IN-SITU SCOUR TESTING DEVICE (ISTD), STATE DEMONSTRATIONS OF FIELD SOIL TESTS, BOSTON, KY

Emerging ISTD technology uses an innovative erosion head that more accurately measures soil erosion resistance, resulting in more cost-effective foundation designs and greater reliability and resiliency in bridge performance.

The demonstration group observes the ISTD field test.

Source: FHWA

INTRODUCTION

The ISTD is an advanced system designed by the hydraulics research team at the Turner-Fairbank Highway Research Center to measure the erosion resistance of fine-grained, cohesive soils directly in the field. The system features an innovative erosion head that, when inserted into a standard drill casing, can direct a horizontal radial water flow across the surface of the soil, resulting in erosion. The erosion resistance is measured in terms of critical shear stress, which, when coupled with the decay of hydraulic shear forces (water loads) with scour depth, is the basis of the Federal Highway Administration's (FHWA's) NextScour research initiative for improving the accuracy of future bridge scour estimates.

BACKGROUND

The Kentucky Transportation Cabinet (KYTC) hosted the 11th ISTD field demonstration on State Route 62 at the bridge over Rolling Fork, KY, located 2 mi west of Boston, KY. The demonstration was held east of the river in the floodplain under the bridge. KYTC planned to replace the 13-span bridge, originally built in 1938, with a shorter, nine-span structure by lengthening the embankment on the eastern side.

While KYTC's original 1938 bridge plan contained the historical subsurface soil profile at the site, KYTC conducted a new geotechnical investigation in March and April 2019 to get updated soil information. KYTC took 13 borings located at the proposed piers and abutments of the new bridge. These borings revealed layers of medium-stiff to stiff, brown, and gray clay down to 30 ft. Near the surface, some borings revealed a layer of sandy clay. One day before the demonstration, KYTC conducted a cone penetration test (CPT) at the site to obtain more detailed information about the soil profile. The CPT confirmed that beneath an initial 2-ft layer of sandy silt and clay were alternating layers of clay and silty clay from 3 to 24 ft. The N-values jumped quickly to 30 at 3-ft depth but then dropped to around 10 by 6 ft and then ranged between 5–10 down to 24 ft. The layer starting around 7 ft was chosen as the targeted testing layer for the ISTD.

TEST PROCEDURE

The demonstration took place on May 30, 2019, but the drill crew and the hydraulics team arrived a day earlier to conduct as much ISTD field testing as possible in the two-day span. To access the floodplain area underneath the bridge deck, the crews used an access road entrance to a farm about 1,000 ft east of the bridge. When they arrived at the proposed drilling location, it was inaccessible because of brush overgrowth, so both groups agreed to move the test two span lengths closer to the east abutment. At this point, the weather took an unfortunate turn. Heavy rains fell at the site and continued over the two days of testing. The drill crew proposed positioning the rig under the bridge deck, but there was not enough clearance to raise the rig mast. Fortunately, they were able to position the rig adjacent to the deck to offer everyone some relief from the rainfall. The drillers ended up augering to a depth of 12 ft, a 5-ft segment past the targeted depth. The hydraulics team then assembled the remaining equipment, including the water tank, pump, piping, hoses, linear drive, and laptop to prepare for the first test.

RESULTS

Over the course of the testing, the hydraulics team collected almost 3 h of erosion data, captured in eight test runs ranging

The ISTD equipment assembled in front of the drill rig.

Source: FHWA

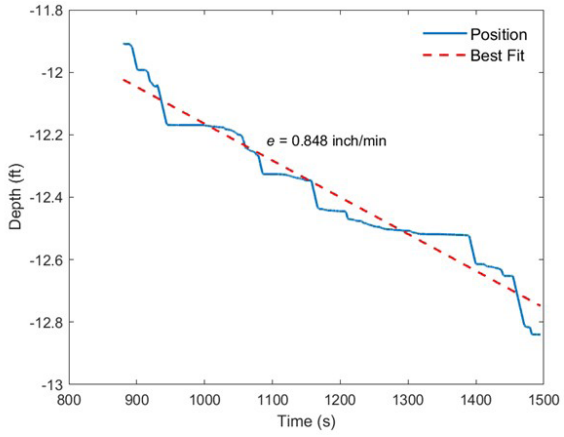
from 6–50 min in length. They tested about 5 ft of soil with eight different flow rates ranging from 0.144–0.271 ft³/s.

Despite some early difficulties with a stuck sensor and an instance where 10 inches of clay washed out quickly from the Shelby tube, the testing was very successful, obtaining a wide range of data points. With this data, FHWA identified nine different segments and extracted erosion rates using a best-fit line through each set of data. The corresponding mean flow rates were also calculated for each segment. The nine data points are detailed in the Summary of Results table. The erosion rates are plotted against flow rates, showing the correlation between the two values. With more data points, a nonlinear power curve can be fit to the data to extract the critical flow rate.

Due to the presence of some low erosion rates during testing, this ISTD demonstration revealed that this location could potentially have a clay layer with erosion resistance. However, additional testing is needed to confirm this result and produce more consistent data.

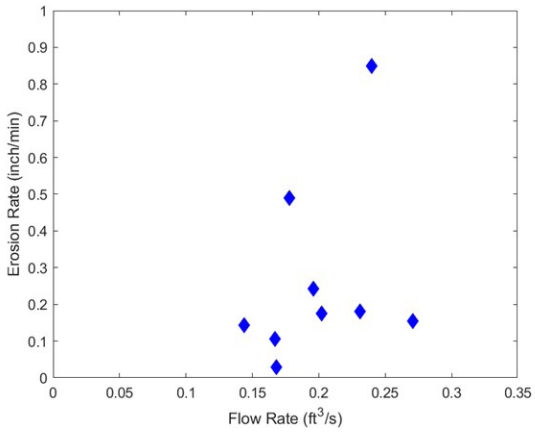
Summary of Results

Depth (ft)	Duration (min)	Flow Rate (ft³/s)	Erosion Rate (inch/min)
13.35	25:35	0.196	0.243
13.90	23:55	0.271	0.155
15.22	1:25	0.231	0.180
11.87	13:40	0.168	0.029
11.91	10:15	0.240	0.849
13.16	24:50	0.144	0.143
13.53	14:30	0.178	0.490
14.17	19:35	0.167	0.106
14.43	27:50	0.202	0.175



Source: FHWA

Soil layer's erosion rate (e) calculated from the slope of the best-fit line.



Source: FHWA

Erosion rate versus flow rate for the Boston ISTD demonstration. With more data points, a nonlinear fitted power curve could be used to extract the critical flow rate where erosion begins.

Soil Properties

Parameter	Value
Depth (ft)	12.4–14.4
Water content (%)	33.6
Liquid limit (%)	51.0
Plasticity index (%)	22.0
Clay fraction (%)	47.6
Percent fines (%)	96.8
Soil classification (USCS)	MH
Soil classification (AASHTO)	A-7-6(26)
Unconfined compressive strength (psi)	11.77

USCS = Unified Soil Classification System; AASHTO = American Association of State Highway and Transportation Officials.

ADDITIONAL RESOURCES

ISTD Field Demonstration Webinar:
https://connectdot.connectsolutions.com/ph8wgrf8erz7

AASHTO *Hydrolink* Newsletter:
https://transportation.org/design/wp-content/uploads/sites/31/2023/05/Hydrolink-Issue-16.pdf

NextScour Journal Paper:
https://doi.org/10.1680/jfoen.20.00017

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U.S. Department of Transportation
Federal Highway Administration

https://highways.dot.gov/laboratories/hydraulics-research-laboratory/hydraulics-research-laboratory-overview

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