Section 406. PRECAST THREE-SIDED, ARCH, AND BOX CULVERTS

406.01. Description. This work consists of the following:

A. Designing, load rating, manufacturing, and constructing precast three-sided, arch, and concrete box culverts and appurtenances;
B. Providing dewatering;
C. Maintaining the water flow during construction stages; and
D. Providing and installing gaskets and geotextile fabric to seal culvert joints.

406.02. Materials. Provide materials in accordance with the following:

Concrete ......................................................................................... 701
Mortar, Type R-2 ............................................................................ 702
Cement Type I, Type III .................................................................. 901
Granular Material Class II, III, IIIA .................................................. 902
Coarse Aggregate 6A, 6AA, 17A.................................................... 902
Fine Aggregate 2NS ....................................................................... 902
Open-Graded Aggregate 34R ........................................................ 902
Concrete Admixtures ...................................................................... 903
Fly Ash ............................................................................................ 903
Asphaltic Materials ......................................................................... 904
Steel Reinforcement ........................................................................ 905
Sealers for Culvert Joints ............................................................... 909
External Rubber Gaskets ............................................................... 909
Geosynthetics ................................................................................. 910

Provide natural coarse aggregate for 6A, 6AA, and 17A, in accordance with subsection 902.02. Provide aggregate with a gradation meeting Michigan Series 6AA or 17A, the physical requirements of 6AA, and not exceeding the following nominal maximum size requirements:

A. One-fifth the narrowest dimension between forms,
B. One-third the depth of slabs, and
C. Three-quarters the minimum clear spacing between individual reinforcing bars or wires.

Ensure the Freeze-Thaw Dilation, percent per 100 cycles does not exceed 0.030 percent.

Provide steel with a minimum yield strength of 65,000 psi for welded wire fabric and 60,000 psi for deformed billet-steel bars.

Provide ¾-inch or 1-inch diameter inserts or a Department-approved equal.
Provide epoxy coated steel in headwalls exposed to traffic.

406.03. Construction.

A. Design. Ensure a professional engineer, licensed in the state of Michigan, seals the design for precast three-sided, arch, and box culverts.

1. Precast Three-Sided and Arch Culverts. Provide culverts with the rise, span, skew angle, and minimum waterway area shown on the plans. Obtain the Engineer’s approval for larger spans or rises.

   Select a Department-approved culvert design and manufacture at a Department-approved commercial precast concrete plant.

   Certify the precast three-sided or arch culvert design in accordance with current AASHTO LRFD Bridge Design Specifications and ASTM C 1504. Base the design on the AASHTO loads shown on the plans. Investigate all load factor combinations to produce the positive and negative extremes (minimum load factors applied to loads that reduce the force effect being investigated). Include with the certification, in tabular format, the maximum factored inward and outward horizontal forces, and vertical forces, at the base of the culvert wall. Ensure the maximum factored horizontal and vertical forces are less than the horizontal and vertical capacities of the footings, as shown on the plans. Ensure the footing dimensions, including width, depth, and keyway size, and footing concrete compression strength, as shown on the plans, are compatible with the culvert design. Determine maximum inward and outward horizontal forces by appropriate usage of minimum and maximum load factors. Submit all design calculations for the culvert sections, headwalls, and wingwalls. Design headwall connections and wingwalls for sliding and overturning.

2. Precast Concrete Box Culverts. Design precast box culverts in accordance with current AASHTO LRFD Bridge Design Specifications and ASTM C 1577. Design the culvert to carry live loads as specified in Table 1 of ASTM C 1577. As an alternative to using the design tables in ASTM C 1577, the Contractor may use the current version of the FHWA approved LRFD BOXCAR program to design culverts provided the design includes HL-93 live load without lane load and dynamic load allowance as defined in the AASHTO LRFD Specifications.

   The Department will not allow precast concrete box culverts manufactured using dry cast methods.
Ensure the joint design accommodates the joint sealing material required, and conforms to Section 8 of ASTM C 1577.

B. **Shop Drawings.** Submit shop drawings for culverts greater than 10 feet in span length to the Engineer, for review and approval in accordance with subsection 104.02. Do not begin fabrication until receipt of written approval of the shop drawings from the Engineer.

Include the following in the shop drawings:

1. Load ratings using as-designed conditions;
2. Design assumptions;
3. Design loads;
4. Design calculations;
5. Culvert dimensions;
6. Details of the concrete mix design;
7. Methods of manufacture;
8. Method of joining adjacent culvert elements, if required;
9. Recommended installation procedures; and
10. The manufacturer’s minimum depth of fill required for construction traffic over the culvert.

Provide shop drawings that show insert details and connection details for attaching head walls, wing walls, aprons and curtain walls, as shown on the plans.

The Contractor may submit shop drawings for cast-in-place head walls, wing walls, aprons, and curtain walls as an alternative to precast sections shown on the plans.

Call attention to deviations from the contract on the shop drawings. If deviations are not clearly identified, the Department will not consider the deviations as part of the shop drawing approval.

C. **Load Rating.**

1. **Load Rating Procedure.** Meet legal loads and class A overloads. Before manufacture, perform load ratings on precast three-sided, arch or box culverts greater than 10 feet in span length, in accordance with the AASHTO Manual of Bridge Evaluation, Section 6, Part A, the Michigan Bridge Analysis Guide current at the time load rating is performed, and the Michigan Structure Inventory and Appraisal Guide. Use as-designed conditions and assume an in-place future wearing surface to calculate the following ratings:

   a. The Inventory Rating, National Bridge Inventory (NBI) Item 66;
   b. The Operating Rating, NBI Item 64;
   c. The Michigan Operating Rating, MDOT Item 64M; and
d. The Michigan Overload Class, MDOT Item 193.

After construction, review the load rating for as-constructed conditions, using as-constructed conditions, and as-constructed conditions with placement of future wearing surfaces.

2. **Load Rating Documentation.** Before manufacture, deliver the following information to MDOT in paper or electronic format:
   a. Assumption sheet – A list of assumptions made in the analysis regarding material properties, vehicle configurations, live load factors, live load distribution, and other factors;
   b. Program or calculation input and output; and
   c. A complete Bridge Analysis Summary Form.

Resubmit Load Rating Documentation including any changes from as-designed conditions to as-constructed conditions impacting load ratings. Ensure a professional engineer, licensed in the state of Michigan, seals the load ratings.

D. **Manufacture.**

1. **Placement of Reinforcement.** Provide concrete cover for welded wire fabric reinforcement at least three times the wire diameter and at least 1 inch thick. For the reinforcement in the top of the top slab of structures covered by less than 2 feet of fill, provide a minimum concrete cover of at least 2 inches. Assemble reinforcement using a maximum of three layers of welded wire fabric.

The Contractor may use a single layer of deformed steel bars instead of welded wire fabric.

If using deformed steel bars, provide a minimum concrete cover of 2 inches. Ensure the ends of the longitudinal reinforcement are no greater than 2 inches from the ends of the culvert section. The Department will not consider exposure of the ends of longitudinal reinforcement, or spacers used to position the reinforcement, as cause for rejection.

2. **Reinforcement Development Length, Splices and Spacing.** Develop the exterior corner reinforcement and splice circumferential reinforcement in accordance with the current AASHTO LRFD Bridge Design Specifications.

For circumferential reinforcement composed of bars, meet the crack control criteria in the current AASHTO LRFD Bridge Design Specifications. Perform and submit calculations to the Department verifying that proposed bar spacing meets crack control criteria.
3. **Placement of Protective Sealant Coating.** Place the protective sealant coating on the exterior top surface of precast units as required by the contract.

4. **Joints.**
   a. **Precast Three-Sided and Arch Culverts.** Provide a 1 inch by 1 inch or ¾ inch by ¾ inch beveled edge on the external surface of the joint formed between the culvert units.
   b. **Precast Box Culverts.** Provide tongue and groove ends.

5. **Concrete.** Unless otherwise shown on the plans, the precast culvert manufacturer is responsible for the concrete mix design with 28-day compressive strength of at least 5,000 psi and containing 6.5 percent ± 1.5 percent entrained air. If using Type F or Type G admixtures, the Department will allow a maximum air entrainment of 8.5 percent. Proportion and mix cement, aggregate, admixtures, and water to produce a homogeneous concrete that meets strength requirements.

6. **Forms.** Use rigid forms to maintain the culvert dimensions within the tolerances specified in subsection 406.03.E. Use a smooth material for forming surfaces.

7. **Curing.** Cure culvert sections to ensure the required compressive strength. Use one of, or a combination of, the following curing methods.
   a. Low pressure steam-cure the culvert sections in accordance with subsection 708.03.A.11.
   b. Water cure the culvert sections using methods that maintain continuous moisture on the sections for at least 7 days.
   c. Accelerate overnight curing using an external heat source, while minimizing moisture loss from exposed surfaces. Apply the initial heating 2 hours after final concrete placement.
   d. Apply a sealing membrane that conforms to ASTM C 309.

8. **Handling.** Handle the culverts using a method approved by the manufacturer and Engineer. Do not drill holes for handling the precast unit.

Fill holes using one of the following methods before placing backfill:
   a. Fill holes with Type R-2 mortar.
   b. Fill tapered holes with concrete plugs, and secure with Type R-2 mortar, or other approved adhesives.
   c. Fill holes with neoprene plugs, wedged tightly in the holes to eliminate annular space. Affix a 9 inch by 9 inch rubber gasket.
and 24 inch by 24 inch piece of geotextile fabric to the culvert segment, centered over the plug and installed as specified by the manufacturer.

9. **Product Marking.** Use a method approved by the Engineer, to mark the interior of each precast unit with the following information:
   a. Span and Rise,
   b. Date of manufacture,
   c. Name or trademark of the manufacturer, and
   d. Design earth cover.

E. **Tolerances.** Ensure precast elements meet the tolerances specified by the designer and the following:

1. **Internal Dimensions.** Manufacture precast elements so the internal dimensions do not vary from the design dimensions by more than 2 inches. For culverts with haunches, ensure haunch dimensions do not vary more than ¾ inch from the dimensions shown on the shop drawings.

2. **Slab and Wall Thickness.** Manufacture precast elements so the slab and wall thicknesses do not vary from the dimensions shown on the shop drawings by more than 5 percent or ½ inch, whichever is greater. The Engineer will not consider slabs and walls thicker than the required dimension as cause for rejection, unless, in the opinion of the Engineer, the thickness variation prevents joint sealing.

3. **Length of Opposite Surfaces.** Manufacture precast elements so the laying lengths of two opposite culvert section surfaces do not vary by more than 1 inch.

4. **Length of Section.** Manufacture precast elements so the underrun from the required length measures no greater than ½ inch.

5. **Position of Reinforcement.** Manufacture precast elements so the position of reinforcement does not vary more than ½ inch. If the depth of cover over the top surface is less than 24 inches, ensure at least a 2 inch concrete cover over the top slab reinforcement.

F. **Testing and Inspection.**

1. **Testing.** Test the concrete for compressive strength in accordance with Section 10 of ASTM C 1504 for precast three-sided and arch culverts, and Section 10 of ASTM C 1577 for precast box culverts.

2. **Workmanship, Finish and Appearance.** Provide a smooth finish on the culvert surfaces, free of fractures. Fabricate culvert ends...
normal to the walls and centerline, within the required tolerances, unless the culvert is designed for skewed crossings.

3. **Repairs.** Repair manufacturing imperfections, handling damage, or construction damage to culverts as approved by the Engineer, in accordance with section 712, and at no additional cost to the Department.

4. **Rejection.** The Engineer may reject precast three-sided, arch, and box culverts due to the following:
   a. Fractures or cracks in the slab or wall;
   b. Defects that indicate imperfect proportioning, mixing, or forming;
   c. Honeycombed or open textured surfaces;
   d. Damaged ends preventing required joint construction;
   e. Concrete that does not attain the required compressive strength;
   f. Out of tolerance dimensions;
   g. Low or high air content; or
   h. Exposed reinforcing steel.

5. **Quality Assurance.** For culvert spans greater than 20 feet, provide the Department access to perform quality assurance inspection. Notify the Engineer at least 2 weeks before beginning fabrication. The Department does not consider this inspection a substitute for the manufacturer’s quality control requirements.

G. **Installation.** Construct the culvert in accordance with section 206 and section 706, as shown on the plans, and as specified in this subsection.

Perform dewatering or pumping and temporary drainage to maintain stream flow during construction. During dewatering or pumping and temporary drainage operations, avoid damaging adjacent property or structures and interfering with the rights of the public, adjacent property owners, vehicular traffic, or other contractors. Do not disturb the soil under and next to existing structures during dewatering and temporary pumping operations. Direct water from dewatering operations through a filter bag before discharging to an existing drainage facility. Do not overload or obstruct existing drainage facilities.

Construct the wingwalls, headwalls, and aprons for precast concrete culverts with a positive connection to the adjoining precast section as shown on approved shop drawings. Use \( \frac{3}{4} \)-inch or 1-inch diameter threaded bars to make the connection, unless otherwise shown on the plans.
Lay the culvert sections in stages to coincide with maintaining traffic, dewatering, temporary pumping, and part width phased construction sequencing, and as approved by the Engineer.

The Contractor may use precast wing walls, headwalls, and aprons, as alternatives to cast-in-place wingwalls, headwalls, and aprons. Attach precast wing walls or headwalls as shown on the shop drawings.

Place backfill in accordance with subsection 206.03. Place and compact backfill on opposite sides of the culvert at the same time, so backfill levels on opposite sides do not differ by more than 2 feet. Hand compact backfill within 1 foot of the structure. Use vibratory compactors meeting the culvert manufacturer’s specifications.

The Contractor is responsible for construction traffic on the culvert.

Do not exceed the maximum design loads, as noted on the shop drawings, with construction traffic. Replace damaged units at no additional cost to the Department.

1. **Precast Three-Sided and Arch Culverts.** Construct the footing from cast-in-place concrete in accordance with the contract. Construct the footing keyway level to minimize the height of the shims for leveling the precast sections. The Engineer may approve alternate procedures that provide a uniform bed of Type R-2 mortar under the culvert sections.

   Before placing the culvert sections onto the footing, survey the surface of the keyway and locate the high spot. Use the high spot as the control elevation for the bottom of the culvert sections. Add 1 inch to the high spot and place shims to that elevation. Use shims that are not susceptible to corrosion. Ensure the shims maintain the elevation of the culvert until the mortar surrounding the shims cures.

   Set the shims 12 inches from each corner of the culvert sections. If installing the culvert sections on a sloping grade, establish elevation control points at 50-foot increments and run a string line between these elevations to set other shims. Provide joints no greater than 1 inch wide. After placing the culvert sections, grout underneath the culvert leg sections, and to the tops of the sides of the keyway with Type R-2 mortar. Grout by mounding the mortar on one side of the leg and vibrating until it passes through to the other side of the leg. If mortar does not pass through the leg, repeat the process on the other side.

   Before sealing joints between adjacent culvert sections, provide smooth surfaces, free of debris. If using cast-in-place headwalls or
wingwalls, seal the joints between the culvert elements and headwalls, and the joints between headwalls and wingwalls. Make the joints watertight.

If using precast headwalls or wing walls, seal the joints between the culvert elements and headwalls, and the joints between headwalls and wingwalls, watertight using the same method for joints between adjacent culvert sections.

Seal the joints between the adjacent precast culvert sections using a \( \frac{\pi}{4} \) inch by \( \frac{1}{4} \) inch butyl rope conforming to ASTM C 990. Place the butyl rope between the units in the bevel.

If the manufacturer recommends sealing joints using non-shrink grout, and if approved by the Engineer, the Contractor may omit the butyl rope.

Cover the butyl rope with an external type rubber gasket at least 9 inches wide, conforming to ASTM C 877, centered over the joint. Use a primer compatible with the rubber gasket to secure the gasket. Install the gasket in accordance with the manufacturer’s recommendations. Cover the joint with a 24-inch wide strip of geotextile blanket centered over the joint.

Make the completed joint watertight. The Engineer will consider the joint watertight if no visible signs of leakage appear around the joint for the duration of the project. If the joint is not watertight, create a watertight seal at no additional cost to the Department.

If limited spacing between culvert legs of adjacent spans of multiple span structures prevents sealing culvert leg joints for adjacent spans, use self-compacting engineered fill to prevent leakage of fill through joints. Prevent migration of fines through the engineered fill.

2. **Box Culverts.** Construct culvert bedding for the box culvert structure as shown on the plans. Use at least 9 inches deep, coarse aggregate 6A, at least 80 percent crushed, covered with 3 inches of open-graded aggregate 34R to construct the bedding. Before placing the open-graded aggregate 34R, compact the course aggregate 6A using at least three passes of a vibrating plate compactor. Compact the open-graded aggregate 34R using at least one pass of a vibrating plate compactor. If unstable soil conditions or obstructions other than rock require excavation of the trench below the elevation shown on the plans, undercut, backfill, and compact the trench as directed by the Engineer. Use 6A, 17A, or 34R aggregate as backfill material for undercutting.
Fill the space between the box culvert joints during placement of box sections with closed-cell rubber extrusion type gaskets in accordance with AASHTO M 198. Use the gasket sizes and installation methods recommended by the manufacturer and approved by the Engineer. After placement, treat every precast concrete box culvert exterior joint with cold applied culvert joint sealer and cover with a 36-inch strip of geotextile blanket centered on the joint.


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<th>Pay Item</th>
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<tbody>
<tr>
<td>Culv, Precast Three-Sided or Arch,</td>
<td>Pay Unit</td>
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<tr>
<td>(span) foot × (rise) foot</td>
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<tr>
<td>Culv, Precast Conc Box, (span) foot ×</td>
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<td>(rise) foot</td>
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A. Precast Three-Sided or Arch Culvert. The Engineer will measure Culv, Precast Three-Sided or Arch along the centerline of the structure, from fascia to fascia. The Department will pay for Culv, Precast Three-Sided or Arch, of the type required, in accordance with the span-rise combination shown on the plans. The unit price for Culv, Precast Three-Sided or Arch includes the following:

1. Designing, manufacturing, load rating, and installing precast elements;
2. Headwalls and wing walls, precast or cast-in-place;
3. Providing and placing shims to level the precast elements;
4. Type R-2 mortar;
5. Joint sealer;
6. Inserts;
7. Required geotextile blankets;
8. Dewatering and maintaining the stream flow during construction stages; and
9. Providing plan modifications, including design, plan quantities, and pay items, to accommodate precast units.

The Department will pay for Culv, Precast Three-Sided or Arch by plan quantity in accordance with subsection 109.01.A.

The Department will pay separately for cast-in-place concrete, other than for culvert segments, wingwalls, and headwalls; excavation; protective coating; providing and placing backfill material, including engineered fill between adjacent spans and drainage materials; by plan quantity in accordance with subsection 109.01.A.
B. **Box Culvert.** The unit price for **Culv, Precast Conc Box** includes the cost of the following:

1. Designing, manufacturing, load rating, and installing the precast elements;
2. Cold applied culvert joint sealer;
3. Closed-cell rubber extrusion type gaskets;
4. Geotextile pipe wrap for box culvert joints;
5. Inserts for bars; and
6. Dewatering and maintaining the stream flow during construction stages.

The Department will pay separately for excavation and backfill.

The Department will pay for cast-in-place wingwalls, headwalls, aprons, and curtain walls provided as an alternative to precast equivalents, as the corresponding cast-in-place wing wall, headwall, apron, and curtain wall pay items.

The unit prices for trench undercut and backfill pay items include undercutting, backfilling, and compacting trenches excavated due to unstable soil conditions or obstructions other than rock, in accordance with subsection 402.04.E.

C. **Culvert Bedding, Box Culvert.** The Engineer will measure **Culv Bedding, Box Culv** by volume compacted in place to the depth, length, and width shown on the plans or as directed by the Engineer. The unit price for **Culv Bedding, Box Culv** includes placement and compaction of the coarse aggregate 6A and open-graded aggregate 34R.

D. **Rock Excavation.** The Engineer will measure and the Department will pay separately for rock excavation in accordance with subsection 205.04.