Section 29 - Culverts and Arches

29.1 General Criteria

1. The design of cast-in-place concrete culverts, precast concrete box culverts, precast concrete arch structures and precast concrete three-sided structures shall conform to Subsection 5.14.5 and Section 12 of the *AASHTO LRFD Bridge Design Specifications*.
2. Designers may advance the use of precast concrete member usage. That is, it is not necessary to establish alternate methods of culvert construction to meet project specific requirements. Use of precast concrete box culverts, precast concrete arch structures or three (3) sided precast concrete structures is generally permitted.
3. As specified in Subsection 3.10.1 of the *AASHTO LRFD Bridge Design Specifications*, consideration of seismic effects on buried structures in New Jersey is not required.

29.2 Waterway Openings

For establishing waterway openings, reference for guidance shall be made to the following documents:

- *AASHTO LRFD Bridge Design Specifications* Article 2.6
- *AASHTO Model Drainage Manual*
- U.S. Department of Transportation, Federal Highway Administration, Publication No. FHWA HI-96-032 November, 1995, Hydraulic Engineering Circular (HEC) documents
- The *NJDEP Stream Encroachment Technical Manual*

29.3 Hydraulic and Hydrologic Data

1. The following tabulation with complete information shall be shown on preliminary bridge plans and final bridge plans:

Hydraulic And Hydrologic Data	
Drainage Area (SQ.MI)	
Design Discharge (C.F.S.)	
Design Water Surface Elevation (FT)	
Energy Line Elevation (FT)	
Frequency	100 YR.

2. All culverts shall be designed, through methods outlined in Section 42 of this Manual, to resist scour.

29.4 General

1. For cast-in-place reinforced concrete box culverts, the horizontal joint between the walls and top slab shall be designated **Optional Construction Joint** when the height between the upper and lower horizontal joints is 8 feet or less. If the Contractor elects to omit the joint, he shall delay placing the concrete in the top slab for at least 2 hours after the concrete in the walls has been placed.

In addition, the joint between the invert slab and the side walls shall be detailed as a construction joint, and the invert slab concrete shall achieve a minimum compressive strength of 3000 psi prior to the construction of the remainder of the culvert.

2. Wingwall footings at their junction with the invert slab shall be detailed without a construction or contraction joint so that the footing concrete is placed monolithically with the invert slab.
3. In order to minimize adverse hydraulic characteristics, large storm drains (2 feet diameter or larger) shall not be discharged through walls of culverts.
4. The illustration on Guide Plate 3.12-4 shows guidelines for establishing excavation payment limits for roadway and bridge items of work.
5. Guide Plates 3.12-1 and 3.12-2 provide guidelines for developing uniform details on contract drawings for single and twin cell box culverts, respectively. The designer shall design and detail the culvert on the plans assuming cast-in-place concrete construction.
6. The Special Provisions for select projects (such as where staging is required or where limited construction time is essential to restore normal vehicular or rail traffic) may require precast culvert construction.

   In such cases, the Structural Design Engineer shall select opening sizes for the cast in place concrete culvert which are obtainable in standard precast concrete sections. The Designer shall contact various local precasters to obtain the latest information on standard precast culvert sizes that are commercially available.
7. Provisions for a low flow fish passage in the form of a fish trough or other means may be required for culverts in certain locations. Environmental regulatory criteria should be verified when planning the design for such conditions.
8. In order to increase the inlet performance and for improved flow through the culvert, the bottom of inner top slab and walls edges shall be beveled as follows at the entrance of the culvert:

   a. For single cell box culverts, a 45 degree bevel of ½ inch per foot of culvert clear height shall be provided for the top slab and bottom edge of the culvert entrance. A 45 degree bevel of ½ inch per foot of culvert clear width shall be provided for both side walls and inside edges of the culvert waterway entrance.

   b. For twin cell box culverts, in addition to the bevels specified above, the center wall shall have a 45 degree of 2½ inches on both sides. This is based on a minimum 8 inch wall thickness. For every 1 inch increase in the center wall thickness, there shall be a ½ inch increase of the bevel on both sides.

29.5 Design Criteria For Precast Reinforced Concrete Box Sections For Culverts

1. Precast reinforced concrete box sections shall not be used where the top slab is to be used as a riding surface.
2. When the earth fill above the top of culvert is less than 2 feet, the design dead load shall include 25 pounds per square foot for future application of a 2 inch thick wearing surface.

3. The minimum concrete usage for precast concrete elements shall be Class "P" and have a minimum design compressive strength of f'_c = 5000 psi.

4. The minimum concrete cover over the circumferential reinforcement shall be 1½ inches except on the exterior side of the top slab where it shall be 2 inches.

5. The wall thickness for precast culverts shall be a minimum of 8 inches. The top and bottom slab thickness shall be a minimum of 10 inches. Dependent on project site conditions these thicknesses may be reduced. Any reduction must account for an adherence to concrete cover requirements and provision of required reinforcement size and distribution. Calculations shall be provided and shall account for the reduction.

6. A flexible watertight rubber gasket shall be provided at the joint between the precast units. The gasket shall be continuous around the circumference of the joints. Details of the transverse joint between the culvert sections shall be provided on the plans.

7. A coarse aggregate layer shall be provided under the precast reinforced concrete box culvert sections. The depth of the coarse aggregate layer shall be a minimum of 2 feet. It shall extend 1 foot on each side of precast reinforced concrete box culvert section.

8. A waterstop shall be provided to prevent water from entering vertical joints between the end of precast culvert sections and any cast-in-place appurtenances such as wingwalls, cutoff walls, aprons and cast-in-place culvert end sections.

9. Two rows of threaded inserts or bar extensions (longitudinal tie bolts) shall be provided in the end culvert section to facilitate the attachment of the culvert end section to the wingwalls. A detail of this connection shall be provided on the plans.

10. As per item 9, provide the same detail, if applicable, for the headwall attachment.

11. If precast concrete units are used in parallel for multicell installations, the parallel units shall be placed a maximum of 6 inches apart. The 6 inch space between the units shall be filled in conformance with the Standard Specifications. The purpose of this procedure is to ensure a positive means of lateral support between the parallel precast units.

12. The use of precast concrete end sections, including headwalls and wingwalls, are permitted.

    However, precast end sections shall not be used when the skew angle requirements result in a situation where the short wall of a precast end section is less than 3 feet.

    If approved for use, adequate provisions shall be made for cast in place appurtenances such as wingwalls, aprons and cutoff walls.

13. When the earth fill over the precast culvert is less than 2 feet, the top mat of reinforcement, and ties, in the top slab shall be corrosion protected.

14. Lifting devices or holes will be permitted in each box section for the purpose of handling and erection. All lifting holes shall be filled with nonshrink grout, after

the grout has cured, the area shall be coated with an epoxy waterproofing seal coat.

15. Placement of precast units:
    - The precast units shall be pulled against the prior installed section such that an adequate seal is obtained between the two connecting units and the rubber gasket.
    - Prior to backfilling, a 2 foot wide strip of filter fabric shall be placed over the top and side transverse joints.
    - To provide continuity and concrete shear transfer between the precast box sections, a longitudinal tie rod or prestressing strand shall be placed in position through a 1½ inch diameter hole.
    - Four (4) longitudinal ties, one in each corner of the precast section, shall be provided.
    - Longitudinal ties that are used to tie the precast units together shall be ¾ inch diameter high tensile strength steel bars conforming to AASHTO M 275 (ASTM A 722) Type I or ½ inch 7 wire Grade 270 ksi strands conforming to AASHTO M 203 (ASTM A 416) or equivalent. The Designer shall evaluate the practicality of using steel bars. Issues such as needed length and shipping may preclude the use of steel bars. Under such circumstances wire strands will be more practical.
    - No splices are permitted in the strands. Bars shall be galvanized in accordance with AASHTO M 111.
    - End anchorages (nuts, washers and anchor plates) shall be compatible with the tie rod system and shall be galvanized in accordance with AASHTO M 111.
    - The anchorages and end fittings for the ½ inch 7 wire strand and the corrosion protection method shall be detailed on the plans.
    - Each tie rod shall be stressed to a tension of 30 kips.
    - After tensioning, the exposed ends of the ties shall be removed so that no part of the ties, or of the end fittings, extend beyond a point 1 inch inside the anchorage pocket.
    - All hardware associated with the end anchorage systems shall be galvanized. After tensioning has been completed the exposed parts of the end fittings shall be coated with two coats of bituminous paint.
    - If hand holes are used for the installation of longitudinal ties, they shall be spaced appropriately.
16. Precast reinforced concrete culvert units shall be manufactured in steel forms and steam cured.
17. Precast reinforced concrete culvert units shall not be shipped until 72 hours after fabrication and the 28 day compressive strength requirement is met.
18. Precast reinforced concrete culvert units shall be given one coat of an epoxy waterproofing seal coat on the exterior of the roof slab. This coating shall be provided at the precasting plant. In addition, any top slab hand hole pockets or lifting holes, which are grouted in the field, shall receive one coat of epoxy waterproofing seal coat after the grout has properly cured.
19. Working drawings shall be submitted for the design of the culvert units.

20. Materials used for precast concrete box culverts shall conform to the current edition of the NJDOT Standard Specifications for Road and Bridge Construction.

    Reinforcement steel shall conform to AASHTO M31, Grade 60. Welded deformed steel wire fabric, conforming to AASHTO M221 and having a diameter of at least 3/8 inches may be substituted for deformed bars.

    Longitudinal tie bolts, where utilized, shall conform to the requirements of current ASTM designation A307 and shall be hot-dip galvanized after fabrication, including threading in accordance with the requirements of current ASTM A153.

29.6 Precast Concrete Arch Structures

1. Precast concrete arch structures are a cost effective solution to short span bridges or tunnels. The system includes precast arch elements, and precast wingwalls that are founded on cast-in-place footings.
2. Working drawings shall be provided for the design of such structures. The drawings shall provide the following detailing:
    a. Plan, Elevation and Section views of the arch units. Also, details for all appurtenances; such as, wingwalls and headwalls and details of the joint sealing method between the units shall be indicated.
    b. Erection details that indicate handling points, section lengths, profiles and dimensions of each unit, reinforcement layout and lifting loads.
3. Hydraulic data, as indicated in Subsection 29.3, shall be provided by the Designer. This will facilitate the design of the precast concrete arch structure. The precast units shall be designed with a minimum concrete compressive strength of 5000 psi (Class P concrete).
4. When the earth cover over the arch units is less than 2 feet, corrosion protected reinforcement shall be provided in the outside/top of reinforcement.
5. The concrete cover over the reinforcement steel shall be 2 inches on the outside face of the arch unit and 1½ inches on the inside face.
6. The arch units shall be founded on cast-in-place concrete footings that conform to Class B concrete. The footing shall be a monolithic body either through a single concrete pour or tied together by construction joints.

29.7 Precast Reinforced Concrete Three-Sided Structures

1. Precast unit thicknesses and concrete cover stipulations shall conform to the respective requirements that are provided in Subsection 29.5 for precast box culverts.
2. Other requirements stated in Subsection 29.5 for concrete class, watertight rubber gaskets, waterstops and corrosion protected reinforcement location shall be applied for the design of three-sided precast concrete structures.
3. Concrete foundation requirements shall be the same as those stated in Item 6 of Subsection 29.6.