



Florida Department of Transportation

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STEPHANIE KOPELOUSOS
SECRETARY

December 14, 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 410
Proposed Specification: **4100000.D02**

Dear Dr. McCarthy:

We are submitting, for your approval, two copies of a proposed Supplemental Specification for Precast Concrete Box Culvert.

This change was proposed by Tom Malerk of the State Materials Office to specify that precast concrete box culverts be obtained from producers with accepted Quality Control Programs, and that producers comply with the requirements of 105-3. Additionally, a modification proposed by Steve Nolan of the State Structures Design Office to change the permitted joint on the outside face from 1 inch to 1 ½ inches has been included.

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

PRECAST CONCRETE BOX CULVERT.**(REV 12-07-07)**

SECTION 410 (of the Supplemental Specifications) is deleted and the following substituted:

**SECTION 410
PRECAST CONCRETE BOX CULVERT**

410-1 Description.

Obtain precast box culverts 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 requirements of Section 6.3 of the Materials Manual, which is available at the following URL:*

www.dot.state.fl.us/specificationsoffice/materialsmanual/section63.pdf

Provide precast four-sided concrete box culverts as an alternative to the structure shown in the Contract Documents. Only monolithic segments, or two-piece segments with three-sided bottom sections and a simple support top slab section, are permitted. Two-piece segments are limited to installations with a minimum of two feet fill height above the top slab.

Construct headwalls, wingwalls and other special features using cast-in-place concrete. Precast wingwalls, cut-off walls or headwalls are not permitted unless otherwise noted in the Contract Documents.

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 *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.

410-2 Materials.

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

Portland Cement Concrete	Section 346
Reinforcing Steel	Section 415
<i>Precast Concrete Drainage Products</i>	<i>Section 449</i>
Wire for Site Cage Machines.....	ASTM A 82, ASTM A 496
.....	or ASTM A 615
Coarse Aggregate.....	Section 901*
Fine Aggregate.....	Section 902*
Curing Materials for Concrete	Section 925

Materials For Concrete Repair	Section 930
Non-Shrink Grout	Section 934
Joint Materials	ASTM C 443, ASTM C 877
.....	or ASTM C 990
Geotextile Fabrics	Section 985
* The gradation requirements of aggregates are not applicable when using dry-cast concrete.	

410-3 Materials Acceptance and Testing of Precast Box Culverts.

410-3.1 General: Meet the requirements of Section 346, except as modified herein:

Prepare, cure, and test the test cylinders in accordance with ASTM C 31 and ASTM C 39 test methods. The use of 4 x 8 inch test cylinders is allowed for the testing of precast concrete box 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 box sections. Cure the 28-day strength test cylinders 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 Article 105-5. Test all QC samples for compressive strength in a laboratory meeting the requirements of 6-9.

410-3.2 Quality Assurance Inspection and Testing: The Engineer will perform periodic inspections, sampling, and testing to ensure of the quality and acceptability of the materials, methods, techniques, procedures and processes being utilized by the manufacturing facility in the fabrication of precast concrete box culverts.

410-3.3 Special Requirements for Dry-Cast Concrete: Dry-cast concrete is defined as a very low slump concrete that requires continuous and intense vibration to compact the concrete, enabling immediate removal of the side forms without detrimental effects to the concrete when used in a dry-cast manufacturing process.

The target slump and air content ranges of 346 - Table 2 and the plastic property tolerances of 346 - Table 6 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 C 497. The absorption of each specimen must not exceed 9.0 percent of the dry mass for Test Method A procedure or 8.5 percent for Test Method B procedure. All specimens must be free of visible cracks and must represent the full thickness of the product. Test specimens after 28-days of standard curing, or prior to the date of shipping if the precast box sections are to be shipped before to the completion of the 28-day curing period.

Core three specimens for Test Method B in accordance with ASTM C 42 and meet the sampling location and size requirements of ASTM C 497. Prepare or core a minimum of one specimen for Test Method A in accordance with the test cylinder requirements of ASTM C 497. When the initial absorption specimen from a concrete box section fails to conform to this Specification, the absorption test may be made on another specimen from the same box section and the results of the retest may be substituted for

the original test results for acceptance of the LOT. The manufacturer may test each box section within a LOT and cull the box sections not meeting absorption requirements marking them as deficient with waterproof paint or other approved means. Deficient box sections must not be shipped to the project site. Reduce the frequency of absorption tests to one test every five LOTs when the results of five consecutive LOTs meet the specified limit.

410-4 Design of Precast Concrete Box Sections.

410-4.1 General: In lieu of a cast-in-place concrete box section or if specified in the Contract Documents, provide precast box culverts in accordance with Design Standards Index No. 291 and the following:

Segment lengths must be between 4 feet and 16 feet. Short-side wall lengths for end segments of skewed culverts, may be less than 4 feet when approved by the Engineer.

Provide tongue and groove joints at the ends of segments. For two-piece box culvert segments, provide keyed joints for the top slab-to-wall connection to prevent lateral displacement at the top of the walls, and double-sided tongue and groove joints in the bottom slab to minimize differential settlement between segments. Alternate methods to prevent differential settlement may be used when included in the Contract Documents or approved by the Engineer. Concrete cover at the joints may be reduced from the nominal cover shown in the Contract Documents, in accordance with the Design Standards, but not less than 1 inch clear to the ends or inside mating surfaces of the joints or 1 1/2 inches clear to the outside surface of the joint for slightly and moderately aggressive environments, or 2 inches clear to the outside surface for extremely aggressive environments.

Meet one of the following design options:

410-4.1.1 Equivalent to Cast-In-Place Designs: Provide precast box segments identical to the plan details, including reinforcing steel grade, sizes and spacings, concrete cover, concrete class, and slab and wall dimensions. Reinforcing bar sizes and spacings may be reduced provided the equivalent area of reinforcing is provided in each layer. Haunch dimensions may be increased with the approval of the Engineer, but not greater than 8 inches for box culverts with internal spans less than 6 feet, or 12 inches for box culverts with larger internal spans.

410-4.1.2 Standard Precast Designs: Provide precast box segments in accordance with Design Standards Index No. 292 with the same hydraulic opening, fill height and reinforcing steel cover as shown in the plans, for the most critical design loading combination. *Perform a bridge load rating in accordance with the Structures Design Guidelines, for any multiple barrel culverts with a total span equal to or greater than 20 feet, when measured between the inside face of end supports, along the centerline of the roadway crossing.*

410-4.1.3 Modified or Special Designs: Provide Modified Designs which differ from the standard precast designs in 410-4.1.2 with modifications to the wall and slab thickness, or haunch dimensions. Provide Special Designs for sizes, elements and loads other than those referenced in 410-4.1.2. Redesign box culverts using the same AASHTO design specification, live load, hydraulic opening, fill height, minimum concrete class and concrete cover as shown in the Contract Documents. Special Designs will be required for all two-piece concrete box culvert segments. Provide a minimum

member thickness not less than 75 percent of the thickness of the corresponding member of an equivalent Index No. 292 box culvert, but not less than 7 inches for culverts with 2 inch concrete cover or 8 inches for 3 inch concrete cover. Perform a bridge load rating in accordance with the Structures Design Guidelines, for any redesign with *a* total span equal to or greater than 20 feet, when measure between the inside face of end supports, along the centerline of the roadway crossing.

410-4.2 Design Submittals: Submit shop drawings for all design options in accordance with 410.12. Submit design calculations, revised plans and load rating when required for approval in accordance with Section 5 for Modified or Special Designs. Ensure that a Specialty Engineer performs the design for Modified Designs of the box culvert and signs and seals the calculations.

Ensure that the Contractor's Engineer of Record performs any bridge load rating and the design for any Special Designs and signs and seals the revised plans, calculations and load rating.

410-5 Other Elements of a Precast Box Culvert System.

Extend reinforcing from precast sections to provide adequate splice lengths or utilize a mechanical rebar splicing system listed on the Department's Qualified Products List (QPL) for securing reinforcing dowels for headwalls, toe walls and wingwalls.

Cast all elements of the headwalls and wingwalls (footing and stem) in-place, unless otherwise noted in the Contract Documents. Cast all cut-off or toe walls for precast box end segments in-place only. Extend the depth of cut-off or toe walls an additional 6 inches with the limits of the bedding material. Bedding material and compaction requirements for wingwalls are the same as required for precast box sections, except that the granular material may be placed to the inside edge of the toe wall, unless otherwise specified in the Contract Documents. Bedding material is not required for cast-in-place wingwall footings.

All requirements of Section 400 and Section 415 apply to the fabrication of these elements. Backfill the locations behind the walls in accordance with the requirements of Section 125.

410-6 Fabrication.

410-6.1 Casting: Cast precast elements in unyielding beds and forms. Ensure bearing surfaces in casting forms are level and straight, and vertical surfaces are plumb prior to casting. Ensure surfaces within the forms against which concrete will be cast, are clean and free from rust and hardened residual concrete. Provide full concrete cover clearance to all form wires and other miscellaneous pieces of metal, except as permitted by Section 415. Bend all tie wires away from the form surface to provide maximum concrete cover. 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 inch of the perimeter of the metal device located within the concrete cover.

410-6.2 Surface Finish: Finish the precast elements in accordance with 400-15.1.

410-6.3 Curing: Perform the curing by any method prescribed in Sections 400 and 450, or by any other Department approved alternate curing method included in the approved Quality Control Plan (QCP), or combinations thereof that have provided satisfactory results.

410-6.4 Fabrication Tolerances:

410-6.4.1 Internal Dimensions: Ensure the internal dimensions do not vary more than 1 percent from the design dimensions, with a maximum of 3/4 inch. Ensure the haunch dimensions do not vary more than 1/4 inch from the design dimensions.

410-6.4.2 Slab and Wall Thickness: Ensure the slab and wall thickness are not be less than that shown in the plans or approved shop drawings by more than 5 percent or 3/16 inch, whichever is greater. A thickness more than that required in the design will not be a cause for rejection although payment will be for plan quantity only.

410-6.4.3 Length of Opposite Surfaces: Ensure the variations in laying lengths of two opposite surfaces of the box section are not more than 1/8 inch/ft of clear span, with a maximum of 5/8 inch for precast boxes with a clear span of up to 7 feet and a maximum of 3/4 inch for boxes with a clear span greater than 7 feet. The exception to this is when beveled ends, for the purpose of laying curves, or skewed ends are specified by the Engineer.

410-6.4.4 Length of Section: Ensure the under run in length of sections is not more than 1/8 inch/ft of length with a maximum of 1/2 inch in any box section.

410-6.4.5 Tongue and Groove Joints or Ends: Ensure the planes formed by the ends of box sections do not vary perpendicular from the joint axis by more than 1/4 inch for internal spans or heights less than 5 feet, or more than 3/8 inch for internal spans or heights of 5 feet or greater.

410-6.4.6 Position of Reinforcement: Meet the requirements of 415-5.10.2 for the maximum variation in the position of slab steel. Meet the requirements of 415-5.8.2 for the maximum variation of 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.

410-6.4.7 Area of Reinforcement: Provide the area of reinforcement as indicated in the plans or approved shop drawings as a minimum. If welded wire reinforcement is utilized in lieu of mild steel reinforcement, the provisions of 415-6 apply.

410-6.5 Removal of Forms: Remove forms after the concrete has attained the minimum compressive strength requirements included as part of the ~~QCP~~ *Quality Control Plan*, but not less than the following:

Vertically cast walls and slabs for four-sided sections	1000 psi
Three-sided box culvert bottom section	2500 psi
Horizontally cast self-supporting slabs or walls	2500 psi

Products manufactured with dry-cast concrete, are exempt from these requirements.

410-6.6 Lifting and Removal From Casting Area: Handle all products, including those manufactured with dry-cast concrete, after the concrete attains sufficient compressive strength as determined by the manufacturer but not less than the following, unless otherwise approved in the QCP:

Vertically cast and stored elements (walls and slabs)	1000 psi
Form/pallet supported elements (walls or slabs)	1000 psi

Self-supporting four-sided sections	1000 psi
Self-supporting horizontal slabs or three-sided sections	2500 psi

Limit the flexural tension stresses from handling to a maximum allowable stress of three times the square root of the concrete compressive strength in psi, prior to the concrete attaining the required 28-day strength.

410-7 Handling, Storage, and Shipping.

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

The manufacturer is permitted to verify the shipping strength test, before 28 days, by testing compressive strength cylinders that are cured under the conditions similar to the product or by testing temperature match cured cylinders. The manufacturer may use the maturity method, ASTM C 1074, pulse velocity method in accordance with ASTM C 597, or any other approved nondestructive test method to estimate the strength of concrete for determining form removal and handling strengths or before verification of shipping strength by test cylinders.

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

The shipping strength test is the average compressive strength of two test cylinders. Do not ship any products until the 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.~~

410-8 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 ~~QCP~~ *Quality Control Plan*. Ensure that the original performance and durability of the repaired box culverts are maintained.

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

410-9 Marking.

Ensure each section of Precast Box Culvert has permanently and clear marking on an inside face by indentation, waterproof paint, or as specified in the ~~QCP~~ *Quality Control Plan*, showing the manufacture date, serial number, project number, and manufacturer's name or symbol. The top of the box culvert must also be clearly indicated with waterproof paint or as specified in the ~~QCP~~ *Quality Control Plan*.

410-10 Trench, Foundation, Laying, and Backfill.

410-10.1 General: Meet the requirements of Section 125 and/or Section 121, for trench excavation, foundation construction, laying and backfilling and the following:

Lay all precast box culvert sections on a dry, slightly yielding foundation, to ensure uniform bearing across the full width of the bottom slab. Provide dewatering devices, if applicable, in accordance with 455-29, capable of maintaining a stable and surface-dry trench bottom. Construct any temporary sheet piling used in cofferdams, retaining walls and to incorporate the Contractor's specific means and methods, in accordance with 125-3.

410-10.2 Bedding: Provide bedding that consists of a minimum 6 inch depth of select material, with not more than 15% fines passing the No. 200 U.S. Standard sieve, in accordance with Design Standards Index No. 505 or other granular material approved by the Engineer. Place bedding in maximum 6 inch compacted layers below the culvert to a minimum width of 12 inches outside the exterior walls of the culvert and meet the density requirements of 125-9.2. When coarse aggregate is approved for use as an alternate bedding material, wrap the bottom and sides of the coarse aggregate with a layer of Type D-4 geotextile filter fabric as specified in Design Standards Index No. 199, and substituted the coarse aggregate with select material within 4 feet of the cut-off or toe walls at each end of the precast box culvert. Obtain the Engineer's approval before using flowable fill for bedding material. Provide other special bedding material, when required by the Contract Documents.

Set grade forms 12 inches outside each exterior wall of the box culvert. Uniformly compact this material and then grade off using the forms. Set the grade forms approximately 1/8 to 1/4 inch above the theoretical grade line to allow for soil compression. Adjust this distance to yield the proper grade, but do not use in lieu of the proper compaction of the granular bedding material. Remove the forms after placing the precast box culvert section.

410-10.3 Placement of Precast Box Culvert Sections: Obtain the Engineer's approval of the method of controlling line and grade during culvert installation. Use a method that allows rapid checking of the previously laid sections. Maintain line and grade on sections previously set. The Engineer will consider sections which do not retain the plan line within 0.10 foot or grade within 0.10 foot during laying of subsequent sections, as not having been laid to line and grade. Take up and relay sections not to line and grade without additional compensation.

410-10.4 Placement of Multiple Barrel Culverts: For multiple barrel installations using single-cell precast box sections, provide positive lateral support between the precast box culverts consisting of non-shrink grout, Class I (Nonstructural) concrete or non-excavatable flowable fill prior to backfilling. Provide partial height backfill or bracing to maintain alignment, when approved by the Engineer.

410-10.5 Backfilling: Begin backfilling only after the Engineers approval. Seal blockouts and holes provided for lifting or joint restraint by plugging using an epoxy mortar or non-shrink grout in accordance with Sections 926 or 934 and properly cure to ensure a sound and watertight plug, prior to backfilling.

410-11 Joints.

410-11.1 General: Make field joints for precast concrete box culvert sections with either profile rubber gaskets or preformed joint sealants, unless otherwise detailed in

the plans or approved shop drawings. Joint performance must meet the requirements of ASTM C 990, and joint openings *at the outside face* must not exceed 1 1/2 inches in the assembled position at any location along the joint perimeter ~~inclusive of all tolerances in 410-6.~~ *Ensure a minimum 50 percent overlap of the joint tongue and groove around the entire perimeter of the box in the assembled position.*

Completely wrap the outside of each joint with geotextile filter fabric. Use fabric meeting the physical requirements of Class D, Type 3 specified on Design Standards, Index No. 199. Provide fabric with a minimum width of 2 feet and a length sufficient to ensure a minimum overlap of 24 inches. The filter fabric must extend a minimum of 12 inches beyond each side of the joint. Secure the fabric tightly against the box culvert sections with metal or plastic strapping. Other methods which will hold the fabric securely against the wall of the culvert until the backfill is placed and compacted, may be used when approved by the Engineer. When specified in the plans, secure the joint by a suitable device capable of holding the sections to line and grade as well as fully home. Remove these devices and repair locations as necessary if intrusive into the concrete after placing and compacting sufficient backfill to secure the sections.

410-11.2 Profile Rubber Gaskets: Install field joints in accordance with the joint manufacturer's instructions and meet the following:

1. Meet the requirements of Article 6 of ASTM C 443,
2. Store all gaskets in a cool place prior to use,
3. Furnish to the Engineer written details regarding configuration of the joint and gasket required to create a soil-tight seal. Do not apply mortar, joint compound or other filler which would restrict the flexibility of the joint.

410-11.3 Preformed Flexible Joint Sealants: Install field joints in accordance with the joint manufacturer's instructions and meet the following:

1. Meet the requirements of ASTM C 990,
2. Furnish to the Engineer a written recommendation of the size (cross-sectional area) of joint sealant which will create a soil-tight seal. Ensure that this amount is the minimum quantity of bitumen sealant used. Do not brush or wipe joint surfaces which are to be in contact with the joint sealant with cement slurry. Fill minor voids with non-shrink grout,

3. Thoroughly clean and dry all joint surfaces which are to be in contact with the sealant material. When recommended by the sealant manufacturer, apply a primer of the type recommended to all joint surfaces which are to be in contact with the sealant material.

4. Apply sealant to form a continuous seal around each joint. The sealant must be protected by a removable wrapper. Do not remove the paper wrapper on the exterior surface of the preformed flexible joint sealant until immediately prior to joining the precast sections. Apply the joint sealant only to dry surfaces. When the atmospheric temperature is below 60°F, either store the joint sealant in an area above 70°F, or artificially warm the joint sealant to 70°F in a manner satisfactory to the Engineer. After assembly ensure that there is full contact and compression of the sealant for the entire perimeter of the joint, as evidenced by the presence of minor bulging along any visible edges of the sealant. Neatly trim any extruded sealant flush with the concrete surface.

410-11.4 Water-tight Joint Treatment: Provide water-tight joints when shown in the Contract Documents. Utilize an external sealing band in accordance with ASTM C

877 in addition to the requirements of 410-11.2 or 410-11.3. Determine the minimum width of sealing bands by substituting the larger of the clear rise or span of the precast concrete box section, for the equivalent pipe diameter in ASTM C 877 Tables 1 and 2. Install external sealing band wrap in accordance with the manufacturer's instructions prior to wrapping the joint with geotextile filter fabric.

410-12 Shop Drawings.

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

410-13 Method of Measurement.

The quantity to be paid for will be plan quantity for the structure shown in the Contract Documents in accordance with 400-22 and 415-7.

410-14 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including the cost of special bedding material and its placement, additional cut-off or toe wall depth, temporary sheet piling, graded forms, joint materials, filter fabric material, attachment of the filter fabric, dewatering, excavation, channel excavation and lining, backfilling, restraining devices and any other materials or equipment necessary to make a complete and accepted installation.

Payment will be made under pay items for concrete (culverts) and reinforcing steel (roadway).

PRECAST CONCRETE BOX CULVERT.**(REV 12-07-07)**

SECTION 410 (of the Supplemental Specifications) is deleted and the following substituted:

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PRECAST CONCRETE BOX CULVERT**

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Obtain precast box culverts 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. Provide precast four-sided concrete box culverts as an alternative to the structure shown in the Contract Documents. Only monolithic segments, or two-piece segments with three-sided bottom sections and a simple support top slab section, are permitted. Two-piece segments are limited to installations with a minimum of two feet fill height above the top slab.

Construct headwalls, wingwalls and other special features using cast-in-place concrete. Precast wingwalls, cut-off walls or headwalls are not permitted unless otherwise noted in the Contract Documents.

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For training and other qualifications meet the requirements of Article 105-5. Test all QC samples for compressive strength in a laboratory meeting the requirements of 6-9.

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to one test every five LOTs when the results of five consecutive LOTs meet the specified limit.

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Meet one of the following design options:

410-4.1.1 Equivalent to Cast-In-Place Designs: Provide precast box segments identical to the plan details, including reinforcing steel grade, sizes and spacings, concrete cover, concrete class, and slab and wall dimensions. Reinforcing bar sizes and spacings may be reduced provided the equivalent area of reinforcing is provided in each layer. Haunch dimensions may be increased with the approval of the Engineer, but not greater than 8 inches for box culverts with internal spans less than 6 feet, or 12 inches for box culverts with larger internal spans.

410-4.1.2 Standard Precast Designs: Provide precast box segments in accordance with Design Standards Index No. 292 with the same hydraulic opening, fill height and reinforcing steel cover as shown in the plans, for the most critical design loading combination. Perform a bridge load rating in accordance with the Structures Design Guidelines, for any multiple barrel culverts with a total span equal to or greater than 20 feet, when measured between the inside face of end supports, along the centerline of the roadway crossing.

410-4.1.3 Modified or Special Designs: Provide Modified Designs which differ from the standard precast designs in 410-4.1.2 with modifications to the wall and slab thickness, or haunch dimensions. Provide Special Designs for sizes, elements and loads other than those referenced in 410-4.1.2. Redesign box culverts using the same AASHTO design specification, live load, hydraulic opening, fill height, minimum concrete class and concrete cover as shown in the Contract Documents. Special Designs will be required for all two-piece concrete box culvert segments. Provide a minimum member thickness not less than 75 percent of the thickness of the corresponding member of an equivalent Index No. 292 box culvert, but not less than 7 inches for culverts with 2 inch concrete cover or 8 inches for 3 inch concrete cover. Perform a bridge load rating in accordance with the Structures Design Guidelines, for any redesign with a total span

equal to or greater than 20 feet, when measure between the inside face of end supports, along the centerline of the roadway crossing.

410-4.2 Design Submittals: Submit shop drawings for all design options in accordance with 410.12. Submit design calculations, revised plans and load rating when required for approval in accordance with Section 5 for Modified or Special Designs. Ensure that a Specialty Engineer performs the design for Modified Designs of the box culvert and signs and seals the calculations.

Ensure that the Contractor's Engineer of Record performs any bridge load rating and the design for any Special Designs and signs and seals the revised plans, calculations and load rating.

410-5 Other Elements of a Precast Box Culvert System.

Extend reinforcing from precast sections to provide adequate splice lengths or utilize a mechanical rebar splicing system listed on the Department's Qualified Products List (QPL) for securing reinforcing dowels for headwalls, toe walls and wingwalls.

Cast all elements of the headwalls and wingwalls (footing and stem) in-place, unless otherwise noted in the Contract Documents. Cast all cut-off or toe walls for precast box end segments in-place only. Extend the depth of cut-off or toe walls an additional 6 inches with the limits of the bedding material. Bedding material and compaction requirements for wingwalls are the same as required for precast box sections, except that the granular material may be placed to the inside edge of the toe wall, unless otherwise specified in the Contract Documents. Bedding material is not required for cast-in-place wingwall footings.

All requirements of Section 400 and Section 415 apply to the fabrication of these elements. Backfill the locations behind the walls in accordance with the requirements of Section 125.

410-6 Fabrication.

410-6.1 Casting: Cast precast elements in unyielding beds and forms. Ensure bearing surfaces in casting forms are level and straight, and vertical surfaces are plumb prior to casting. Ensure surfaces within the forms against which concrete will be cast, are clean and free from rust and hardened residual concrete. Provide full concrete cover clearance to all form wires and other miscellaneous pieces of metal, except as permitted by Section 415. Bend all tie wires away from the form surface to provide maximum concrete cover. 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 inch of the perimeter of the metal device located within the concrete cover.

410-6.2 Surface Finish: Finish the precast elements in accordance with 400-15.1.

410-6.3 Curing: Perform the curing by any method prescribed in Sections 400 and 450, or by any other Department approved alternate curing method included in the approved Quality Control Plan, or combinations thereof that have provided satisfactory results.

410-6.4 Fabrication Tolerances:

410-6.4.1 Internal Dimensions: Ensure the internal dimensions do not vary more than 1 percent from the design dimensions, with a maximum of 3/4 inch.

Ensure the haunch dimensions do not vary more than 1/4 inch from the design dimensions.

410-6.4.2 Slab and Wall Thickness: Ensure the slab and wall thickness are not be less than that shown in the plans or approved shop drawings by more than 5 percent or 3/16 inch, whichever is greater. A thickness more than that required in the design will not be a cause for rejection although payment will be for plan quantity only.

410-6.4.3 Length of Opposite Surfaces: Ensure the variations in laying lengths of two opposite surfaces of the box section are not more than 1/8 inch/ft of clear span, with a maximum of 5/8 inch for precast boxes with a clear span of up to 7 feet and a maximum of 3/4 inch for boxes with a clear span greater than 7 feet. The exception to this is when beveled ends, for the purpose of laying curves, or skewed ends are specified by the Engineer.

410-6.4.4 Length of Section: Ensure the under run in length of sections is not more than 1/8 inch/ft of length with a maximum of 1/2 inch in any box section.

410-6.4.5 Tongue and Groove Joints or Ends: Ensure the planes formed by the ends of box sections do not vary perpendicular from the joint axis by more than 1/4 inch for internal spans or heights less than 5 feet, or more than 3/8 inch for internal spans or heights of 5 feet or greater.

410-6.4.6 Position of Reinforcement: Meet the requirements of 415-5.10.2 for the maximum variation in the position of slab steel. Meet the requirements of 415-5.8.2 for the maximum variation of 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.

410-6.4.7 Area of Reinforcement: Provide the area of reinforcement as indicated in the plans or approved shop drawings as a minimum. If welded wire reinforcement is utilized in lieu of mild steel reinforcement, the provisions of 415-6 apply.

410-6.5 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 the following:

Vertically cast walls and slabs for four-sided sections	1000 psi
Three-sided box culvert bottom section	2500 psi
Horizontally cast self-supporting slabs or walls	2500 psi

Products manufactured with dry-cast concrete, are exempt from these requirements.

410-6.6 Lifting and Removal From Casting Area: Handle all products, including those manufactured with dry-cast concrete, after the concrete attains sufficient compressive strength as determined by the manufacturer but not less than the following, unless otherwise approved in the QCP:

Vertically cast and stored elements (walls and slabs)	1000 psi
Form/pallet supported elements (walls or slabs)	1000 psi
Self-supporting four-sided sections	1000 psi
Self-supporting horizontal slabs or three-sided sections	2500 psi

Limit the flexural tension stresses from handling to a maximum allowable stress of three times the square root of the concrete compressive strength in psi, prior to the concrete attaining the required 28-day strength.

410-7 Handling, Storage, and Shipping.

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

The manufacturer is permitted to verify the shipping strength test, before 28 days, by testing compressive strength cylinders that are cured under the conditions similar to the product or by testing temperature match cured cylinders. The manufacturer may use the maturity method, ASTM C 1074, pulse velocity method in accordance with ASTM C 597, or any other approved nondestructive test method to estimate the strength of concrete for determining form removal and handling strengths or before verification of shipping strength by test cylinders.

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

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

410-8 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 box culverts are maintained.

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

410-9 Marking.

Ensure each section of Precast Box Culvert has permanently and clear marking on an inside face by indentation, waterproof paint, or as specified in the Quality Control Plan, showing the manufacture date, serial number, project number, and manufacturer's name or symbol. The top of the box culvert must also be clearly indicated with waterproof paint or as specified in the Quality Control Plan.

410-10 Trench, Foundation, Laying, and Backfill.

410-10.1 General: Meet the requirements of Section 125 and/or Section 121, for trench excavation, foundation construction, laying and backfilling and the following:

Lay all precast box culvert sections on a dry, slightly yielding foundation, to ensure uniform bearing across the full width of the bottom slab. Provide dewatering devices, if applicable, in accordance with 455-29, capable of maintaining a stable and surface-dry trench bottom. Construct any temporary sheet piling used in cofferdams, retaining walls and to incorporate the Contractor's specific means and methods, in accordance with 125-3.

410-10.2 Bedding: Provide bedding that consists of a minimum 6 inch depth of select material, with not more than 15% fines passing the No. 200 U.S. Standard sieve, in accordance with Design Standards Index No. 505 or other granular material approved by the Engineer. Place bedding in maximum 6 inch compacted layers below the culvert to a minimum width of 12 inches outside the exterior walls of the culvert and meet the density requirements of 125-9.2. When coarse aggregate is approved for use as an alternate bedding material, wrap the bottom and sides of the coarse aggregate with a layer of Type D-4 geotextile filter fabric as specified in Design Standards Index No. 199, and substituted the coarse aggregate with select material within 4 feet of the cut-off or toe walls at each end of the precast box culvert. Obtain the Engineer's approval before using flowable fill for bedding material. Provide other special bedding material, when required by the Contract Documents.

Set grade forms 12 inches outside each exterior wall of the box culvert. Uniformly compact this material and then grade off using the forms. Set the grade forms approximately 1/8 to 1/4 inch above the theoretical grade line to allow for soil compression. Adjust this distance to yield the proper grade, but do not use in lieu of the proper compaction of the granular bedding material. Remove the forms after placing the precast box culvert section.

410-10.3 Placement of Precast Box Culvert Sections: Obtain the Engineer's approval of the method of controlling line and grade during culvert installation. Use a method that allows rapid checking of the previously laid sections. Maintain line and grade on sections previously set. The Engineer will consider sections which do not retain the plan line within 0.10 foot or grade within 0.10 foot during laying of subsequent sections, as not having been laid to line and grade. Take up and relay sections not to line and grade without additional compensation.

410-10.4 Placement of Multiple Barrel Culverts: For multiple barrel installations using single-cell precast box sections, provide positive lateral support between the precast box culverts consisting of non-shrink grout, Class I (Nonstructural) concrete or non-excavatable flowable fill prior to backfilling. Provide partial height backfill or bracing to maintain alignment, when approved by the Engineer.

410-10.5 Backfilling: Begin backfilling only after the Engineers approval. Seal blockouts and holes provided for lifting or joint restraint by plugging using an epoxy mortar or non-shrink grout in accordance with Sections 926 or 934 and properly cure to ensure a sound and watertight plug, prior to backfilling.

410-11 Joints.

410-11.1 General: Make field joints for precast concrete box culvert sections with either profile rubber gaskets or preformed joint sealants, unless otherwise detailed in the plans or approved shop drawings. Joint performance must meet the requirements of ASTM C 990, and joint openings at the outside face must not exceed 1 1/2 inches in the assembled position at any location along the joint perimeter. Ensure a minimum 50

percent overlap of the joint tongue and groove around the entire perimeter of the box in the assembled position. Completely wrap the outside of each joint with geotextile filter fabric. Use fabric meeting the physical requirements of Class D, Type 3 specified on Design Standards, Index No. 199. Provide fabric with a minimum width of 2 feet and a length sufficient to ensure a minimum overlap of 24 inches. The filter fabric must extend a minimum of 12 inches beyond each side of the joint. Secure the fabric tightly against the box culvert sections with metal or plastic strapping. Other methods which will hold the fabric securely against the wall of the culvert until the backfill is placed and compacted, may be used when approved by the Engineer. When specified in the plans, secure the joint by a suitable device capable of holding the sections to line and grade as well as fully home. Remove these devices and repair locations as necessary if intrusive into the concrete after placing and compacting sufficient backfill to secure the sections.

410-11.2 Profile Rubber Gaskets: Install field joints in accordance with the joint manufacturer's instructions and meet the following:

1. Meet the requirements of Article 6 of ASTM C 443,
2. Store all gaskets in a cool place prior to use,
3. Furnish to the Engineer written details regarding configuration of the joint and gasket required to create a soil-tight seal. Do not apply mortar, joint compound or other filler which would restrict the flexibility of the joint.

410-11.3 Preformed Flexible Joint Sealants: Install field joints in accordance with the joint manufacturer's instructions and meet the following:

1. Meet the requirements of ASTM C 990,
2. Furnish to the Engineer a written recommendation of the size (cross-sectional area) of joint sealant which will create a soil-tight seal. Ensure that this amount is the minimum quantity of bitumen sealant used. Do not brush or wipe joint surfaces which are to be in contact with the joint sealant with cement slurry. Fill minor voids with non-shrink grout,
3. Thoroughly clean and dry all joint surfaces which are to be in contact with the sealant material. When recommended by the sealant manufacturer, apply a primer of the type recommended to all joint surfaces which are to be in contact with the sealant material.
4. Apply sealant to form a continuous seal around each joint. The sealant must be protected by a removable wrapper. Do not remove the paper wrapper on the exterior surface of the preformed flexible joint sealant until immediately prior to joining the precast sections. Apply the joint sealant only to dry surfaces. When the atmospheric temperature is below 60°F, either store the joint sealant in an area above 70°F, or artificially warm the joint sealant to 70°F in a manner satisfactory to the Engineer. After assembly ensure that there is full contact and compression of the sealant for the entire perimeter of the joint, as evidenced by the presence of minor bulging along any visible edges of the sealant. Neatly trim any extruded sealant flush with the concrete surface.

410-11.4 Water-tight Joint Treatment: Provide water-tight joints when shown in the Contract Documents. Utilize an external sealing band in accordance with ASTM C 877 in addition to the requirements of 410-11.2 or 410-11.3. Determine the minimum width of sealing bands by substituting the larger of the clear rise or span of the precast concrete box section, for the equivalent pipe diameter in ASTM C 877 Tables 1 and 2.

Install external sealing band wrap in accordance with the manufacturer's instructions prior to wrapping the joint with geotextile filter fabric.

410-12 Shop Drawings.

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

410-13 Method of Measurement.

The quantity to be paid for will be plan quantity for the structure shown in the Contract Documents in accordance with 400-22 and 415-7.

410-14 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including the cost of special bedding material and its placement, additional cut-off or toe wall depth, temporary sheet piling, graded forms, joint materials, filter fabric material, attachment of the filter fabric, dewatering, excavation, channel excavation and lining, backfilling, restraining devices and any other materials or equipment necessary to make a complete and accepted installation.

Payment will be made under pay items for concrete (culverts) and reinforcing steel (roadway).