

CHAPTER 10

BOX CULVERTS AND BRIDGE STRUCTURES

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CHAPTER 10: BOX CULVERTS AND BRIDGE STRUCTURES

10.1 Introduction

The object of this chapter is to offer guidance on the design and construction of structures that are part of a roadway network needed as a result of land development. Only general methods are offered to assist in establishing proper criteria and methodology. They are not intended to restrict the engineer in exercising proper engineering judgment.

10.2 General

A box culvert, rectangular or square, is a structure built to allow water to pass underneath a road, railroad, or embankment. Box culverts may be completely enclosed (four sided) or bottomless (three sided).

A bridge is a structure built to span a valley, road, railroad, river or stream, floodplain or floodway, body of water, or any other physical obstacle. Designs of bridges will vary depending on the function of the bridge and the nature of the terrain where the bridge is to be constructed.

Any proposed crossings requiring an opening greater than fifty (50) square feet shall be designed as a structure. Box culverts and bridges shall be designed as single opening or single span structures. Multiple span or multiple opening structures may only be designed with prior approval from the Carroll County Department of Public Works (Department). The latest Federal Highway Administration manuals and guidance, AASHTO specifications and State Highway Administration policies and specifications shall be used when designing structures. Structural designs and construction documents shall be sealed by a professional engineer licensed in the State of Maryland.

During the initial evaluation, the following structure types shall be evaluated in order of preference:

1. concrete box culvert (cast-in-place)
2. concrete box culvert (precast with cast-in-place headwalls and wingwalls)
3. precast concrete slabs on concrete abutments
4. precast concrete girders on concrete abutments
5. structural steel beams on concrete abutments.

The use of other structure types must be approved by the Department before proceeding with design. Aesthetics should be considered. Use of form liners and other aesthetic treatments is encouraged if compatible with the area and the expense can be justified.

The use of mechanically stabilized earth (MSE) retaining walls in lieu of cast in place concrete abutments will not be allowed.

All structures must have a Federal Highway Administration crash-tested traffic barrier system in accordance with NCHRP Report 350 guidelines.

Utilities may not be supported by or attached to any box culvert or bridge structure without prior approval by the Department.

Structure design shall meet the requirements of all other governing agencies, such as the MD Department of the Environment, MD Department of Natural Resources, US Army Corps of Engineers, and the Carroll County Bureau of Resource Management.

10.3 Design

10.3.1 Geotechnical Investigation and Foundation Design

A minimum of two borings for each bridge support is required. For culverts, a minimum of two borings are required, one at each end, diagonal of each other. Borings shall be strategically located to evaluate both foundation requirements and scour potential. Borings shall be taken after approval of the Type, Size and Location (TS&L) submission. Boring logs shall be included on the plans, identifying type of material and the proposed minimum bottom of footing elevation. A foundation report shall be prepared, and shall contain the following: approved TS&L plan and elevation with plotted boring locations; written report containing an interpretation and analysis of the proposed structure and boring data; recommendations for foundation design; construction considerations; and any other pertinent information relating to the site, soil/rock data, and the foundation recommendations.

10.3.2 Clear Roadway Width

The minimum clear roadway width for box culverts is dependant on the depth of fill over the box culvert. For culverts with 5'-0" or less of fill, the length of the culvert shall be determined by placing the concrete headwall in alignment with the approach traffic barrier. The location of traffic barrier shall follow the specifications in the Design Manual. For culverts carrying more than 5'-0" of fill, the typical section shall be carried across the culvert. The depth of fill will be measured from the profile grade line to the top of the box culvert.

The minimum clear roadway width for bridges shall be 28-feet. Additional travel lane and shoulder width may be required, based on the approach lane widths, paved shoulder widths, prevailing speed, sidewalk requirements, etc.

10.3.3 Design Specifications

An HS25 design loading will be used for all bridge spans 35-feet and greater, and all other structures. For all bridge simple spans less than 35-feet, an HS27 design loading shall be used. Design loading should also include a provision for future 2-inch hot mix asphalt wearing course.

The design specifications include the following:

Bridge Design: AASHTO LRFD Specifications, latest edition, including all interim specifications

Concrete Design: Service Load Design Method, $f_c = 1,200$ psi

Reinforcing Steel Design: $f_s = 24,000$ psi

10.3.4 Scour Analysis and Design

Scour is the result of the erosive action of flowing water. All bottomless structures shall be evaluated for scour potential and designed to resist scour. Scour evaluations shall be performed by an interdisciplinary team of engineers with requisite knowledge in structural, hydraulic, river mechanics and geotechnical engineering. A scour evaluation report shall be prepared, and shall contain the following: introduction and background; study scope; summary and recommendations; hydrology study; site investigation; stream classification, geomorphology and stability study; TS&L plan and elevation; line, grade and typical section of approach roadways; hydraulic study; scour evaluation and development of scour cross-section under the structure; significance of scour evaluation; structural and geotechnical design considerations; scour countermeasures; and appendices and documentation.

Foundations, either spread footings or deep (pile supported), shall be designed to withstand the conditions of scour for the design flood (the more severe of the 100 year storm or the overtopping flood) and the check flood (500-year flood).

10.4 Submissions

Reviews shall be submitted based on the following schedule. Each submission must be approved before proceeding with additional work.

10.4.1 Type, Size and Location (TS&L)

This submission shall include a general plan and elevation showing pertinent dimensions and clearances, general notes, typical section, and preliminary hydrologic and hydraulic calculations, if applicable. The TS&L documents are due as part of the preliminary plan stage process.

10.4.2 Foundation and Scour

This submission shall include the same information as the TS&L, except that soil boring data and foundation recommendations shall be incorporated. Any changes to the approved TS&L shall be identified at this time. Soil borings shall be coordinated with other on-site geotechnical work for pavement design and stormwater management design. The foundation report, scour evaluation report, and plans shall be submitted and approved with the preliminary plan phase.

10.4.3 Structural

The structural submission builds on the previously approved submissions, and includes details, sections, and special features of the structure.

10.4.4 Final

The final submission shall consist of a complete set of plans, incorporating all revisions from the structural review. The final documents shall be submitted and approved with the final road plans. Structure plans shall be submitted as a subset of plans within the road plans. Submit all design calculations and load rating calculations for H15, HS20 and Type 3 loadings (inventory and operating) using the load factor method, or load and resistance factor rating method (LRFR) HL-93, at this time. A bound hard copy of calculations shall be submitted, as well as an electronic version (PDF).

10.4.5 Structure Inventory and Appraisal (SIA) Forms

Initial inspection, completion of SIA forms, and submission to the MD State Highway Administration is required within ninety (90) days of the completion of the structure. Acceptance of structures and roadways will be simultaneous.

The Department must approve the load rating calculations and SIA forms before acceptance of the structure and roadways.

10.5 Construction

Approved shop drawings and an approved material list must be submitted to the Department before ordering any materials and before any construction commences.

Contractors performing this work must be pre-qualified in the structures categories. Construction of all structures shall be in accordance with the MD State Highway Administration Standard Specifications for Construction and Materials, latest edition.

10.6 References

- Federal Highway Administration (FHWA) HEC-18, Evaluating Scour at Bridges
- FHWA HY-9, Scour at Bridges
- MD State Highway Administration (SHA) Structural Standards Manual
- MD SHA Standard Specifications for Construction and Materials, latest edition, including all interim specifications
- AASHTO LRFD Bridge Design Specifications, latest edition, including all interim specifications
- MD SHA Guide for Completing Structure Inventory and Appraisal Input Forms
- MD SHA Office of Bridge Development Manual of Hydrologic and Hydraulic Design