INSTRUMENTATION FOR MEASURING SCOUR AT BRIDGE PIERS AND ABUTMENTS

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Scour is the erosion of waterway soils and sediment that provide support for bridge foundations. More bridge failures are due to scour than to all other factors combined. The resulting disruptions of river crossings represent a safety hazard for travelers and can have devastating impacts on local economies. Thus it is important for bridge owners to know the scour susceptibility of their bridges.

An ongoing scour evaluation program being conducted by the Federal Highway Administration and all state highway agencies has led to the identification of more than 17,000 scour-critical bridges and nearly 100,000 bridges with unknown foundations. An additional 86,000 bridges screened as scour-susceptible have not been evaluated. Given the limited time and funding available, the scour-critical bridges cannot be immediately repaired or replaced, nor can the scour-susceptible bridges be immediately evaluated, and the bridges with unknown foundations will require monitoring.

Problem

Scour is the primary cause of bridge failure in the United States. Because scour holes generally fill in as stream flows diminish, postflood inspections are not adequate for fully determining the extent of scour damage. Methods for measuring the maximum scour depth are needed in the management of scour-susceptible bridges.

Solution

Technically and economically feasible instruments for monitoring scour depth were developed under National Cooperative Highway Research Program Project 21-3, Instrumentation for Measuring Scour at Bridge Piers and Abutments. Two instrument systems—a low-cost sonic fathometer and a magnetic sliding collar device using a driven-rod support—were installed and tested in the field under a wide range of bridge substructure geometry, flow, and geomorphic conditions.

The low-cost sonar device (see Figure 1) consists of a simple fish-finder-type sonar connected to a data logger that tells the sonar when to turn on, how much data to collect, and when to turn off. The systems were installed successfully on riverine and tidal bridges by a state highway agency using in-house equipment and personnel.

The magnetic sliding collar device (see Figure 2) consists of a stainless steel pipe driven into the channel bottom with a sliding collar that drops down the pipe as the scour progresses. The location of the collar is detected by the magnetic field created by magnets on the collar. Installations conducted in cooperation with state highway agencies demonstrated that this simple, low-cost instrument is adaptable to various field situations, and can be installed with the equipment and technical skills normally available at the district level of a state highway agency.

Another innovation, developed independently of the NCHRP project, is a float-out device. This device consists of a radio transmitter buried in the channel bed at a predetermined depth. When the scour reaches that depth, the float-out device rises to the surface and begins transmitting a radio signal that is detected by a receiver in an instrument shelter on the bridge. A conventional drill rig with a hollow stem auger is used to install the transmitter. After reaching the desired depth, the transmitter is dropped down the center of the auger.

NCHRP Report on Scour-Measurement Devices

NCHRP Report 396, *Instrumentation for Measuring Scour at Bridge Piers and Abutments*, documents all phases of the development work for the devices described in this article. Findings from laboratory and field testing are presented for each device, and a detailed discussion of the significance of these findings is presented. The companion manuals (NCHRP Report 397A, *Sonar Scour Monitor: Installation, Operation, and Fabrication Manual*; and NCHRP Report 397B, *Magnetic Sliding Collar Scour Monitor: Installation, Operation, and Fabrication Manual*), provide guidance for selecting the device most suitable for a bridge and its location. Detailed instructions, including fabrication drawings and parts lists, are included to permit fabrication of the monitors in most machine shops. Instructions for operation and maintenance are also given.

Application

In preparation for storm events driven by El Niño, a variety of instruments were installed at bridges in the southwestern United States in late 1997 and early 1998. Five bridges were instrumented in California, five in Arizona, and four in Nevada. The equipment included automated sliding collar, low-cost sonar, multichannel sonar, and float-out devices. These installations provided an opportunity to test a number of new concepts, including two- and four-channel sonar devices, application of early warning concepts (through definition of threshold scour levels and automated calls to pagers when that threshold is exceeded), and development and refinement of the float-out instrument concept.

During the testing, the SR 101 bridge over the Salinas River near Soledad, California, experienced several scour events that triggered threshold warn-ings. In one case the automated sliding collar dropped 1.5 m (5 ft), causing a pager call-out. Portable sonar measurements confirmed the scour recorded by the sliding collar. Several days later, another pager call-out occurred from a float-out d-evice buried about 4 m (13 ft) below the streambed. In both cases, the critical scour depth was about 6 m (20 ft) below the streambed, and no emergency action was needed to ensure public and bridge safety. Because pager call-out was ineffective in alerting maintenance personnel during nonoffice hours, a programmed voice synthesizer call-out to human-operated 24-hour communications centers was implemented at other bridges.

Benefits

The instruments developed under this research and through additional commercial development have been tested extensively and are fully field-deployable. Use of these instruments for scour monitoring will provide state highway agencies with an essential element of their action plans for bridges that are scour-critical or scour-susceptible, or have an unknown foundation. Use of these devices will allow monitoring of scour-critical bridges so that solutions can be developed before the problem becomes severe. In some circumstances, this monitoring will be able to provide a long-term alternative countermeasure for scour.

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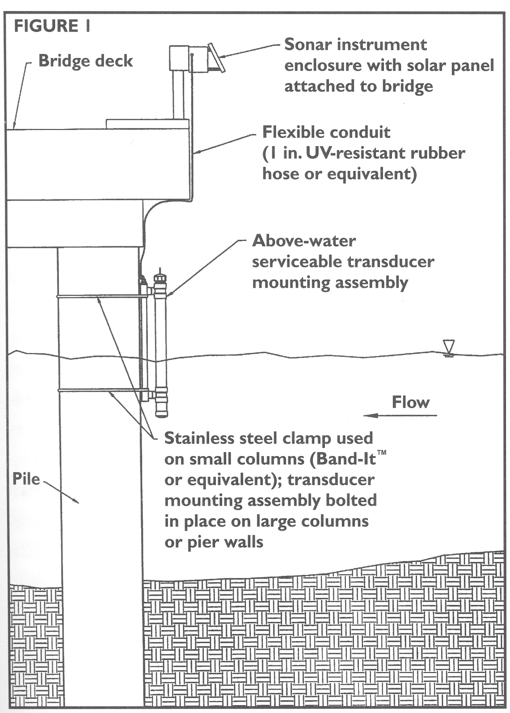
Suggestions for "Research Pays Off" topics are welcome. Contact G. P. Jayaprakash, Transportation Research Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418 (telephone 202-334-2952, e-mail *gjayapra@nas.edu*).



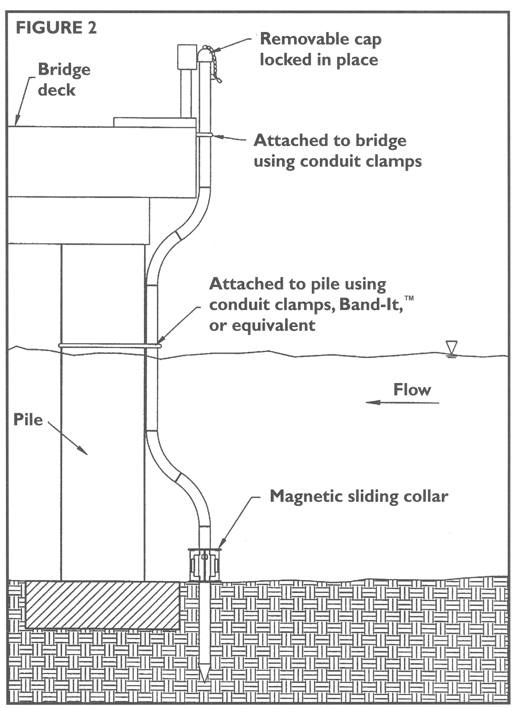


FIGURE 1 Typical sonar monitor installation.

FIGURE 2 Typical magnetic sliding collar monitor installation.