

HIGHWAY DESIGN MANUAL

REVISION 63

**CHAPTER 19: REINFORCED CONCRETE BOX
CULVERTS AND SIMILAR STRUCTURES
(Limited Revision)**

MAY 19, 2011

<u>Section</u>	<u>Changes</u>
19.5	Updated Section 19.5 to refer to NYSDOT LRFD Bridge Design Specifications as the required design criteria.
19.6.	Changed software reference from NYSDOT Culvert Program to ETCulvert.
19.14	Updated References.

CHAPTER 19
REINFORCED CONCRETE BOX CULVERTS AND SIMILAR STRUCTURES

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design assistance is required, contact the Regional Structures Engineer or the Structures Design and Construction Division. If assistance in the determination of appropriate type of wall is required contact the Geotechnical Engineering Bureau or Regional Geotechnical Engineer.

Wingwall alignment is highly dependent on site conditions and should be evaluated on a case-by-case basis. The angle(s) of the wall(s) on the upstream end should direct the water into the culvert. It is also desirable to have the top of the wall elevation at its end above the design high water elevation to prevent overtopping of the wall.

When precast wingwalls are allowed the designer should be aware of potential conflicts with ROW, M&PT, utilities, etc. The footprint of the footing and excavation, especially for bin type walls, can be extensive. Note(s) should be placed on the plans alerting the Contractor to these requirements when they exist.

Due to the skew and/or grade differences between the precast culvert unit and precast wingwalls it is necessary to do a cast-in-place closure pour between the culvert end unit and the wingwalls. A closure pour is not required if cast-in-place wingwalls are used. See the current BD-CBx sheets for details.

19.5 DESIGN GUIDELINES FOR REINFORCED CONCRETE CULVERTS

Reinforced concrete box culverts (prismatic precast or cast-in-place, four-sided or three-sided) subjected to either earth fill and/or highway vehicle loading shall be designed in accordance with NYSDOT LRFD Bridge Design Specifications and the guidelines in Sections 19.5.1 - 19.5.10.

19.5.1 Design Method

The design and analysis method shall be in accordance with NYSDOT LRFD Bridge Design Specifications.

19.5.2 Dead Load and Earth Pressure

The dead load on the top slab shall consist of the pavement, soil, and the concrete slab. For simplicity, assume the pavement as soil.

The following criteria shall be used in determining dead load and earth pressures for design:

Soil	=	19 kN/m ³ , (120 pcf)
Concrete	=	24 kN/m ³ , (150 pcf)
Lateral earth pressure	=	2.9 kPa max., 1.45 kPa min. (60 pcf max., 30 pcf min.)

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19.5.3 **Live Load**

Reinforced concrete box culverts shall be designed for HL-93 vehicle live load and the NYSDOT Design Permit Vehicle.

19.5.4 **Wall Thickness Requirements**

Exterior wall thickness requirements for reinforced concrete box culverts shall be controlled by design, except that minimum exterior wall thickness requirements have been established to allow for a better distribution of negative moment, corner reinforcement as follows:

<u>CLEAR SPAN</u>	<u>MINIMUM EXTERIOR WALL THICKNESS</u>
<2.44 m	150 mm
≥2.44 m & < 4.27 m	200 mm
≥4.27 m & < 6.096 m	250 mm
≥6.096 m	300 mm

Interior wall thickness, in multicell applications, shall be controlled by design but shall not be less than 150 mm in any instance.

19.5.5 **Concrete Strength**

Reinforced concrete box culverts shall be designed for the following concrete strengths:

Precast	$f'_c = 35 \text{ MPa, min. to } 50 \text{ MPa, max. (increments of } 5 \text{ MPa)}$
Cast-in-place	$f_c = 21 \text{ MPa}$

19.5.6 **Reinforcement Requirements**

Reinforcement shall be either bar reinforcement, welded wire fabric (plain), or welded wire fabric (deformed) in accordance with NYSDOT LRFD Bridge Design Specifications.

When the fill height over the box culvert is less than 600 mm, all reinforcing steel in the top mat of the top slab shall be epoxy-coated or the concrete shall contain corrosion inhibitor.

All faces of reinforced concrete box culverts not requiring design or distribution reinforcement shall be reinforced with the equivalent of #13 bar reinforcement at 300 mm centers in each direction. Under no circumstances shall any reinforcement be spaced greater than 300 mm.

Shear reinforcement and/or slab and wall thicknesses shall be designed to have adequate shear capacity in accordance with NYSDOT LRFD Bridge Design Specifications.

19.5.7 **Skewed Precast Units**

Skewed precast culvert sections shall be designed for whichever of the following two conditions controls:

The skewed end clear span analyzed without the skew effect.

The square end clear span analyzed with the skew effect.

19.5.8 **Detailing Requirements**

The minimum reinforcing bar cover requirements for cast-in-place and precast box culverts shall be as indicated in Section 15 of the Bridge Manual.

Top and bottom slab, outside-face, transverse steel shall be full-length bars, unless spliced to top and bottom corner reinforcing steel.

19.5.9 **Load Rating Requirements**

Bridge-size culverts, as defined by the *Uniform Code of Bridge Inspection*, shall require the submission of two (2) copies of detailed load rating calculations prepared in accordance with the current *AASHTO Manual for Bridge Evaluation* with all interim provisions in effect. Calculations shall be certified and stamped by a professional engineer currently registered and authorized to practice in New York State and shall specify which method (Allowable Stress or Load Factor) was used in load rating computations. Load ratings will also be computed by the Load and Resistance Factor Rating (LRFR) method.

Bridge-size precast box culverts shall be load rated by the fabricator's licensed professional engineer and the both load ratings shall be shown on the approved fabrication drawings,

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which are to be included in the record plans. Cast-in-place box culverts shall be load rated by the licensed professional engineering designer and the load rating shall be shown on the contract plans. Load rating calculations shall be based on the AASHTO HS or MS live-load vehicle for the Allowable Stress or Load Factor rating and HL-93 live load vehicle for the Load and Resistance Factor Rating. Inventory and operating values shall be reported in either English or metric tons. Level one load ratings shall be maintained in the Regional Office.

19.5.10 Span-to-Rise Ratios

Three-sided box culverts and frames with clear span-to-rise ratios that exceed 4-to-1 are not recommended. Designers of these units typically compute moments, shears, and thrusts based on fully pinned support conditions that are able to resist horizontal forces and prevent horizontal displacements. When span-to-rise ratios exceed 4-to-1, frame moment distribution is more sensitive to support conditions, and positive moments at mid-span can significantly exceed computed values even with relatively small horizontal displacement of frame leg supports.

If it is necessary to use a three-sided frame with a span-to-rise ratio in excess of 4-to-1, the structure should be analyzed for mid-span positive moment using pin-roller support conditions. Fully pinned support conditions could be used if site and construction conditions are able to prevent horizontal displacement of frame leg supports. Such a condition may exist if footings are on rock, and frame legs are keyed into footings with adequate details and construction methods.

19.6 COMPUTER DESIGN AND ANALYSIS PROGRAM

This section provides an overview of the software currently used by NYSDOT for design and analysis of reinforced concrete culverts. It should not be construed as an endorsement of any software by NYSDOT. Unless noted by contract, consultants to NYSDOT are not required to use this software. Users should refer to the corresponding manuals for more detailed instructions and limitations

The current version of *ETCulvert* by Eriksson Technologies is used by the Office of Structures. It has been distributed to NYSDOT Regional Structures personnel and is also used by the Precast Concrete Association of New York (PCANY). Questions regarding the use of this program or how to obtain a copy and/or a User's Manual should be addressed to Eriksson Technologies at www.lrfd.com.

ETCulvert will design and/or analyze a one-cell reinforced concrete box culvert with prismatic members (precast or cast-in-place), with or without bottom slab in accordance with the design criteria in *NYSDOT LRFD Bridge Design Specifications* or *AASHTO Standard Specifications for Highway Bridges*. The program will design wall and slab thicknesses and required reinforcement for a box culvert and provide the bar schedule and Load Rating.

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19.14 REFERENCES

1. *AASHTO Bridge Design Specifications*, 4th Edition 2007 with 2008 and 2009 interims, American Association of State Highway and Transportation Officials, 444 North Capital Street, N. W. Suite 249, Washington, D. C. 20001.
2. *Standard Specifications for Highway Bridges*, 17th Edition 2002, American Association of State Highway and Transportation Officials, 444 North Capital Street, N. W. Suite 249, Washington, D. C. 20001.
3. *Standard Specifications of Construction and Materials*, May 4, 2006, and all addendums, Design Quality Assurance Bureau, New York State Department of Transportation, Albany, NY 12232.
4. *Model Drainage Manual*, 2005, American Association of State Highway and Transportation Officials, 444 North Capital Street, N. W. Suite 225, Washington, D. C. 20001.
5. *Bridge Manual, 4th Edition*, April 2006, and all addendums, Structures Design and Construction Division, New York State Department of Transportation, Albany, NY 12232.
6. Bridge Detail Sheets BD-CBx, Structures Design and Construction Division, New York State Department of Transportation, Albany, NY 12232.