In-Situ Scour Testing Device (ISTD), State Demonstrations of Field Soil Tests, Bay City, MI

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 Bay City ISTD field test.

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. It 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 a 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 program for improving the accuracy of future bridge scour estimates.

BACKGROUND

The second ISTD demonstration, hosted by the Michigan Department of Transportation (MDOT), was held in a field south of the east abutment of the Lafayette Street Bridge, which crosses the East Saginaw River in Bay City, MI. MDOT had listed the bridge as scour critical and begun the design process for a replacement structure. Preliminary geotechnical work for the project was scheduled for the summer of 2018.

The subsurface soil profile of the site was determined from boring logs taken in September 2016. After initial layers of topsoil; organic material; and medium-dense, fine sand, at 26.5 ft the soil transitioned to stiff, gray, lean clay with traces of sand and gravel. Previous standard penetration tests (SPT) found that at 40 ft the clay was very stiff with an N-value of 29. However, by 45 ft the N-value dropped to 22, and by 50 ft the N-value was only 10, which remained consistent down to 60 ft. The softer clay layer between 50 and 60 ft was the targeted testing layer for the ISTD.

TEST PROCEDURE

The demonstration took place on Wednesday, July 25, 2018. The drill crew experienced difficulties when wood chips from the layer of organic material became caught in the auger teeth, which caused the Shelby tubes to crumple when pushed into the clay. The ISTD erosion test is conducted inside the Shelby tube, so this outcome was a significant setback that resulted in lengthy delays. Eventually, a new borehole was drilled and flushed with water to remove any remaining organic material. The Shelby tube and casing were lowered into the auger and successfully pushed 16 inches into the clay. The hydraulics team then assembled the remaining ISTD equipment, including the hoses, water tank, pump, piping, control box, and laptop. Finally, the erosion head was lowered into the casings to prepare for the erosion test.

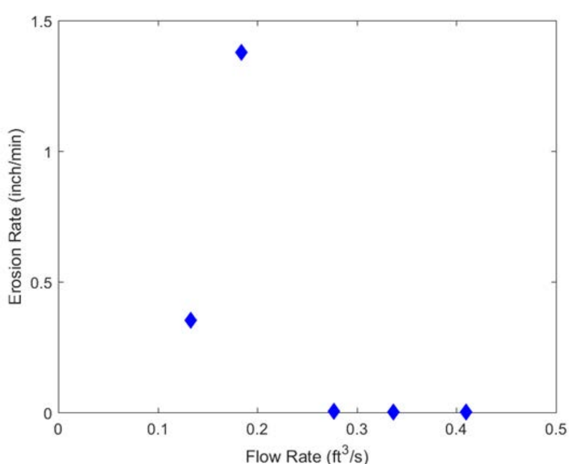
RESULTS

Over the course of the day, the hydraulics team collected a total of 3 hr of erosion data captured in eight separate test runs ranging from 6 to 60 min per run. They tested roughly 24 inches of soil with five different flow rates ranging from 0.133 to 0.410 ft3/s.

The ISTD equipment assembled in front of the drill rig.

Unfortunately, only two of the test runs produced viable data; the remaining runs were discarded because they involved flushing out sludge material or attempting to free the erosion head after it became stuck in the Shelby tube. From the two runs, five different segments were identified, and erosion rates were extracted using a best-fit line through each set of data. The corresponding mean flow rates were also calculated for each segment. The five data points are detailed in the Summary of Results table. Ideally, a nonlinear power curve can be fitted to the data to determine the critical flow rate of the soil, but the data points varied greatly between the two runs, indicating that the actual soil conditions were not consistent. The first test might have contained soil disturbed from the augering process, while the second test was more typical of undisturbed soil from the targeted layer.

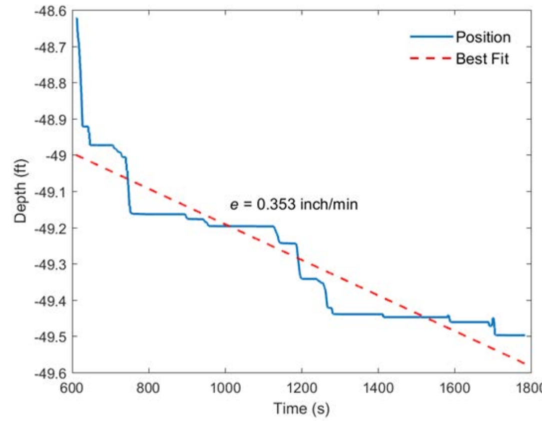
Due to the presence of extremely low erosion rates during one of the test runs, this ISTD demonstration revealed that this location could potentially have a clay layer with significant erosion resistance. However, additional testing is needed to confirm that result and produce more consistent data.



Source: FHWA.

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

Summary of Results			
Depth (ft)	**Duration (min)**	**Flow Rate (ft^3/s)**	**Erosion Rate (inch/min)**
47.79	5:07	0.184	1.377
48.62	19:35	0.133	0.353
55.84	12:50	0.277	0.003
55.85	12:25	0.337	0.000
55.85	20:35	0.410	0.002



Source: FHWA.

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

Soil Properties	
Parameter	**Value**
Depth (ft)	45–47.5
Water content (%)	15
Liquid limit (%)	25
Plasticity index (%)	13
Clay faction (%)	37
Percent fines (%)	72
Soil classification (USCS)	CL
Soil classification (AASHTO)	A-6(6)
Unconfined compressive strength (psi)	17.71

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://design.transportation.org/wp-content/uploads/sites/21/2018/02/Hydrolink-Issue-16.pdf

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U.S. Department of Transportation
Federal Highway Administration

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