

**SECTION 13**  
**BURIED STRUCTURES**

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## **SECTION 13** **BURIED STRUCTURES**

### **13.1 REINFORCED CONCRETE BOX CULVERTS AND FRAMES (REV. 12/19)**

#### **13.1.1 General**

Reinforced concrete box culverts may be made of either precast or cast-in-place concrete. Generally, when conditions warrant a box culvert and frames, for reasons of economy, shall be made of precast concrete. Full-length cast-in-place concrete box culverts shall only be used with the approval of the **CTDOT**. Sections of box culverts may be cast in-place when required by site conditions such as transitions between different size culverts, transitions between new and existing box culverts, adjacent utilities that cannot be relocated, or highly skewed culvert ends.

The culvert dimensions shall be consistent with the hydraulic characteristics of the waterway. Preferably, the height of the box culvert or frame (the dimension from the top of the floor (invert) to the bottom of the roof) should be a minimum of 6 feet to facilitate its maintenance and inspection. For culverts that are designed to “silt in” with soil, the height should be measured from the invert of the channel.

For precast culverts and frames, the size selection should be coordinated with the manufacturers to be consistent with standard sizes that are readily available. On projects requiring more than one culvert or frame, of different size openings, an economic study should be conducted to determine if it is possible to use the same size opening for more than one structure.

Box culverts do not need to be analyzed for scour. However, erosion countermeasures may be required if recommended by the Hydraulics Report.

#### **13.1.2 Excavation**

For excavation requirements, refer to **BDM** [5].

#### **13.1.3 Foundation**

For excavation requirements, refer to **BDM** [5].

##### **13.1.3.1 Culvert Bedding**

Generally, box culverts shall be founded on 12 inches of “Granular Fill” to provide slightly yielding uniformly distributed support over the bottom width of the box section. The fill shall extend 2 feet beyond the sidewalls of the box culvert.

Box culverts founded on unyielding foundations, such as rock or piles, are not permitted.

### **13.1.3.2 Cutoff and Return Walls**

The inlet and outlet ends of box culverts shall rest on cutoff walls. The cutoff walls shall have return walls below the outside walls that extend a minimum of 4 feet from the rear face of the cutoff wall. These walls shall be embedded a minimum of 4 feet below the finished elevation of the bottom of the channel. The walls shall have a minimum thickness of 12 inches. Cutoff and return walls shall be constructed of Class PCC0334Z. The floor of the box culverts shall be connected to the cutoff walls with dowels.

### **13.1.3.3 Nosings between Adjacent Parallel Multicell Box Culverts**

The inlet and outlet ends of the walls between adjacent parallel multicell box culverts shall be protected with nosings. The nosings may be either cast-in-place or precast. Cast-in-place concrete nosing shall be constructed of Class PCC0334Z. The nosings shall be founded on the cutoff wall and connected to the walls.

The maximum allowable joint width between adjacent parallel units shall be one inch. In order to provide a positive means of lateral bearing between parallel units, after placing the nosing, the joint shall be filled with sand made flowable by mixing it with water.

### **13.1.3.4 Sills**

Sills shall be provided at the inlet and outlet ends of box culverts when warranted by hydraulic or environmental conditions. The dimensions shall be as recommended by the Hydraulic Report. The sills shall have a minimum thickness of 12 inches and shall be connected to the floor of the box culverts with dowels. Sills shall be constructed of Class PCC0334Z.

### **13.1.3.5 Headwalls (Rev. 12/19)**

Headwalls at the inlet and outlet shall be provided to satisfy the site grading conditions. Headwalls shall be constructed of Class PCC0334Z. The headwalls shall have a minimum thickness of 1.25 feet at the top. On precast concrete box culverts and frames, dowel bar mechanical connectors shall be used to connect headwall stems to the roof of the structure. The rear face of headwalls shall be dampproofed. Railings or fences shall be placed on all headwalls in accordance with the requirements of **BDM** [12].

*Commentary: The box culvert or frame roof thickness may be governed by the development of the reinforcement required to connect the headwall to the box culvert or frame.*

### **13.1.3.6 Wingwalls (Rev. 12/19)**

Generally, cast-in-place concrete wingwalls shall be provided at the inlet and outlet of all box culverts and frames. The designer should coordinate with the hydraulic engineer as to the appropriate angles for the flared wingwalls. The wingwalls should abut the ends of the outside walls of the box culvert or frame. Wingwall stems and footings shall be made

independent of the culvert or frames walls, cutoff and return walls. The elevation of the bottom of the wingwall footings shall match the cutoff, return walls, and frame foundation. Wingwalls shall be constructed of Class PCC0334Z concrete. The minimum thickness at the top of wingwall stems shall be 1.25 feet. The rear face of wingwalls shall be dampproofed. Railings or fences shall be placed on all wingwalls in accordance with the requirements of **BDM** [12].

### **13.1.3.7 Dampproofing**

Dampproofing is not required on precast concrete box culverts and frames.

### **13.1.3.8 Subsurface Drainage**

Provisions for subsurface drainage are not required for the culvert and frame backfill.

### **13.1.3.9 Backfill Requirements**

#### **13.1.3.9.1 General**

Unless otherwise directed, all box culverts, frames and their associated wingwalls shall be backfilled with “Pervious Structure Backfill” in accordance with the requirements of **BDM** [5].

#### **13.1.3.9.2 Backfill Limits**

Place a wedge of Pervious Structure Backfill above a slope line starting at the top of the heel and extending upward at slope of 1:1.5 (rise to run) to the bottom of the subbase. In cut situations, the following note, with a leader pointing to the slope line, shall be placed on the plans:

Slope line except where undisturbed material obtrudes within this area.

Rock fill or boulders shall not be placed within two feet of top of box culverts and frames. The following note, with leaders pointing to the limits, shall be placed on the plans:

No rock fill or boulders shall be placed within these limits.

In cut situations, if the material is soft silt or clay, the backfill limits shall be determined by the designer and submitted for review and approval with the Geotechnical Report.

#### **13.1.3.10 Membrane Waterproofing Requirements**

When the distance from the top of the box culvert and frame roof to top of the roadway surface is less than 2 feet, membrane waterproofing shall be placed on the box culvert and frame. The membrane waterproofing shall be “Membrane Waterproofing (Cold Liquid Elastomeric).” The membrane shall cover the entire exterior surface of the roof and extend 12 inches down the sidewalls.

#### **13.1.3.11 Railing and Fences**

For railing and fence requirements, refer to **BDM** [12].

### **13.1.4 Precast Concrete Box Culverts (Rev. 04/19)**

#### **13.1.4.1 General (Rev. 12/19)**

Precast concrete box culverts are items that are furnished and installed by the Contractor in accordance with the owned special provision “\_x\_ Precast Concrete Box Culvert.” The designer is responsible for reviewing the Contractor’s shop and working drawing submittals for the box culverts.

The designer is responsible for designing and detailing precast concrete box culverts including all other box culvert components, such as cutoff and return walls, nosings, sills, headwalls and wingwalls.

Precast concrete box sections shall be designed for all construction load effects that may be applied during all stages/phases of construction.

#### **13.1.4.2 Concrete**

The concrete for the precast box culvert sections shall have a minimum compressive strength ( $f'_c$ ) of 5,000 psi and a minimum electrical resistivity of 29  $k\Omega$ -cm in accordance with AASHTO T 358 at 28 days. The concrete mix design is submitted by the Contractor in accordance with the special provision “\_x\_ Precast Concrete Box Culvert” for review by the designer.

#### **13.1.4.3 Reinforcement Details (Rev. 12/19)**

The reinforcement shall conform to the requirements of **BDM** [6.3.2.3].

Generally, the minimum concrete cover over all reinforcement on any surface of the roof, floor and walls shall be 2 inches. In structures exposed to salt water, the minimum concrete cover over all reinforcement on any surface of the roof, floor and walls shall be 3 inches.

The designer shall determine the concrete cover requirements and note the requirements on the plans.

The reinforcement spacing to control cracking shall be based on Class 2 exposure conditions.

#### **13.1.4.4 Minimum Thickness of Floor, Sides and Roof**

The minimum thickness of the culvert floor, sides and roof shall be 8 inches. The designer shall note the minimum thickness requirements of the box culvert elements on the plans.

*Commentary: The thickness of the roof of the box culvert sections at the inlet and outlet may be governed by the development of the reinforcement required to connect the headwall to the box culvert.*

#### **13.1.4.5 Headwalls**

Headwalls are typically connected to box culvert roofs with dowel bar mechanical connections. The designer is responsible for designing and detailing the headwall connection to the box culvert. The designer shall check to ensure that the end sections of precast concrete box culverts adequately resist the load effects from the headwall.

### **13.1.5 Cast-In-Place Concrete Box Culverts (Rev. 04/19)**

#### **13.1.5.1 General**

The designer is responsible for designing and detailing cast-in-place concrete box culverts including all other box culvert components, such as cutoff and return walls, nosings, sills, headwalls and wingwalls.

#### **13.1.5.2 Concrete**

Cast-in-place concrete box culverts shall be constructed of Class PCC04462.

#### **13.1.5.3 Minimum Thickness of Floor, Sides and Roof**

The minimum thickness of the culvert floor, sides and roof shall be 12 inches.

#### **13.1.5.4 Reinforcement Details**

The reinforcement shall conform to the requirements of **BDM** [6.3.2.3].

The minimum cover over all reinforcement shall be 2 inches, except the cover over the outer reinforcement in the floor slab shall be 3 inches. The cover over all reinforcement in structures exposed to salt water shall be 4 inches.

### **13.1.5.5 Expansion, Contraction and Construction Joints**

Expansion and contraction joints in the culvert floor, sides and roof shall be provided in accordance with **AASHTO LRFD**. Construction joints shall be placed as conditions warrant.

No reinforcement shall pass through expansion and contraction joints. Reinforcement shall pass through construction joints.

### **13.1.6 Precast Concrete Frames (Rev. 12/19)**

#### **13.1.6.1 General**

Precast concrete frames are 3-sided rigid frames that have uniform wall and top slab thicknesses. Precast concrete frames are furnished and installed by the Contractor in accordance with the special provision "Precast Concrete Frame." The designer is responsible for reviewing the Contractor's shop and working drawing submittals for the frames.

The designer is responsible for designing and detailing precast concrete frames including all other frame components, such as footings, nosings, headwalls and wingwalls.

Precast concrete frame sections shall be designed for all construction load effects that may be applied during all stages/phases of construction.

#### **13.1.6.2 Concrete**

The concrete for the precast concrete frame sections shall have a minimum compressive strength ( $f'_c$ ) of 5,000 psi and a minimum electrical resistivity of 29 k $\Omega$ -cm in accordance with AASHTO T 358 at 28 days. The concrete mix design is submitted by the Contractor in accordance with the special provision "Precast Concrete Frame" for review by the designer.

#### **13.1.6.3 Reinforcement**

The reinforcement shall conform to the requirements of **BDM** [6.3.2.3].

## **13.2 REINFORCED CONCRETE JUNCTION BOXES**

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