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NCHRP Report 761

Risk-based methods predict bridge scour

Bridge engineers design foundations to withstand scour—the erosion of streambed or bank material around critical piers and abutments that support the structure. NCHRP research responded to a perception among engineers that the hydraulic models used in scour-resistant designs have been too conservative, leading to unnecessarily deep (and costly) foundations.

A complex problem

With NCHRP Project 24-34, researchers set out to close the gaps between hydraulic predictions and the field experience of structural engineers by using a risk-based methodology.

"The problem with scour prediction is that hydrologic phenomena are governed by the laws of chance," says Pete Lagasse, senior hydraulic engineer for Ayres Associates and principal investigator for the project. "Scour is a complex process that has eluded mathematical modeling."

Scour can excavate soil and rocks from around bridge piers, putting the structure at risk for premature failure.

Consequently, improving scour prediction requires incorporating uncertainty into models. Such models provide a range of different scour estimates and assign them a probability of occurrence based on the bridge's particular structure and location and the chance of various hydraulic events, such as a flood of a given magnitude. As part of NCHRP 24-34, researchers developed a probability-based Monte Carlo simulation for scour and integrated it into the most widely used hydraulic modeling software, HEC-RAS.

"This is the kind of method that engineers already use for estimating how much weight bridges can bear using load and resistance factor design," says Lagasse. "Bridge hydraulic engineers can now similarly incorporate probability into scour prediction."

> "This is really about taking hydraulic models ... and seeing how well they fit the real world."

A risk-based tool for engineers

The document resulting from the project, *NCHRP Report 761: Reference Guide for Applying Risk and Reliability-Based Approaches for Bridge Scour Prediction*, is now an important tool for bridge engineers that impacts practice on a national scale.

"The methodology outlined in this report allows engineers to quantify the uncertainty involved in several steps of hydraulic analysis," says Waseem Dekelbab, TRB senior program officer. "This allows them to quantify their confidence in a hydraulic model's estimate instead of relying on intuition."

"This is really about taking hydraulic models developed in the laboratory and seeing how well they fit the real world," says Steve Ng, former Caltrans bridge engineer and chair of the NCHRP 24-34 project panel. "That gives engineers confidence about which scour equations they can hang their hats on, and which need further refinement." This also gives hydraulic engineers more credibility with structural and geotechnical engineers when recommending scour-resistant designs.

More cost-effective structures

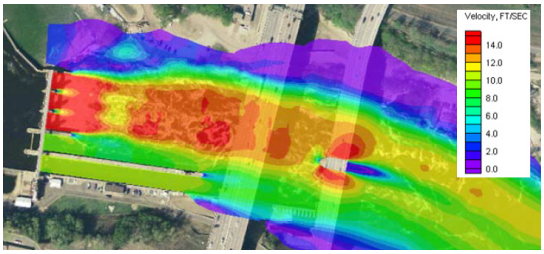
NCHRP 24-34 is the latest effort in a scour-related research program that NCHRP has been engaged in for more than two decades. These efforts led in 2009 to the publication of FHWA's *Hydraulic Engineering Circular No. 23* (HEC-23), which details scour countermeasures, and in 2012 to updates to two other widely used scour-related documents, HEC-18 and HEC-20.

"NCHRP 24-34 addressed one of the last remaining unknowns in the scour design process," says Lagasse, "which was to achieve a statistical basis for scour estimates comparable to the approach geotechnical and structural engineers use in bridge design." This will help lead to more cost-effective structures by reducing the costs of preventing scour, he adds.

> "With this project we really conducted the right research at the right time."

The NCHRP 24-34 results are very timely, appearing in advance of a recent executive order establishing a Federal Flood Risk Management Standard meant to ensure that federally funded projects address changing flood risks in a way that allows infrastructure to last for the intended service life. "With this project we really conducted the right research at the right time," Dekelbab says.

NCHRP Report 761 is available on the TRB website at www.trb.org/Publications/Blurbs/169762.aspx.



Randomness in hydraulic phenomena, as seen in this visualization of stream velocities, makes scour difficult to model and predict. A risk-based method incorporates uncertainty into models.

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