Standards and Training for Scour Prevention

Transportation agencies have long needed comprehensive guidance on riprap and other bridge scour countermeasures. Two NCHRP projects established this guidance and resolved a design dilemma concerning riprap that has long interested engineers. The projects' principal investigators played a critical role in implementing the results, helping to author FHWA Hydraulic Engineering Circulars and communicate results to state DOTs.

Bridge Scour Countermeasures: A Need for Practical Guidance

The most common cause of highway bridge failures in the United States is bridge scour, a type of erosion in which moving water displaces sediments such as sand and rocks from around bridge piers and abutments. The gaps left by scour can weaken the support for bridges and lead to their collapse.

NCHRP Projects 24-07(2) and 24-23 developed comprehensive guidance for countermeasures to bridge scour, a leading cause of highway bridge failures.

To prevent bridge scour, engineers use a variety of countermeasures, including piers in waterways to control flow, and riprap placed around piers and abutments to protect them from erosion. Because countermeasures are both necessary to bridge integrity and costly, their selection, design, and construction are important issues for transportation agencies. There has long been a need for practical guidance on the use of scour countermeasures for pier protection.

> "Implementation is more successful when there's a product in demand."

To address this need, NCHRP managed several research projects investigating the prediction, evaluation, monitoring, and prevention of bridge scour. In particular, the need for comprehensive design guidance on bridge scour countermeasures led to NCHRP Project 24-07(2) and the resulting product, *NCHRP Report 593: Countermeasures to Protect Bridge Piers from Scour* (www.trb.org/Main/Public/Blurbs/156796.aspx).

A related effort, NCHRP Project 24-23, addressed the design of riprap countermeasures in particular. At the time the project was initiated, existing techniques and procedures for design of riprap protection were confusing and difficult to apply, and there were inconsistencies in the literature as to the best methods for determining the size and extent of riprap installation, which can vary widely depending on the circumstances. Consequently, most states had differing specifications for classifying riprap size and gradation, and construction practices varied widely in effectiveness.

AASHTO and FHWA initiated research to develop standard specifications and construction practices to ensure proper placement and performance of riprap countermeasures, resulting in *NCHRP Report 568: Riprap Design Criteria, Recommended Specifications, and Quality Control* (www.trb.org/Main/Public/Blurbs/155703.aspx).

Paths to Practice

Communicating results with FHWA

Getting the research results into the hands of practitioners was the first step to implementing the findings. FHWA's Hydraulic Engineering Circulars (HECs) provided the ideal avenue for accomplishing this step.

> "Implementation really comes down to states trying out these countermeasures. As they do so, they may find that some things work better than others."

"For years, the FHWA Hydraulic Engineering Circulars have been the bible for designing and evaluating scour countermeasures," says NCHRP 24-23 panel member Stan Davis, consultant to the Maryland State Highway Administration (SHA). "They've really been a very good resource for putting out information."

(continued)

Implementation Strategies *AT A GLANCE*

- **Leveraging FHWA Channels to Communicate Results:** Results were incorporated into widely used FHWA Hydraulic Engineering Circulars.
- **Tailoring Research to Practitioner Needs:** Because scour is a leading cause of bridge failure, the results were quickly used to meet an urgent need.
- **Continued Research Team Involvement:** PIs helped write circulars and conducted conference presentations and National Highway Institute training.
- **Improving Established Methods and Specifications:** Panel members from Maryland, California, and Colorado led efforts to apply the scour countermeasures to their states' practices and guidelines.

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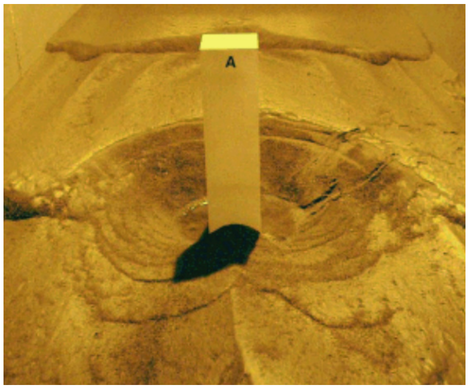

Lab tests on scale model bridge piers indicated that riprap performed best when it extended a distance of twice the pier width in all directions.

The results of *NCHRP Reports 593* and *568* directly fed into updating HECs, which have a wide reach with engineers nationwide. "This made coordination with FHWA a natural part of project implementation," says NCHRP 24-07(2) panel member Catherine Crossett Avila, an engineer formerly with the California Department of Transportation.

The results of NCHRP 24-07(2) have been incorporated into Hydraulic Engineering Circular 23 (HEC 23), *Bridge Scour and Stream Instability Countermeasures*. The results of NCHRP 24-23 have also been incorporated into that circular as well as HEC 18, *Evaluating Scour at Bridges*, which Davis co-authored.

A high-quality product that's in demand

Reaching practitioners with the information, however, is just part of the implementation equation. "Implementation is more successful when there's a product in demand," Davis says. "Scour countermeasures are of continuing interest for state DOTs."

Not only are the HECs widely used by engineers, but their update modifies a key equation critical to riprap design. In implementing results, researchers took rock slope protection specifications and made them more robust, modifying the equation so that practitioners have better guidance on how to use riprap as a pier scour countermeasure.

Further, the NCHRP research resolved a problem of great interest to engineers.

> "For years, the FHWA Hydraulic Engineering Circulars have been the bible for designing and evaluating scour countermeasures."

"There had been a question as to which methods for designing riprap countermeasures were most appropriate for bridges," Davis says. "Everyone recognized that this was something we needed to know, and *NCHRP Report 568* resolved this issue in favor of FHWA's method after examining a number of other methods." The study also provided helpful information about using the U.S. Army Corps of Engineers' riprap design method for application at other locations.

Proactive principal investigators make a critical difference

Also critical to the successful implementation of *NCHRP Reports 593* and *568* was the direct involvement of principal investigator Pete Lagasse, who helped to write HEC 18 and HEC 23. He and co-investigators were very active in disseminating project results.

> "It's critical to successful implementation to pick principal investigators who will stick with a project and go the extra mile."

"Not only did the PIs for NCHRP 24-07(2) essentially implement the project results by authoring HEC 23," Avila says, "but they also gave several conference presentations."

They reached out to state DOTs as well. According to Arun Shirole, NCHRP 24-07(2) chair and former New York State DOT deputy chief engineer, the principal investigator conducted training courses in about a dozen states, via FHWA's National Highway Institute. "Introducing the results of these projects to state DOTs is important for implementation to succeed," Shirole says.

Selecting the right principal investigator is key to implementation. "You want a PI who's well connected to the community, who you want to implement the results, and who is proactive about communicating these results," Avila says. "In general, it's critical to successful implementation to pick principal investigators who will stick with a project and go the extra mile."

> "NCHRP 24-23 is one of the most successful NCHRP projects I've been involved with because it resolved a specific dilemma about the preferred design method for riprap countermeasures for bridges."

An Implementation Success

Ultimately, implementation is a matter of how state and local agencies use results. "Implementation really comes down to states trying out these countermeasures," Avila says. "As they do so, they may find that some things work better than others."

Avila herself has been involved in implementing the new riprap methods on a bridge in Chico, Calif., and knows of its use on a Colorado bridge. Maryland SHA is also actively using research results. "The Office of Structures incorporated this information into Maryland's highway design manual," Davis says, "and Maryland SHA has already adopted these methods."

Overall, the interviewed panel members see NCHRP Projects 24-07(2) and 24-23 as exceptional examples of successful implementation.

"NCHRP 24-07(2) is one of NCHRP's great success stories, and the most successful NCHRP project I've worked on," Avila says.

Davis feels similarly about NCHRP 24-23. "NCHRP 24-23 is one of the most successful NCHRP projects I've been involved with," Davis says, "because it resolved a specific dilemma about the preferred design method for riprap countermeasures for bridges."

If properly designed, inspected, and maintained on a regular basis, riprap placed around bridge piers can provide long-term protection against scour. (Image courtesy Virginia DOT)

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