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JUST THE FACTS

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Principal Investigator:
Guoping Zhang, Ph.D., P.E.
Associate Professor
Louisiana State University

Administrative Contact:
Chris Abadie, P.E.
Associate Director, Research
LTRC
225-767-9124

Technical Contact:
Walid Alaywan, MSCE, P.E.
Sr. Structures Research Engineer
LTRC
walaywan@dotd.la.gov

SPECIAL POINTS OF INTEREST:

- Problem Addressed
- Objectives of Research
- Methodology Used
- Implementation Potential

Evaluation of Design Methods to Determine Scour Depths for Bridge Structures

PROBLEM

Scour, an engineering term for erosion, is the result of the erosive action of flowing water excavating and carrying away material from the bed and banks of streams and from around the piers and abutments of bridges. For analysis purposes, total scour at a bridge foundation consists of three independent components: (1) long-term aggradations or degradations of the river/stream bed, (2) general scour (including contraction scour) at the bridge, and (3) local scour at the piers or abutments of the bridge.

Aggradations and degradations are long-term stream bed elevation changes. Aggradations are the deposition of material eroded from the channel or watershed upstream of the bridge, while degradations are the lowering or scouring of the stream bed due to a deficit in sediment supply from upstream. General scour is a lowering of the stream bed across the stream or waterway bed at the bridge, usually resulting from contraction of the flow or from other conditions such as flow around a bend. Contraction scour is the removal of bed material due to the reduction of flow area of a stream at flood stage either by a natural contraction of the stream channel or by a bridge. General scour is different from long-term degradations in that general scour may be cyclic and/or related to the passing of a flood. Local scour is the removal of bed material from around piers, abutments, spurs, and embankments due to an acceleration of flow and resulting vortices induced by obstructions to the flow. Pier scour and abutment scour are the local scours that happen at the pier and abutment, respectively. Pier scour is the removal of the bed material around the foundation of a pier; abutment scour is the removal of the bed material around an abutment at the junction between a bridge and embankment. Two conditions exist for contraction and local scour: clear water and live bed scour. Clear water scour occurs when no movement of the bed material is involved in the flow upstream of the structure, while live bed scour takes place when there is transport of bed material from the upstream into the crossing.

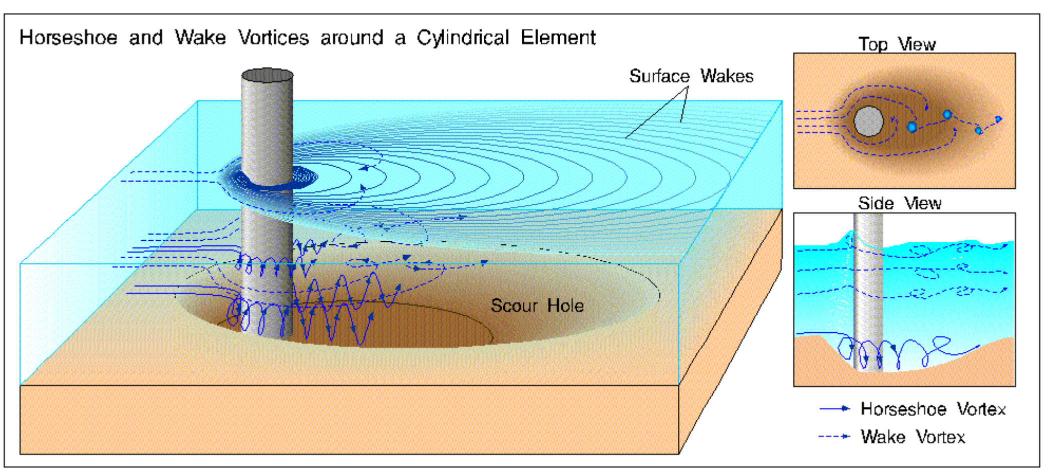

Figure 1
Schematic illustration of scour at a cylindrical pier by vortices

In the United States, approximately 575,000 bridges are built over waterways, accounting for 85 percent of all bridges in the nation (FHWA, 1989). In the past 30 years, more than 1,000 bridges in the states failed, and 60 percent of those failures were due to bridge scour (Yang, 2006). In fact, scour of bridge foundations is the most common cause of bridge failure. The Federal Highway Administration (FHWA) has developed design manuals, including HEC-18, HEC-20, and HEC-23 (Richardson & Davis, 2001), for the state DOT's to evaluate the scour potential of existing bridges and estimate the scour depths for new bridges.

OBJECTIVES

The overall goal of this project is to develop a more reliable tool for scour depth and scour rate prediction in the state of Louisiana, with the consideration of the Louisiana's special meteorological and climatic characteristics and soil/sediment properties. The newly developed technique will still be based on the fundamental frameworks set by FHWA approved HEC-18, but it will include some new statistically derived components and/or parameters in the models.

METHODOLOGY

Bridge scour is a complex natural process involving three components: (1) the soil (or rock) through its properties (e.g., erosional resistance, particle size distribution or gradation, and cohesive strength or cohesion), (2) the water through its flow velocity, (3) and the geometry of the obstacle (e.g., bridge piers and abutments) through its size and shape. As such, multidisciplinary fundamental knowledge of these three components is needed for studying and solving a bridge scour problem. The research methods selected by the multidisciplinary research team mainly include: (1) a review of existing knowledge and literature on bridge scour, (2) analysis of historical field measurements on scour depths in the Louisiana Department of Transportation and Development (LADOTD) scour database and comparison with the LADOTD design/prediction scour data obtained via HEC-18 design method, (3) re-development of the hydrological data through current or archived meteorological data obtained by satellite remote sensing and through geographical information system (GIS) data for the selected watersheds, (4) hydraulic analysis of the hydrometeorological data for each selected bridge site, (5) geotechnical analysis and laboratory testing of soil properties in the bridge site, and (6) development of a scour depth and scour rate prediction method by using multi-variants statistical analysis of field survey scour data, continuous hydrometeorological/hydraulic data, and soil geotechnical properties.

This research focuses on evaluating and developing design methods to determine scour depth and scour rate for bridge structures in Louisiana. The potential application areas of the anticipated research findings are mainly scour analysis for bridge design, bridge scour inspection, and bridge scour countermeasures installation. The forms of research findings will be mathematical models or formulas and design guidelines and procedures. The organizations and groups that may benefit from the new design methods include the LADOTD hydraulics section on scour analysis and bridge design, consulting firms, bridge scour assessment and repair firms, and other state DOT's.

IMPLEMENTATION

Three means of technology transfer are proposed to facilitate successful implementation: (1) an implementation seminar can be developed and presented to the LADOTD engineers and other personnel to become familiar with the newly developed bridge scour prediction methods; (2) a bridge scour analysis and design guideline can be published and distributed by LADOTD; and (3) if necessary or under the request of the Louisiana Transportation Research Center (LTRC) or LADOTD, the research team can develop a short course to disseminate and publicize the newly developed bridge scour prediction methods with the assistance of the LTRC's Technology Transfer and Training Program.