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5.8.4 Deck drains

This article covers deck drains placed near the edge of a bridge deck at a railing or curb. The basis for the hydraulic analysis is the FHWA publications HEC-21 and HEC-22.

5.8.4.1 General

With minor modifications the design procedures and details described in this article meet AASHTO LRFD Specifications [AASHTO-LRFD 2.6.6 and 9.4.2]. In addition to the AASHTO sections listed above, the designer should review related articles in this manual for decks [BDM 5.2] and continuous concrete slabs (CCS) [BDM 5.6.1].

5.8.4.1.1 Policy overview

Deck drains are generally beneficial for roadway drainage performance. Two of the primary benefits of deck drains are the rapid removal of water from the bridge deck during lighter rains and removal of water from the deck during snowmelt to minimize refreezing. In addition, removal of deck drainage prior to the bridge end will reduce water damage attributed to leaky joints and undermining of bridge approaches. The intent is to handle the drainage incrementally in lieu of managing large amounts of water at the bridge ends.

Typically deck drains require routine maintenance and cleaning. Lack of maintenance due to limited resources greatly reduces their effectiveness and if improperly placed, discharge from deck drains can cause unintended damage. Careful overall design and planning (not limited to quantity and location) of deck drainage is vital for pond-free bridge decks. The need for deck drains should be based on engineering judgment along with bridge features, site constraints for water discharge, consideration of local maintenance practices, and hydraulic evaluation.

5.8.4.1.2 Design information

Reserved.

5.8.4.1.3 Definitions

Open system is a simple drain assembly with a minimum of piping that conducts drainage directly downward to below the bottom of the superstructure.

Closed system is a drain/piping assembly that conducts drainage horizontally to a pier or abutment where the drainage is directed to the ground or a storm sewer. The system typically consists of a drain grate, scupper, lengths of pipe, elbows, and cleanouts.

5.8.4.1.4 Abbreviations and notation

CCS, continuous concrete slab
CWPG, continuous welded plate girder
HEC-21, FHWA's Hydraulic Engineering Circular 21 [BDM 5.8.4.1.5]
HEC-22, FHWA's Hydraulic Engineering Circular 22 [BDM 5.8.4.1.5]
PPCB, pretensioned prestressed concrete beam
RSB, rolled steel beam

5.8.4.1.5 References

Brown, S.A., S.M. Stein, and J.C. Warner. *Urban Drainage Design Manual, Hydraulic Engineering Circular 22 (HEC-22), Second Edition.* Washington: Federal Highway Administration (FHWA), 2001. (Available on the FHWA web site at: http://www.fhwa.dot.gov/engineering/hydraulics/pubs/10009/10009.pdf)

Young, G.K., S.E. Walker, and F. Chang. *Design of Bridge Deck Drainage, Hydraulic Engineering Circular 21 (HEC-21).* Washington: Federal Highway Administration (FHWA), 1993. (Available on the FHWA web site at: http://www.fhwa.dot.gov/engineering/hydraulics/pubs/hec/hec21.pdf)

5.8.4.2 Edge drains

5.8.4.2.1 Analysis and design

The designer shall use the guidelines provided below for determining the deck drain design.

(1) Location guidelines

These location guidelines may be waived if they conflict with the restrictions of drain placement listed under (2). When the guidelines are waived, the designer shall confirm adequacy of deck drainage by hydraulic analysis as outlined in (4). The designer also may elect to reverse the process by beginning with a hydraulic analysis and adding additional drains as needed to meet the guidelines below.

- A minimum of one deck drain should be placed in each interior span and two deck drains in each end span. For normal crown situations the minimum number of drains should be placed along each edge of deck; for decks draining to one edge the minimum number of drains should be placed on the low edge only. Drain spacing should not exceed 50 feet for tube drains or 100 feet for scupper drains.

- Roadway profile grade is a factor in deciding the need for deck drains. Consider additional drains in situations with extremely flat grades (< 0.3%).

- For both structural and hydraulic reasons low points should be located off the bridge. However, if the design requires a low point on the bridge, place one drain at the low point and one flanking drain each way from the low point where the tangent to the gutter slope equals 0.3%, generally at 5 to 10 feet.

- For superelevated decks, place drains on the low side only.

- Take care to intercept gutter flow in horizontal curvature or superelevation transitions to assure that water does not flow across a bridge deck.

- Do not place drains at a high point on a crest of a curve. Place the first drain at a maximum of 50 feet each way from the crest.

- Place deck drains near and upslope, generally 10 to 15 feet, from bridge ends and interior expansion joints to intercept as much water as practical.

- Consult with the Design Bureau to avoid or minimize approach roadway drainage onto the bridge.

- For an open system, place drains at least 10 feet from centerline of pier to keep corrosive salt water off the pier. For bridges with free fall greater than 25 feet, consider increasing the distance to 20 feet to reduce the likelihood that discharge will be carried by the wind to substructure elements.

- It is acceptable to place an open system drain over macadam or erosion stone slope protection (refer to bridge standard sheets 1006C-1006E).

- Even if all the guidelines above are met there are unique situations when the adequacy of the bridge deck drain design should be confirmed by hydraulic analysis. Such situations include, but are not limited to, bridges with stub abutments, low points, superelevation or superelevation transition, or width greater than 60 feet.

(2) Location restrictions

Placement of open system deck drains is not allowed over the following site features:

- Traffic lanes and shoulders (existing and future)

- Sidewalks, bike trails, or shared use paths

- Concrete slope protection (potential undermining). However, placing drains over the toe of concrete slope protection is acceptable.

- Railroad right-of-way

- MSE or other retaining walls

- Levees or drainage toward a levee

(3) Type and size selection

Selection of the type and size of drain is required for hydraulic analysis. For typical bridges the Bureau selects from three types described below.

- Tube drains (open system): Tube drains are typically 4-inch x 8-inch galvanized tubes at the curb or barrier railing, either anchored at the deck [BSB SS 4380, 4383-4385] or anchored to the sides of steel girders [BSB SS 1059]. They are completely open (no grates), discharge directly downward, and are visible on the exterior to motorists passing under a bridge.

- Scupper drains (open system): This drain type is similar to a tube drain but has a drain trench or scupper in the deck that extends from the curb or barrier rail inward beyond the exterior beam or girder [BSB SS 1054]. The scupper has a deck grate and at the low end discharges into an 8-inch galvanized pipe that discharges directly downward. The scupper will interrupt deck reinforcement and will require special local reinforcement. Because these drains are intended to be essentially hidden to motorists passing under a bridge, they generally are termed aesthetic drains.

- Scupper drains (closed system): This drain type is a closed system consisting of a deck grate, scupper, and piping system to conduct the deck drainage to an abutment or pier where it can be discharged near ground level. The scupper usually will interrupt deck reinforcement

and may require special local reinforcement. A closed scupper drain/longitudinal piping system generally should be avoided and only considered in extreme conditions to address site constraints. Generally, the pipe should be a minimum of 8 inches in diameter, sloped at 8% or more, and provided with cleanouts. Before selecting this type the designer shall consult with the supervising Unit Leader.

(4) Hydraulic analysis guidelines

Per *Design of Bridge Deck Drainage, Hydraulic Engineering Circular 21* (HEC-21) [BDM 5.8.4.1.5], the hydraulic analysis is to be based on a 10-year, 5-minute rainfall design event and consideration of a 25-year, 5-minute check storm event.

The spread of water for the design storm event generally is limited to the width of the shoulder. If there is no shoulder present, part of a traffic lane may be used to carry runoff. For primary highways with a posted speed of less than 45 mph, a maximum encroachment for a two lane roadway is 3 feet onto the traveled lane. Where there are two or more adjacent lanes in a given direction, allowable encroachment is 6 feet onto the outside traveled lane in that direction. In a two lane urban section with curb and gutter, the spread of water should generally be limited to 7 feet from the bridge barrier. For multiple urban lanes or unusual sections, the designer should check with the Design Bureau to determine the allowable encroachment.

During the check storm event, it is desired to maintain at least one 12-foot lane width accessible to traffic.

For the preferred analysis method for both the design storm event and check storm event see the “Bridge Deck Drainage” document provided in the commentary [BDM C5.8.4.2.1].

5.8.4.2.2 Detailing

Drain tubes or pipes for an open system shall extend a minimum of 12 inches below the bottom beam flange, if practical, and the extension does not encroach on the vertical clearance envelope. For slab bridges drains shall extend 6 inches below the slab.

A tube drain for a PPCB or RSB bridge should be attached to deck forms with steel nailer angles and anchored in the deck with welded bars [BSB SS 4380, 4383-4385].

A tube drain outside the exterior girder of a CWPG bridge should be attached to the girder with two brackets, if the girder is more than 54 inches deep [BSB SS 1059]. A tube drain between girders should be attached as shown on the standard sheet [BSB SS 1059].

All parts of a tube drain, including bolts, anchors, attachments and tube shall be galvanized. Galvanizing may be according to ASTM A 53 or ASTM A 123. Since most drain tubes involve welding attachments to the tube, ASTM A 123 is typically the appropriate specification since the assembly should be hot dipped galvanized after welding. For steel bridges a tube drain also shall be painted over the galvanizing to match the color of the steel bridge [IDOT SS 2509].

All scupper drain grates are to have the grate bars perpendicular to the direction of traffic to improve safety for motorcycles and bicycles.

Consider a splash basin for open system drain discharge over an unpaved embankment or unprotected ground. See Design Bureau’s rock splash basin detail [DB SRP EC-301 Type 4].