PennDOT LTAP
technical
INFORMATION
SHEET #152
SUMMER/2012

DEBRIS CONTROL FOR BRIDGES AND CULVERTS

by H.R. Riggs, Professor, University of Hawaii and
Clay Naito, Associate Professor, Lehigh University

Debris management is imperative to maintain proper operation of culverts and bridges during storm events. Improper management increases the likelihood of blockage of the opening, which can lead to flooding of adjacent areas, undermining of the bridge foundation, increased hydraulic loading on the bridge, and potential damage to the structure from debris impact. The bottom line for debris management is:

- Owners are required by PA Code 25 to inspect bridges and culverts at least once per year for existing debris.
- The debris should be cleared if the water channel is constricted by more than 10 percent.
- Debris removal within 50 feet upstream and downstream of the bridge or culvert in Pennsylvania is allowed under general permit, BWM-GP-11.
- Under this permit, removal of debris and accumulated sediment is allowed to ensure adequate hydraulic capacity for bridges or culverts. During cleaning, tree and shrub growth on stream banks must not be disturbed unless absolutely necessary. Cleaning must be done following the Department of Environmental Protections's Standards for Channel Cleaning at Bridges and Culverts.

This technical brief discusses some structural measures that can be taken for existing bridges in particular. (New bridges can include design modifications to lessen debris build-up.) The focus here is also on medium to large floating, vegetative debris, as compared to sediment accumulation. It is a summary of the related discussion in *Debris Control Structures – Evaluation and Countermeasures*, FHWA-IF-04-016, HEC-09 (FHWA) by J.B. Bradley, D.L. Richards, and C.D. Bahner. That document is a comprehensive report that covers site evaluation, debris risk assessment, and countermeasures, including design guidelines.

CULVERTS

Structural measures appropriate for culverts include debris deflectors, debris racks, debris risers, debris cribs, debris fins, and debris dams and basins (FHWA). Smaller structures appropriate for floating debris is the focus here. Debris cribs are most effective for coarse sediment (bed load) build-up, and debris dams and basins are often large structures that trap and store debris away from the culvert (or bridge) entrance. Hence, they won't be discussed here.

Debris deflectors

Debris deflectors are triangular-shaped frames that deflect floating debris away from the culvert entrance. They can also be designed to resist boulders. Figure 1 shows a steel rail deflector. The apex angle should be between 15° and 25°, and the combined area of the two sides should be at least 10 times the area of the culvert opening (FHWA). Although the figure shows a vertical member at the apex, a sloping member may be more effective in guiding debris away from the culvert opening.

pennsylvania
DEPARTMENT OF TRANSPORTATION
PennDOT Local Technical Assistance Program
400 North Street, 6th Floor
Harrisburg, PA 17120
1-800-FOR-LTAP • FAX (717) 783-9152
www.ltap.state.pa.us

The spacing of the horizontal members on the sides is chosen to allow smaller debris to pass through but to prevent debris that is large enough to plug the culvert. Therefore, a spacing of two-thirds the culvert diameter would be appropriate. Although the horizontal bars on the top may be needed structurally, they are only needed for debris if the water elevation is expected to overtop the deflector.

Figure 1 Upstream view of a steel debris deflector (FHWA)

Debris racks

Debris racks are similar to debris deflectors in that they trap the debris but don't necessarily redirect the debris. They can be placed either at the culvert entrance (Figure 2, left) or upstream as a "fence" of vertical posts (Figure 2, right). Particularly on the latter, debris impact forces need to be considered, and they are not typically used for large debris. Again, the spacing should be such as to allow smaller debris to pass through but to catch the larger debris that might plug the culvert. However, in urban areas the maximum spacing is about 6 inches to prevent children entering the culvert (FHWA). Such a small spacing will increase the need for maintenance to keep the rack clear.

Debris risers

Debris risers are vertical members, usually metal pipes, that provide a secondary flow path should the culvert opening become blocked (Figure 3). They are most effective in areas where the water level can rise above the culvert without causing problems.

Figure 3 Debris riser provides backup flow path (FHWA)

Debris fins

Debris fins are vertical walls extending from interior culvert walls that are meant to orient large debris so that it will more likely pass through (Figure 4). When fins are used, the culverts have an opening of 4 feet or larger (FHWA). The top of the fin can be sloping (as shown) or horizontal. If sloped, larger debris that becomes trapped by the fin may ride up along the top, allowing smaller debris to flow underneath. A fin can also be a solid concrete section. The upstream edge should be rounded to lessen debris becoming trapped. The fin length is recommended to be 1.5 to 2 times the height of the culvert (FHWA). Debris fins may not be appropriate if the culvert is expected to be overtopped.

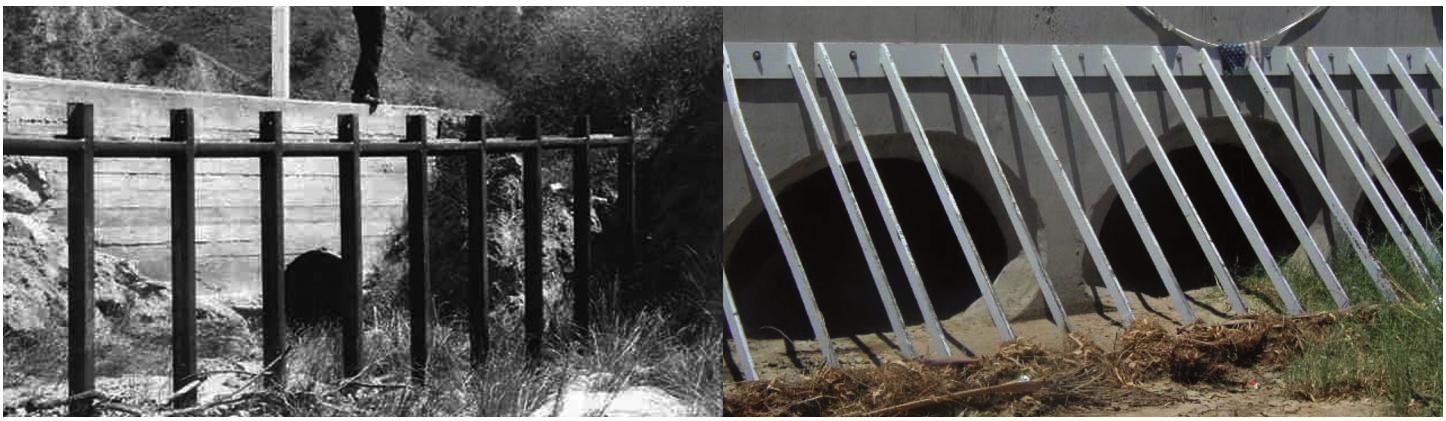

Figure 2 Debris racks (FHWA)

Figure 4 Debris fins (FHWA)

BRIDGES

Structural measures appropriate for bridges include debris deflectors, debris fins, and debris sweepers. Other measures, such as debris dams, basins and booms, are upstream structures to retain the debris upstream until it can be cleared. Also, measures to control and direct the river flow are used to control sediment transport. Those measures will not be discussed.

Debris fins

Debris fins for bridges are conceptually and structurally the same as the fins for culverts, although their geometric design is somewhat more complicated (FHWA).

Debris deflectors

Debris deflectors for bridges are actually similar in function to fins, in that they are meant to orient large debris to flow under the bridge. Figure 5 shows two vertical poles upstream of a bridge that are designed to orient debris such as trees or logs so that it passes under the bridge longitudinally. The deflectors may also be located directly in front of a pier. For bridge deflectors to work, the flow direction needs to be fairly stable. The design of this type of system is complicated, and physical model tests may be necessary (FHWA).

Figure 5 Debris deflectors for a bridge

Debris cribs

Debris cribs for bridges are used when the piers are formed by open-pile bents. The cribs are constructed to prevent debris from becoming trapped between the piles. Care should be used when the bents are not parallel to the river flow, because otherwise the cribs can actually trap the debris.

Debris sweepers

A debris sweeper is a vaned, cylinder located in front of a pier that rotates with the flow and "sweeps" the debris away from the pier and into the flow between piers (Figure 6). Sweepers are usually polyethylene and float up and down so they can move with the water surface. ◆

Figure 6 Debris sweepers

ADDITIONAL ONLINE RESOURCES

- Debris Control Structures – Evaluation and Countermeasures, Hydraulic Engineering circular 9, Third Edition, FHWA, 2005, www.fhwa.dot.gov/engineering/hydraulics/pubs/04016/
- General Permit BWM-GP-11, Maintenance, Testing, Repair, Rehabilitation, or Replacement of Water Obstructions and Encroachments, Department of Environmental Protection www.clfdccd.com/General%20Permits/GP-11.pdf