Research Brief

Wisconsin Highway Research Program
Project 0092-12-07
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Predicting Scour of Bedrock in Wisconsin

Research Objectives

- Assess the ability of the newly developed methods described in NCHRP Report 717 "Scour at Bridge Foundations on Rock" to characterize the scour potential for various types of Wisconsin bedrock
- Recommend updates to the WisDOT Bridge Manual to better suit structures built on Wisconsin's geologically diverse waterways

Research Benefits

- Determined that scour is typically small to negligible for bridges built on rock types capable of bearing a bridge's weight
- Confirmed that the bedrock at bridge sites representative of Wisconsin are within the durable rock range
- Recommended reductions in future foundation depth that will lower cost of construction without compromising bridge integrity or users' safety
- Provided WisDOT with more comprehensive scour estimation methods

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Background

Bridge scour, the erosion or removal of sediment due to flowing water around piers or abutments, is a major cause of highway bridge failure in the United States. After the collapse of New York's Schoharie Creek Bridge during a flood in 1987, the Federal Highway Administration (FHWA) issued a technical advisory that required evaluation of all bridges to determine vulnerability to scour.

Before laying the foundations for bridges, hydraulic and geotechnical engineers must estimate the depth of scour that will occur in erodible rock over the lifetime of the structure. The current method for determining foundation scour depth is based on the assumption that foundations are built over sand, which can lead to overly-conservative estimates and higher costs for bridge-construction projects. The National Cooperative Highway Research Program (NCHRP) Report 717, "Scour at Bridge Foundations on Rock," recommends assessing hydraulic behavior over the anticipated life of a structure differently when foundations are laid in bedrock rather than sand. The goal of this research was to test the NCHRP methods and recommend updates to the Wisconsin Department of Transportation (WisDOT) Bridge Manual that better suit the diverse geology of Wisconsin's waterways.

Methodology

Drilling in granite on the Eau Claire River.

The project oversight committee and the research team selected 10 bridges, the majority of which rest on spread footings or shallow foundations. The bridge sites were chosen for their higher rate of water flow and representation of bedrock types common to Wisconsin, such as sandstone, limestone/dolostone, gneiss and granite.

The research team conducted comprehensive geological evaluations of the bedrock and visited sites to collect core and hand-picked rock samples and to perform hydrographic field surveys of the channel bottoms. The core and hand samples were subjected to modified slake durability (continuous abrasion) testing as described in NCHRP Report 717. Test results were used to determine the equivalent hourly scour depth and the equivalent hourly stream power, and to estimate the geotechnical scour number (GSN) and

"This research will provide WisDOT with a more comprehensive, accurate and cost effective approach for assessing bedrock scour at many bridge sites across Wisconsin."
– Dan Reid, WisDOT

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the abrasion number (β). Hydraulic modeling analysis was conducted to estimate the annual average scour depth at the river bed and near the bridge piers using the daily stream flow data, and the long-term scour depths were predicted based on the flood frequency analysis.

Results

Sandstone samples subjected to the modified slake test exhibited significant mass loss. Sandstone's GSN and β were higher than those of limestone/dolostone, gneiss and granite, indicating that, under high stream powers, sandstone is more susceptible to higher scour rates than the other rock types investigated.

Bridge abutment on sandstone on WIS 13 in Wisconsin Dells.

Hydraulic modeling and analysis estimated that the annual scour depths of the rock on the riverbed foundations and around bridge piers are typically small to negligible. The two exceptions to this finding were the bridge sites on the Wisconsin River and the Black River, which had significant scouring.

Recommendations for Implementation

Results indicate that some bridge foundations may be laid deeper than necessary, and that reducing the depth would lower costs without compromising the integrity of the bridge. Rock types susceptible to high scour may indicate locations where deep foundations could be more cost effective and preferable to spread footings. WisDOT's Bureau of Structures will consider adding language and guidance relating to the qualitative conclusions of this research and placing foundations on rock. The model for predicting scour will be calibrated as field inspections and measurements are conducted and more data is collected. Typical geotechnical investigation needed for conventional bridge scour analysis, along with the collection of bedrock samples, should be sufficient for supporting these procedures.

The researchers identified limitations of the slake durability test. For instance, the test does not capture the degradability of rotten granite, a highly degradable rock. The test indicates very little loss in mass because the sample fragments are too large to be lost through the mesh of the testing apparatus.

This brief summarizes Project 0092-12-07,
"Predicting Scour of Bedrock in Wisconsin"
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