SECTION 407
THREE-SIDED PRECAST CONCRETE CULVERT

407-1 Description.

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

Meet the requirements of 449-1.

407-2 Materials.

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

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

*The gradation requirements of aggregates are not applicable when using dry-cast concrete.

407-3 Limitations on Use.

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

407-4 Materials Acceptance and Testing.

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

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

Prepare, cure, and test the test cylinders in accordance with ASTM C31 and ASTM C39 test methods. Follow the alternative method of concrete compaction, in accordance with ASTM C497, if the consistency of concrete is too stiff for compaction by rodding or internal vibrations. Expose shipping strength test cylinders to the same curing conditions as the precast concrete sections. The 28-day test cylinders shall be cured in accordance with Section 346.

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

For training and other qualifications meet the requirements of Section 105. Test all QC samples for compressive strength in a laboratory meeting the requirements of Section 105.

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

407-4.3 Special Requirements for Dry-Cast Concrete: Dry-cast concrete is defined as a very low slump concrete that requires continuous and intense vibration to compact the concrete, enabling immediate removal of the side forms without detrimental effects to the concrete when used in a dry-cast manufacturing process.

The target slump and air content ranges in Table 2 in Section 346 and the plastic property tolerances in Table 6 in Section 346 are not applicable to dry-cast concrete.

Perform absorption tests on specimens from each LOT of dry-cast production in accordance with the test methods in ASTM C497. The absorption of each specimen must not exceed 9.0% of the dry mass for Test Method A procedure or 8.5% for Test Method B procedure. All specimens must be free of visible cracks and must represent the full thickness of the product. Test specimens after 28 days of standard curing or prior to the date of shipping if the precast concrete culvert sections are to be shipped before the completion of the 28-day curing period.

Core three specimens for Test Method B in accordance with ASTM C42 and meet the sampling location and size requirements of ASTM C497. Prepare or core a minimum of one specimen for Test Method A in accordance with the test cylinder requirements of ASTM C497. When the initial absorption specimen from a concrete culvert section fails to conform to the requirements of this Section, the absorption test may be made on another specimen from the same culvert section and the results of the retest may be substituted for the original test results for acceptance of the LOT. The manufacturer may test each concrete culvert section within a LOT and cull the culvert sections not meeting absorption requirements marking them as deficient with waterproof paint or other approved means. Deficient culvert sections must not be shipped to the project site. Reduce the frequency of absorption tests to one test every five LOTs when the results of five consecutive LOTs meet the specified limit.

407-5 Design Requirements.

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

Line the channel between footings with either a 6 inch minimum thick cast-in-place reinforced concrete slab with a 30 inch minimum depth toe wall at the inlet and outlet end of the

structure, or a blanket of revetment designed in accordance with the Department Drainage Manual. Use lining designed to withstand the hydraulic forces and extend the lining a minimum of 10 feet beyond the ends of the structure. A riprap rubble ditch lining with a minimum thickness of 18 inches will be permitted if the flow velocity corresponding to the Design Flood Scour Event does not exceed five feet per second. Filter fabric must be used in conjunction with any revetment in accordance with Section 985. Design and construct the connection between the revetment or concrete slab and the culvert footing, to prevent the migration of soil through the connection.

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

407-6 Other Elements of a Precast Culvert System.

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

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

Unless otherwise addressed in the Plans, bedding material and compaction requirements for wingwalls and toe walls shall be the same as required for the footing in 407-12, except that the granular material may be placed to the inside edge of the toe wall.

All requirements of Section 400 and Section 415 apply to the fabrication of cast-in-place elements..

407-7 Fabrication.

407-7.1 Casting: Cast precast elements in unyielding beds and forms. Ensure bearing surfaces in casting forms are level and straight, and vertical surfaces are plumb prior to casting. Ensure surfaces within the forms, against which concrete will be cast, are clean and free from rust and hardened residual concrete. Provide full concrete cover clearance to all form wires and other miscellaneous pieces of metal, except as permitted by Section 415. Bend all tie wires away from the form surface to provide maximum concrete cover. Provide inserts and lifting devices in accordance with 450-9.2.1.

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

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

407-7.4 Fabrication Tolerances:

407-7.4.1 Internal Dimensions: Ensure the internal dimensions do not vary more than one percent or two inches, whichever is less, from the design dimensions, with a maximum of 3/4 inches. The haunch dimensions shall not vary more than 3/4 inches from the design dimensions.

407-7.4.2 Slab and Wall Thickness: Ensure the slab and wall thicknesses are not less than that shown in the design Plans or approved shop drawings by more than five percent or 1/2 inches, whichever is greater. A thickness more than that required in the design will not be a cause for rejection.

407-7.4.3 Length of Opposite Surfaces: Ensure the variations in laying lengths of two opposite surfaces of the culvert segments are not more than 3/4 inch, except where beveled ends for laying curves, or skewed ends are specified by the Engineer.

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

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

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

407-7.4.7 Area of Reinforcement: Provide the area of reinforcement as indicated in the Plans or approved shop drawings as a minimum. If welded wire reinforcement is utilized in lieu of mild steel reinforcement, the provisions of 415-6 shall apply. Reinforcing steel areas greater than specified in the shop drawings will be acceptable when the reinforcing spacing is equal or less than specified in the shop drawings. Substitution of mild steel or welded wire reinforcement for fiber reinforced polymer (FRP) reinforcing, or vice versa, is not permitted.

407-7.5 Removal of Forms: Remove forms after the concrete has attained the minimum compressive strength requirements in the Producer QC Plan, but not less than 2500 psi. Products manufactured with dry-cast concrete, are exempt from this requirement.

407-7.6 Lifting and Removal from Casting Area: Handle all products, including those manufactured by the dry-cast process, upon the concrete attaining sufficient compressive strength as determined by the manufacturer and included as part of the Producer QC Plan, but not less than 2500 psi. Limit the flexural stresses from handling to three times the square root of the specified 28-day strength.

407-8 Joints.

Produce precast units with keyways at the adjoining surfaces or with butt joints between adjacent units. In the keyways, use a non-shrink grout listed on the APL. Design and construct the adjoining surfaces so that when placed together, they make a continuous line of units with a smooth interior free of appreciable irregularities within the permissible variations given in Section 11 of ASTM C1504. Seal all joints between precast units with a bituminous seal or low modulus silicone sealant listed on the APL, and provide an external sealing band in accordance with ASTM C877 along the outside of the joint. Determine the minimum width of sealing bands by substituting the larger of the clear rise or span of the precast concrete box section, for the equivalent pipe diameter in ASTM C877 Tables 1 and 2. Install external sealing band wrap in accordance with the manufacturer’s instructions. Cover the external sealing band with a strip of filter fabric adhered to the precast unit. Ensure that the filter fabric strip is a minimum of

24 inches wide and meets the requirements of Section 985. Obtain the Engineer's approval of the adhesive used. Exercise care during backfilling to prevent damage to the filter fabric.

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

407-9 Handling, Storage, and Shipping.

Handle, store, and ship precast culverts in a manner that prevents chipping, cracks, fractures, and excessive bending stress. Do not ship precast culverts to the project site prior to the completion of the 72 hour curing period and attainment of the required 28-day compressive strength.

The manufacturer is permitted to verify the shipping strength test, before 28 days, by testing compressive strength cylinders that are cured under conditions similar to the product or by testing temperature match cured cylinders. The manufacturer may use the maturity method, ASTM C1074, pulse velocity method in accordance with ASTM C597, or any other approved nondestructive test method to estimate the strength of concrete for determining form removal and handling strengths or before verification of shipping strength by test cylinders.

Curing temperature and cycle must be monitored on a minimum of one precast culvert curing cell from each day of production when nondestructive test methods or temperature match cured cylinders are used to determine concrete strengths.

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

407-10 Repairs and Rejection.

Evaluate cracks, spalls and other deficiencies in accordance with 450-12, except that cracks will be classified in accordance with 400-21. Classify fractures and cracks passing through the wall or slab, except for a single end crack that does not exceed the depth of the joint, as structural cracks. Repair nonstructural cracks in accordance with 400-21 (substructure requirements), and all other deficiencies in accordance with 450-13 or the plant's approved repair methods that are included as part of the Producer QC Plan. Ensure that the original performance and durability of the repaired precast culverts are maintained.

Use materials for concrete repair that will meet or exceed the strength requirement of the class of concrete used. Materials meeting the requirements of Section 930 may be substituted for non-shrink grout when required by 450-13. Precast culvert elements are subject to rejection if they fail to conform to any of the specification requirements after repair or when damaged ends would prevent making a satisfactory joint.

407-11 Marking.

Clearly mark indelibly the following information on the interior of each precast unit by indention, water proof paint, or other approved method as described in the producer QC Plan: three sided structure span, rise, maximum and minimum design earth cover, skew angle, date of manufacture, serial number, project number, and name or trademark of manufacturer.

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 Section 985. At each end of any concrete slab channel lining, substitute the coarse aggregate with select material within four feet of toe walls.

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

Place the units as shown in the shop drawings. Carefully set the structure to the true line and grade. Set the units in a bed of mortar placed in the keyway in the top of the footing. Fill the keyway with mortar, and float the mortar flush with the top of the footing or use shims between the footer and culvert during setting, then inject non-shrink grout under the culvert walls. Seal blockouts and holes provided for lifting or joint restraint by using an epoxy mortar or non-shrink grout in accordance with Sections 926 or 934.

Carefully place backfill against the filter fabric and joint seal to avoid damage to the material. Use mechanical tampers or approved compacting equipment to compact all backfill and embankment immediately adjacent to each side of the structure. Place the backfill within 4 feet of each side of the structure in lifts of 8 inches or less (loose depth). Do not operate heavy compaction equipment within 4 feet of the structure. Ensure that the backfill elevation differential between both sides of the structure does not exceed 24 inches. Backfill behind wingwalls in accordance with Section 125. Carry backfill in front of wingwalls to 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 and any connections. All details must be submitted as a complete package including modifications to cast-in-place elements.

407-14 Method of Measurement.

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

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.