete culvert for the three-sided concrete culvert structure shown in the Contract Documents. Three-sided precast concrete culverts are defined as monolithic arched segments, frame segments with vertical walls and either horizontal or arched top slabs, or three-sided proprietary precast concrete bridge systems.

Obtain the three-sided precast culvert from a plant that is currently on the Department's list of Producers with accepted Quality Control Programs. Producers seeking inclusion on the list shall meet the requirements of 105-3.

At the beginning of each project, provide a notarized statement to the Engineer from a company designated representative certifying that the plant will manufacture the products in accordance with the requirements set forth in the Contract Documents and plant's Quality Control Plan. The Quality Control Manager's stamp on each product indicates certification that the product was fabricated in conformance with the Contractor's Quality Control Plan, the Contract, and this Section. Ensure that each shipment of precast concrete products to the project site is accompanied with a Quality Control signed or stamped delivery ticket providing the description and the list of the products.

407-2 Materials.

Ensure that the materials used for the construction of precast culverts have certification statements from each source, showing that they meet the applicable requirements of the following:

Portland Cement Concrete	Section 346
Reinforcing Steel	Section 415
Precast Concrete Drainage Products	Section 449
Riprap	Section 530
Coarse Aggregate	Section 901
Fine Aggregate	Section 902
Curing Materials	Section 925
Materials for Concrete Repair	Section 930
Non-Shrink Grout	Section 934
Filter Fabric	Section 985

407-3 Limitations on Use.

Do not use three-sided precast culverts in lieu of four-sided culverts described in Section 410, however they may be considered as a VECP in accordance with Section 4.

Provide the required Section 346 concrete class and concrete cover in accordance with the Structures Design Guideline for the environmental classification shown in the plans for the culvert location. Do not use a three-sided precast culvert to extend the inlets of existing multi-cell culverts due to the potential for clogging with debris.

407-4 Materials Acceptance and Testing.

407-4.1 General: Meet concrete materials, testing, inspection, and acceptance requirements of Section 346, as modified herein:

Precast culverts are produced using certification-acceptance criteria; therefore, assume responsibility for performance of all quality control testing and inspections in accordance with Sections 346.

Prepare, cure, and test the test cylinders in accordance with ASTM C 31 and ASTM C 39 test methods. The use of 4 x 8 inch test cylinders is allowed for the testing of precast culverts, provided that it meets the requirements of 450-4.1. Follow the alternative method of compaction, in accordance with ASTM C 497, if the consistency of concrete is too stiff for compaction by rodding or internal vibrations. Expose shipping strength test cylinders to the same curing conditions as the precast concrete sections. 28-day test cylinders shall be cured in accordance with Section 346.

Perform all concrete quality control testing and inspections in accordance with 346-9.2.

For training and other qualifications meet the requirements of Article105-5. Test all QC samples for compressive strength in a laboratory meeting the requirements of Article 6-9.

407-4.2 Quality Assurance Inspection and Testing: The Engineer will perform periodic inspections, sampling, and testing to ensure of the quality and acceptability of the materials, methods, techniques, procedures and processes being utilized by the manufacturing facility in the fabrication of precast concrete culverts.

407-5 Design Requirements.

Provide a design that complies with the requirements of the AASHTO LRFD Bridge Design Specifications and the Structures Design Guidelines, current at the time of letting. Perform a bridge load rating in accordance with the Structures Design Guidelines, for any design with a total span equal to or greater than 20 feet, when measured between the inside face of end supports, along the centerline of the roadway crossing. Submit design calculations, shop drawings and loading rating for approval in accordance with Section 5. Ensure that the Contractor’s Engineer of Record performs the design of the precast culvert and signs and seals the design plans, calculations and load rating. When the channel lining design is not provided in the Contract Documents or must be redesigned, ensure that a hydraulic analysis and scour evaluation is completed, signed, and sealed by the Contractor’s Engineer of Record, and submitted to the Engineer.

Line the channel between footings with either a cast-in-place reinforced concrete slab with a toe wall at the inlet and outlet end of the structure or a blanket of revetment designed in accordance with the Department Drainage Manual. Use a concrete slab with a minimum thickness of 6 inches and with toe walls that have a minimum depth of 30 inches. Use lining designed to withstand the hydraulic forces and extend the lining beyond the ends of the structure a minimum of 10 feet. A riprap rubble ditch lining with a minimum thickness of 18 inches will be permitted if the flow velocity corresponding to

the Design Flood Scour Event does not exceed five feet per second. Filter fabric must be used in conjunction with any revetment and should be sized in accordance with Design Standards Index No. 199. Design and construct the connection between the revetment or concrete slab and the culvert footing, to prevent the migration of soil through the connection.

Ensure that the bottom of spread footings are a minimum of 30 inches below the bottom of the channel lining.

407-6 Other Elements of a Precast Culvert System.

Extend reinforcing from precast sections to provide adequate splice lengths or utilize a mechanical rebar splicing system listed on the Department's Qualified Products List (QPL) for securing reinforcing dowels for cast-in-place headwalls and wingwalls. Precast headwalls, wingwalls and culvert footings are permitted. Precast culvert footings must span a minimum of three culvert units and provide shear connections between adjacent units with keyed joints or cast-in-place closure sections. Precast footings under wingwalls are not permitted.

Submit all connection details for precast elements to the Engineer for approval. All mechanical connections must be galvanized in accordance with 962-7 or Type 316 (UNS S31600) stainless steel, except in extremely aggressive environments only Type 316L (UNS 31603) stainless steel is permitted for welded connections and Type 316 stainless steel for non-welded shapes and fasteners.

Unless otherwise addressed in the plans, bedding material and compaction requirements for wingwalls and toe walls shall be the same as required for the footing in 407-12, except that the granular material may be placed to the inside edge of the toe wall. All requirements of Section 400 and Section 415 apply to the fabrication of cast-in-place elements. Backfill the locations behind the walls in accordance with the requirements of Section 125.

407-7 Fabrication.

407-7.1 Casting: Cast precast elements in unyielding beds and forms. Ensure bearing surfaces in casting forms are level and straight, and vertical surfaces are plumb prior to casting. Ensure surfaces within the forms against which concrete will be cast, are clean and free from rust and hardened residual concrete. Provide full concrete cover clearance to all form wires and other miscellaneous pieces of metal, except as permitted by Section 415. Bend all tie wires away from the form surface to provide maximum concrete cover. Embedded metal lifting devices may be positioned 1/2 inch below the concrete surface, provided blockouts are backfilled with an epoxy mortar within a distance of 1 1/2 inches of the perimeter of the metal device located within the concrete cover.

407-7.2 Surface Finish: Finish the precast elements in accordance with 400-15.1.

407-7.3 Curing: Perform the curing by any method prescribed in Sections 400 and 450, or by any other Department approved alternate curing method included in the manufacturer's Quality Control Plan, or combinations thereof that have provided satisfactory results.

407-7.4 Fabrication Tolerances:

407-7.4.1 Internal Dimensions: Ensure the internal dimensions do not vary more than 1 percent from the design dimensions, with a maximum of 3/4 inch. The

haunch dimensions shall not vary from the design dimensions more than 1/4 inch for straight haunches or 1 inch for radial haunches.

407-7.4.2 Slab and Wall Thickness: Ensure the slab and wall thickness are not less than that shown in the design plans or approved shop drawings by more than 5 percent or 3/16 inch, whichever is greater. A thickness more than that required in the design will not be a cause for rejection.

407-7.4.3 Length of Opposite Surfaces: Ensure the variations in laying lengths of two opposite surfaces of the culvert segments are not more than 1/8 inch/foot of clear span, with a maximum of 1 inch. The exception to this shall be when beveled ends, for the purpose of laying curves, or skewed ends are specified by the Engineer.

407-7.4.4 Length of Section: Ensure the underrun in length of segments is not more than 1/8 inch/foot of length with a maximum of 1/2 inch in any culvert segment. The total under run in length of the in-place precast culvert must not be less than 3 inches from the design length.

407-7.4.5 Tongue and Groove Joints or Ends: Ensure the planes formed by the ends of precast culvert sections do not vary perpendicular from the joint axis by more than 3/8 inch for internal spans or heights less than 15 feet, or more than 1/2 inch for internal spans or heights of 15 feet or greater.

407-7.4.6 Position of Reinforcement: Meet the requirements of 415-5.10.2 for the maximum variation in the position of slab steel. Meet the requirements of 415-5.8.2 for the maximum variation of the wall steel, except that the concrete cover must not be less than 1/4 inch nor more than 1/2 inch from the design dimensions.

407-7.4.7 Area of Reinforcement: Provide the area of reinforcement as indicated in the plans or approved shop drawings as a minimum. If welded wire reinforcement is utilized in lieu of mild steel reinforcement, the provisions of 415-6 shall apply. Reinforcing steel areas greater than specified in the shop drawings will be acceptable when the reinforcing spacing is equal or less than specified in the shop drawings.

407-7.5 Removal of Forms: Remove forms after the concrete has attained the minimum compressive strength requirements included as part of the Quality Control Plan, but not less than 2500 psi. Products manufactured with dry-cast concrete, are exempt from these requirements.

407-7.6 Lifting and Removal From Casting Area: Handled all products, including those manufactured by the dry-cast process, upon the concrete attaining sufficient compressive strength as determined by the manufacturer and included as part of the Quality Control Plan, but not less than 2500 psi.

407-8 Joints.

Produce the precast units with keyways at the adjoining surfaces or with butt joints between adjacent units. In the keyways, use a non-shrink grout listed on the Qualified Products List. Design and construct the adjoining surfaces so that when placed together, they make a continuous line of units with a smooth interior free of appreciable irregularities within the tolerance permitted. Seal all joints between precast units with a bituminous seal or low modulus silicone sealant listed on the Qualified Products List, and provide an external sealing band in accordance with ASTM C 877 along the outside of the joint. Determine the minimum width of sealing bands by substituting the larger of the clear rise or span of the precast concrete box section, for the equivalent pipe diameter in

ASTM C 877 Tables 1 and 2. Install external sealing band wrap in accordance with the manufacturer's instructions. Cover the external sealing band with a strip of filter fabric adhered to the precast unit. Ensure that the filter fabric strip is a minimum of 24 inches wide and meets the requirements of Section 985. Obtain the Engineer's approval of the adhesive used. Exercise care during backfilling to prevent damage to the filter fabric.

Construct headwalls, wingwalls, and other special features in place or as detailed on the shop drawings. Leave sufficient steel exposed or utilize a mechanical rebar splicing system listed on the Qualified Products List, in end units for connection of headwalls, wingwalls and other cast-in-place sections.

407-9 Handling, Storage, and Shipping.

Handle, store, and ship precast culverts in a manner that prevents chipping, cracks, fractures, and excessive bending stress. Do not ship precast culverts before the concrete attains the required 28-day strength.

The manufacturer is permitted to verify the shipping strength test, before 28 days, by testing compressive strength cylinders that are cured under the conditions similar to the product or by testing temperature match cured cylinders. The manufacturer may use the maturity method, ASTM C 1074, pulse velocity method in accordance with ASTM C 597, or any other approved nondestructive test method to estimate the strength of concrete for determining form removal and handling strengths or before verification of shipping strength by test cylinders. Curing temperature and cycle must be monitored on a minimum of one precast culvert curing cell from each day of production when nondestructive test methods or temperature match cured cylinders are used to determine concrete strengths.

The shipping strength test is the average compressive strength of two test cylinders. Do not ship any products until the Quality Control Manager's (QCM) stamp is affixed to the product.

407-10 Repairs and Rejection.

Evaluate cracks, spalls and other deficiencies in accordance with 450-12, except that cracks will be classified in accordance with 400-21. Classify fractures and cracks passing through the wall or slab, except for a single end crack that does not exceed the depth of the joint, as structural cracks. Repair nonstructural cracks in accordance with 400-21 (substructure requirements), and all other deficiencies in accordance with 450-13 or the plant's approved repair methods that are included as part of the Quality Control Plan. Ensure that the original performance and durability of the repaired precast culverts are maintained. Use materials for concrete repair that will meet or exceed the strength requirement of the class of concrete used. Materials meeting the requirements of Section 930 may be substituted for non-shrink grout when required by 450-13. Precast culvert elements are subject to rejection if they fail to conform to any of the specification requirements after repair or when damaged ends would prevent making a satisfactory joint.

407-11 Marking.

Clearly mark indelibly the following information on the interior of each precast unit by indention, water proof paint, or other approved method: span, rise, skew angle,

date of manufacture, serial number, project number, name or trademark of manufacturer, and design earth cover.

407-12 Construction Requirements.

Prior to constructing the footing, prepare the bearing soil in accordance with Section 455 for spread footings. If a precast concrete footing is used, prepare a 4 inch thick layer of compacted granular bedding material to a minimum width of 12 inches outside the footing width and meet the density requirements of 125-9.2. Provide bedding material in accordance with Design Standards Index No. 505 select material, with not more than 15% fines passing the No. 200 U.S. Standard sieve, or other granular material approved by the Engineer.

Accomplish all footing construction in dry or dewatered excavations, as defined in 455-29. When coarse aggregate is approved for use as an alternate bedding or foundation backfill material, fully wrap the coarse aggregate with a layer of Type D-4 geotextile filter fabric, as specified in Design Standards Index No. 199. At each end of any concrete slab channel lining, substitute the coarse aggregate with select material within four feet of toe walls.

Form a 3 inch deep key in the top surface of the footing 4 inches wider than the wall thickness. Ensure that footings reach a compressive strength of 3,000 psi before placing precast units.

Place the units as shown in the shop drawings. Carefully set the structure to the true line and grade. Set the units in a bed of mortar placed in the keyway in the top of the footing. Fill the keyway with mortar, and float the mortar flush with the top of the footing or use shims between the footer and culvert during setting, then inject non-shrink grout under the culvert walls.

Carefully place backfill against the filter fabric and joint seal to avoid damage to the material. Use mechanical tampers or approved compacting equipment to compact all backfill and embankment immediately adjacent to each side of the structure. Place the backfill within 4 feet of each side of the structure in lifts of 8 inches or less (loose depth). Do not operate heavy compaction equipment within 4 feet of the structure. Ensure that the backfill elevation differential between both sides of the structure does not exceed 24 inches. Carry backfill in front of wingwalls to ground lines shown in the plans.

407-13 Shop Drawings.

Submit details of all precast culvert elements and modifications to cast-in-place elements for approval to the Engineer prior to manufacturing in accordance with 5-1.4. These shop drawings must include the proposed layout, full reinforcing details, lifting devices, a note describing the casting method for the precast culverts and full details of any modifications to cast-in-place elements. All details must be submitted as a complete package including modifications to cast-in-place elements.

407-14 Method of Measurement.

The quantity to be paid for will be the plan quantity at the price bid for the sum of the items shown in the Contract Documents. The length of precast culvert is measured along the centerline of the structure, from the outside face of the headwalls at each end. No increase in length will be permitted for multiple barrel precast culvert installations or extension of precast culverts ends to avoid skewed end conditions.

407-15 Basis of Payment.

Price and payment will be full compensation for all work and materials specified in this Section necessary to complete the structure, including dewatering, excavation, channel excavation, channel lining, backfilling, footings, headwalls, wingwalls, toe walls and other miscellaneous items.

Payment will be made under:

Item No. 407-1- Precast Three-Sided Culvert – per foot.