FIELD MONITORING OF BRIDGE SCOUR AT FOUR BRIDGE SITES IN GEORGIA

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Abstract. Erosion of the streambed near bridge foundations is often referred to as "bridge scour." Bridge scour is caused by the interaction between turbulent flows induced by bridge structures and the streambed. These turbulent flows erode the streambed and cause scour holes. The Georgia Institute of Technology (Georgia Tech) and the U.S. Geological Survey (USGS), in cooperation with the Georgia Department of Transportation (GDOT) and the Federal Highway Administration (FHWA), are conducting an investigation to improve bridge scour predictions by combining field monitoring, physical modeling in the laboratory, and three-dimensional numerical modeling of bridge scour. Bridge scour field data are being collected at four sites located in different regions of Georgia. These field data will be used to calibrate the physical and three-dimensional numerical models.

INTRODUCTION

Scour of the streambed at bridge piers and abutments is the leading cause of bridge failures in recent history. Bridge scour is the measure of the decrease in the channel bed elevation due to the interaction of turbulent flows induced by a bridge structure and the streambed. The turbulent flows erode the streambed and cause scour holes. Bridge scour is a function of flow energy, sediment-transport characteristics, and bridge characteristics. Complexities associated with bridge scour have hampered satisfactory analyses and prediction procedures.

Georgia Tech and the USGS, in cooperation with the GDOT and the FHWA, are conducting a bridge scour research project that integrates three-dimensional numerical modeling, physical modeling, and field measurements. The integration of these three components is intended to improve bridge scour predictions using one-dimensional methods. Greater accuracy of bridge scour predictions may lead to increased confidence in bridge design, thus increasing public safety of the citizens who use the bridges. Improved bridge scour predictions may also decrease unnecessary expenses for scour countermeasures, making the bridge design process more efficient.

This paper discusses the four sites chosen for the project. This paper also discusses the fixed-field instrumentation and data being collected at each of the sites. The field data at these four sites will provide detailed field measurements of bridge scour that can be used to calibrate and refine the scale effects of laboratory and numerical models, so that bridge scour prediction techniques may be improved.

CHATTAHOOCHEE RIVER NEAR CORNELIA (02331600)

Site Description

The first site chosen for the research project is the Chattahoochee River near Cornelia, Georgia. The USGS has been gaging stage and streamflow at this site since 1957. The gage is located at the bridge on Georgia Highway 384 (Duncan Bridge Road) at the Habersham-White County line in northeast Georgia. The drainage area at this site is 315 square miles. The channel in the vicinity of the bridge is a long quiet pool about 160 feet wide at lower flows. The pool extends from the rock ledge control about 500 feet downstream of the bridge to about 3,000 feet upstream of the bridge. The banks will overflow at higher stages onto a flat but narrow floodplain. The control is a rock ledge, which runs diagonally from the right bank downstream to the left bank. The bridge piers consist of four concrete square columns, which rest on concrete footings buried below the streambed. There is one bridge pier located in the center of the channel and one bridge pier on each of the banks. The bridge piers are aligned with the flow. The peak discharge of record is 26,400 cubic feet per second, which occurred on March 12, 1963. The 2-year flood event at this site is about 12,000 cubic feet per second, and the 500-year flood event is about 39,500 cubic feet per second (Stamey and Hess, 1993).

Fixed-Field Instrumentation

The fixed-field instrumentation at this site consists of four fathometers, an acoustic velocity meter, a rain gauge, and a stage sensor. The acoustic velocity meter, rain gauge, and stage sensor are interfaced with a Data Collection Platform (DCP), which logs readings from the sensors every 15 minutes. The DCP transmits the 15-minute data from each of the sensors every four hours using satellite telemetry. The four fathometers are interfaced with a data logger, which logs the readings from the fathometers every 30 minutes. The fathometers are attached to the center bridge pier and monitor the bed elevation changes occurring around the bridge pier. The velocity meter is attached to the nose of the center bridge pier and monitors two-dimensional velocities at three points across the approach bridge section.

OCMULGEE RIVER AT MACON (02213000)

Site Description

The second site chosen for the project is the Ocmulgee River at Macon, Georgia. The USGS has been gaging stage and streamflow at this site since 1895. The gage is located at the Fifth Street Bridge (Otis Redding Bridge) in Macon. The drainage area at this site is 2,240 square miles. The channel upstream of the bridge is straight for about 1,000 feet and straight for about 1,500 feet downstream of the bridge. The streambed is smooth and sandy. The right bank is high and is not subject to overflow. The left bank is subject to over flow at high stages, but the highway fill confines all flow to the bridge opening. The control is a shifting sand streambed. The bridge piers consist of four cylindrical columns that rest on concrete footings, which are buried below the streambed. There is one bridge pier in the center of the channel, and there is one bridge pier at each of the banks. All three bridge piers are aligned with the flow. The peak discharge of record is 107, 000 cubic feet per second, which occurred on July 6, 1994. The 2-year flood event is about 28,000 cubic feet per second, and the 500-year flood event is about 109, 000 cubic feet per second (Stamey and Hess, 1993).

Fixed-Field Instrumentation

The fixed-field instrumentation at this site consists of six fathometers and a stage sensor. The stage sensor is interfaced with a DCP, which transmits 15-minute data from each of the sensors every hour. The six fathometers are interfaced with a data logger, which logs the readings from the fathometers every 30 minutes. Five fathometers are attached to the center bridge pier, and one fathometer is located at the nose of the pier on the right bank. The fathometers monitor the change in bed elevation around the bridge piers.

FLINT RIVER AT BAINBRIDGE (02356000)

Site Description

The third site chosen for the research project is the Flint River at Bainbridge, Georgia. The USGS has been gaging stage and streamflow at this site since 1908. The gage is located at the bridge on Georgia Highway 27 Business Route in Bainbridge. The drainage area at this site is 7,570 square miles. The channel is fairly straight for several thousand feet upstream and has a sharp bend about 500 feet downstream. The site is affected by backwater from the Jim Woodruff Reservoir at lower stages. At higher stages, the backwater is negligible, and the banks overflow onto a very wide and flat floodplain. The bridge piers consist of two square concrete columns that rest on very large square concrete footings. The large footings protrude from the streambed. There are two bridge piers in the main channel and both are aligned with the flow. The peak discharge of record is 108,000 cubic feet per second, which occurred on July 14, 1994. The 2-year flood event is about 30,900 cubic feet per second, and the 500-year flood event is about 122, 000 cubic feet per second (Stamey and Hess, 1993).

Fixed-Field Instrumentation

The fixed-field instrumentation at this site consists of seven fathometers, a rain gauge, two acoustic velocity meters, and a stage sensor. The stage sensor, rain gauge, and acoustic velocity meters are interfaced with a DCP, which logs readings from the sensors every 15 minutes. The DCP transmits the 15-minute data from each of the sensors every 4 hours using satellite telemetry. The seven fathometers are interfaced with a data logger, which logs the readings from the fathometers every 30 minutes. Four fathometers are attached to the left center bridge pier, and three fathometers are attached to the right center bridge pier. The fathometers monitor the change in bed elevation around the bridge piers. An acoustic velocity meter is attached to the nose of the left center pier, and measures two-dimensional velocities at three points across the approach bridge section. A second acoustic velocity meter is attached to the downstream end of the left center bridge pier. This velocity meter measures a one-dimensional velocity at point in the center of the main channel. This one-dimensional velocity is used as an index velocity to determine the discharge.

DARIEN RIVER AT DARIEN (02203598)

Site Description

The fourth site chosen for the project is the Darien River at Darien, Georgia. The USGS began gaging stage and streamflow at this site in January 2002. The gage is located at the bridge on Georgia Highway 17 in Darien. The channel is fairly straight in the vicinity of the bridge. The flow at this site is tidally affected and is confined in a 400-foot-wide channel. The bridge piers consist of three rectangular concrete columns, which rest on very large square concrete footings. The footings protrude from the streambed. The midsections of the columns are connect with a flange. There are four bridge piers in the main channel. The two bridge piers near the right bank are protected with wooden bridge fenders.

Fixed-Field Instrumentation

The fixed-field instrumentation at this site consists of seven fathometers, a rain gauge, and a stage sensor. The stage sensor and rain gauge are interfaced with a DCP, which logs readings from the sensors every 15 minutes. The DCP transmits the 15-minute data from each of the sensors every 4 hours using satellite telemetry. The seven fathometers are interfaced with a data logger, which logs the readings from the fathometers every 30 minutes. Three fathometers are attached to the left bridge fender, two fathometers are attached to the right bridge pier, and two fathometers are attached to the left center pier. The fathometers monitor the change in bed elevation around the bridge fenders and piers.

SUMMARY

Fixed-field instrumentation has been installed at four bridge sites, which represent various sediment types in Georgia. Along with the data collected from the fixed-field instrumentation, additional scour data will be collected using mobile instrumentation that will be deployed during selected scour events at all four sites and will include detailed measurement of hydraulic and bathymetric data through the study reach. Bed-material samples have also been collected at all four sites. All the scour data will be used for the calibration and refining of the scaling effects of the physical and mathematical components of the project.

LITERATURE CITED

Stamey, T.C., and G.W. Hess. 1993. Techniques for estimating magnitude and frequency of floods in rural basins in Georgia. U.S. Geological Water-Resources Investigation Report 93-4016, 75 pp.