



Partially Grouted Revetment for Low-Volume Road Bridges

tech transfer summary

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RESEARCH PROJECT TITLE

Partially Grouted Revetment for Low-Volume Road Bridges

SPONSORS

Iowa Highway Research Board
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The Bridge Engineering Center (BEC) is part of the Institute for Transportation (InTrans) at Iowa State University. The mission of the BEC is to conduct research on bridge technologies to help bridge designers/owners design, build, and maintain long-lasting bridges.

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Partially grouted revetments can be used near bridges on the Iowa secondary road system as an affordable and effective countermeasure for scour.

Objectives

- Document the use of scour countermeasures—including grouted revetments—and assess their general performance through a survey of county engineers
- Document the performance and cost-effectiveness of existing countermeasures in the field
- Install partially grouted revetment pilot projects and document their performance
- Develop guidance or best practices for scour countermeasures

Background

The Iowa secondary road system has a large number of scour-susceptible bridges or bridges with unknown foundation conditions. While scour countermeasures have historically included conventional riprap, fully grouted riprap, and other systems, a promising option is a partially grouted revetment (also known as partially grouted riprap).

Partially grouted revetments have been used successfully in Europe and more recently in Minnesota to prevent scour or erosion in riverbeds and at bridge piers and abutments.

Partially grouted revetments are constructed by placing rock, stone, and/or recycled concrete on a subsoil-compatible filter layer and then partially filling the voids in the matrix with a portland cement-based grout material. The intent of partial grouting is to increase the revetment's stability while maintaining the flexibility of a looser matrix. Partial grouting also allows for the use of smaller and less expensive matrix material and a thinner revetment layer.



Partially grouted revetment under a low-volume bridge

Problem Statement

Countermeasures for scour can be costly, especially for counties with limited budgets, and there is a need to investigate alternatives that are both economical and effective. Partially grouted revetments show promise but have not been compared to existing countermeasures or evaluated thoroughly in Iowa conditions.

Research Description

Several types of scour countermeasures were identified and assessed through a literature review, including conventional riprap, fully grouted riprap, partially grouted riprap, articulating concrete block systems, concrete armor units, gabion mattresses, and grout-filled mattresses.

County engineers in Iowa and other states were surveyed to gauge their experience with the countermeasures identified in the literature review. Respondents were also asked whether any negative outcomes or application limitations had been encountered for each countermeasure.

In-use countermeasure types warranting closer investigation were identified, and several sites in Minnesota and Iowa were selected for field visits to assess current performance. The Minnesota sites featured partially grouted revetments that were approximately five years old, and the Iowa sites featured loose riprap, partially grouted riprap, fully grouted riprap, and grout-filled mattresses of various ages.

Partially grouted revetments were constructed at pilot installation sites in Buchanan, Madison, Wayne, and Woodbury Counties in Iowa. Sites were selected to include a variety of geographic locations, site characteristics, and general infrastructure types. Various riprap types and grout mix designs were used, including a grout mix design specified by the Federal Highway Administration (FHWA).



Grout placement under an existing bridge in Buchanan County



Grout placement prior to bridge construction at a Woodbury County site

The pilot installation sites were revisited after approximately five years in service, and their long-term performance was documented.

Key Findings

- While loose riprap is the most economical countermeasure, the costs associated with partial grouting are offset by the system's improved stability and resilience over time. Studies have also found partially grouted riprap to be more economically feasible than grout-filled and gabion mattresses.
- Loose riprap is by far the most common revetment type used by county engineers, followed by partially grouted and fully grouted riprap. Fully grouted riprap has been used by more counties in the past than in the present, which suggests negative experiences with the revetment type.
- During the Minnesota field visits, partially grouted riprap was found to perform well overall when grouted correctly. This finding was confirmed by the Minnesota Department of Transportation (MnDOT).
- At one Minnesota site, excessive splash was found on the face of the stones. This is not detrimental to performance but is likely a sign of excessive flow from the grout pump, a mix that is too fluid, or grout placement too far from the surface of the stone.

- A variety of performance levels were observed during the Iowa field visits. The few partially grouted sites did not appear to be grouted according to FHWA guidelines or the methods used by MnDOT but were nonetheless meeting the performance expectations of the engineer.
- The pilot installations were constructed successfully, though the grout consistency varied considerably. Installation was less labor-intensive when grouting occurred before deck placement and when a smaller hose was used for application.
- Lessons learned from the pilot installations were compiled into a list of recommendations for installation of partially grouted revetment.
- The pilot installations showed satisfactory performance after approximately five years in service.



Partially grouted revetment at a Wayne County site after five years in service

Recommendations on the Use of Partially Grouted Revetments

- When possible, use a hose size smaller than 4 in. for placement (2 to 3 in. is ideal).
- Control the flow out of the pump; the flow should be slow enough that placement can be controlled while maintaining placement efficiency.
- Communicate placement expectations with the contractor early in the project (during bidding or plan development). The Iowa DOT has no guidelines or specifications for partial grouting of revetments, so expectations are unclear unless addressed in the plans.
- When using the FHWA grout mix design, ensure that the consistency is correct. If the mix is too flowable, it will seep into the bottom layer of the riprap; if the mix is too stiff, it will sit on top of the riprap.
- When using partially grouted revetments with new construction/bridge replacement, grout should be applied prior to deck placement to considerably reduce the labor required.
- Placement in water is not recommended.

Implementation Readiness and Benefits

Partially grouted revetments have been used successfully in Europe and Minnesota and were installed successfully at the pilot installation sites in Iowa. These sites have exhibited good long-term performance.

Partially grouted revetments have the potential to be an affordable and effective countermeasure for scour. The comparatively higher costs of installing partially grouted versus loose riprap are offset by the improved stability and resilience of the revetment over time.

The recommendations resulting from this research can be used to place partially grouted revetments effectively and economically.