Research Brief

Wisconsin Highway Research Program
Project 0092-21-02
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Optimizing Bridge Abutment Slope Protection at Stream Crossings

Research Objectives

- Develop guidance for identifying bridge site conditions corresponding to performance issues associated with the WisDOT standard slope protection.
- Develop guidance for alternative slope protection for problematic bridge slope locations with life-cycle cost considerations.

Research Benefits

- Greater understanding of the causes of slope failure at over-water bridge abutments
- Evaluation of current WisDOT practices helps to identify ways to mitigate slope failure in the future

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Background

The Wisconsin Department of Transportation (WisDOT) is concerned with persistent slope movement at over-water bridge abutments. Repair alternatives are costly, and low clearance beneath bridge decks makes replacing riprap beneath an existing bridge very difficult. In addition, repairs can interrupt traffic for material and equipment delivery. Slope flattening may provide better protection; however, it requires additional bridge length, increasing structure costs. The current standard method of slope protection at these crossings uses heavy riprap on top of heavyweight geotextile fabric at a 1.5:1 (H:V) slope.

The goals of this project were to develop guidance for identifying site conditions at over-water bridges which correspond to performance issues associated with WisDOT's standard method for slope protection, and to develop guidance for alternative protection methods at problematic sites, considering life-cycle costs. An initial hypothesis of scour-related concerns was abandoned, and creeping movement was identified as the most likely cause of loss of slope protection in the majority of cases.

Methodology

Synthesis of current research and literature, as well as a review of relevant specifications, was performed. This work summarized knowledge for the evaluation of causes and countermeasures for abutment protection for bridges at stream crossings. Next, identification of Wisconsin bridges with heavy riprap slope failure was undertaken with the goal of documenting and quantifying the conditions which may have led to this failure. A survey was conducted regarding the use of various slope failure countermeasures and their relative success in the upper Midwest. Site visits were completed for a selection of bridges in Wisconsin with measurable slope movement. Results from these visits prompted researchers to change their initial presumption that slope failure was caused by hydraulic scour. Instead, researchers modified the research approach to creeping (gradual) slope movement, which was more consistent with failure beginning at the top or middle of the abutment slope, rather than the bottom.

"Abutment slope repair is a recurring nuisance for WisDOT maintenance personnel. This research provides methods to reduce future maintenance costs at stream crossing bridges."
– Steve Neary, WisDOT

Interested in finding out more?

Final report is available at:
WisDOT Research website

Photos of an abutment and a close-up of erosion along the abutment

Results

Results indicate little need for expansive revisions to current design guidelines. Suggested modifications assert the importance of quality fill, adequate drainage, and compliance to specifications in construction. When free-draining, compactable soils are not available, slopes of 2:1 should be considered. Considering the number of 1.5:1 over-water bridges, it also appears that the criteria for flattening may be underestimating sites of concern.

Recommendations for implementation

The research team suggests proposed revisions to Section 15.2 of the WisDOT Bridge Manual language to include an explicit statement about the possibility of movement at the surface for 1.5:1 (H:V) slopes. Additionally, the team recommends modifying the criteria for flattening over-water bridges by a sufficient amount to increase the design cases by roughly 2%, which may mitigate the current rate of slope failure. Further, the research team suggests changes to the typical remediation of exposed abutment piles. Instead of using a flowable concrete slurry to plug gaps under exposed abutments, which adds considerable weight to the abutment slope, it is recommended that an expanding foam or similar lightweight material be used as standard practice.

This brief summarizes Project 0092-21-02,
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