In-Situ Scour Testing Device (ISTD), State Demonstrations of Field Soil Tests, Lowndesboro, AL

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. 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 Alabama Department of Transportation (ADOT) hosted the seventh ISTD field demonstration on State Route 80 at the bridge over Big Swamp Creek, located about 5 mi west of the town of Lowndesboro. The demonstration was held in the floodplain on the west side of the creek, in the median closer to the eastbound lanes. The eastbound bridge featured aging steel piers. ADOT designated the bridge for replacement and scheduled preliminary drilling for the project to occur in late 2018.

The subsurface soil profile was initially determined from a boring log taken in late August 2018 that showed a layer of moist, brown-gray, silty clay with medium stiffness starting at a depth of 3 ft. At 13.5 ft, the clay began to stiffen, becoming very stiff at 18.5 ft. Approximately two weeks before the demonstration, a cone penetration test (CPT) was conducted at the site to obtain more detailed information about the soil profile. The CPT confirmed a very consistent clay layer beginning at 3 ft. The day before the demonstration, the drillers performed a continuous standard penetration test (SPT) to a depth of 21 ft and found that stiffness did increase at a depth of 12 ft, with N-values ranging from 5 to 10, and then increasing to 12 to 24. The water table was found to start at around 8 ft, so the layer from 8 to 12 ft was chosen as the targeted testing layer for the ISTD.

TEST PROCEDURE

The demonstration took place on November 7, 2018. The drill crew and the hydraulics team arrived one day early to perform the SPTs and conduct as much ISTD field testing as possible in the span of two days. The first borehole drilled for the SPT tests was close to the west abutment, but a piezometer found the water table in the hole was at a depth of 19 ft, which was beneath the ISTD targeted testing layer. In response, the drill crew remobilized much closer to the creek and started a new borehole at that location.

The drill crew augered to a depth of 8 ft and lowered in the casing and Shelby tube. Subsequently, the hydraulics team assembled the remaining equipment including the linear drive, water tank, piping, hoses, and laptop. The hydraulics team successfully completed two erosion tests on the first day. The next morning the team asked the drill crew to start a new borehole at 8 ft to avoid the stiffer layer at 12 ft. The hydraulics team then completed three more erosion tests on the day of the demonstration.

RESULTS

Over the course of the testing, the hydraulics team collected almost 3 h of erosion data, captured in five separate test runs ranging from 10 to 60 min per run. They tested roughly 4 ft of soil with seven different flow rates ranging from 0.11 to 0.19 ft^3/s.

The clay found at this testing site produced some unusual erosion data that made it difficult to analyze. Usually, it is expected that the clay erodes uniformly, with occasional

The ISTD equipment assembled in front of the drill rig.

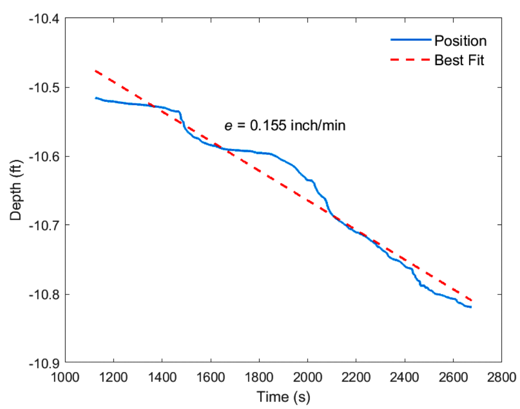
Source: FHWA.

drops as clumps of clay wash away. However, this clay did not follow this pattern. Sometimes the clay would not erode for 20 or 30 min, but then suddenly erode 8 inches or more in a few minutes.

From the data, seven different segments were identified, and erosion rates were extracted by using a best-fit line through each set of data. The corresponding mean flow rates were also calculated for each segment. The seven data points are detailed in the Summary of Results table.

The correlation of the best-fit lines was poor for several of the runs, due to these inconsistent large drops seen with the erosion head. These large drops could be behavior typical of the clay; however, the clay was also very sticky. It is possible that pieces of the clay were adhering to the sensors and interfering with their movement. Usually, when the erosion head was stuck in place and not moving for long periods of time, a single sensor controlled the gap. It seems likely that erosion was still occurring in the tube, while clay was stuck to the controlling sensor.

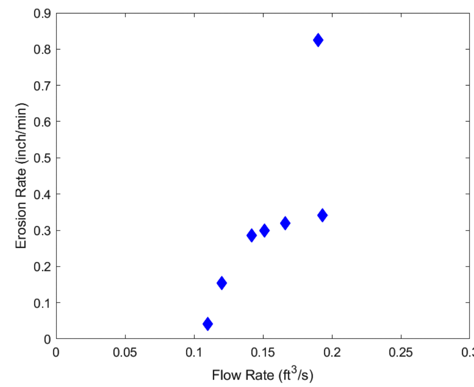
The ISTD demonstration revealed that this location contained soils that were easily erodible and could potentially have a clay layer with weak erosion resistance. However, additional testing would be needed to confirm that result and produce more consistent data.



Source: FHWA.

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

Summary of Results			
Depth (ft)	**Duration (min)**	**Flow Rate (ft^3/s)**	**Erosion Rate (inch/min)**
8.94	27:10	0.193	0.341
10.04	17:40	0.151	0.299
10.52	25:50	0.120	0.155
7.80	16:50	0.142	0.285
8.54	35:50	0.110	0.042
8.81	22:10	0.166	0.319
9.72	9:40	0.190	0.825



Source: FHWA.

Erosion rate versus flow rate for the Lowndesboro 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)	8-10
Water content (%)	32
Liquid limit (%)	56
Plasticity index (%)	36
Clay fraction (%)	53
Percent fines (%)	90
Soil classification (USCS)	CH
Soil classification (AASHTO)	A-7-6(35)
Unconfined compressive strength (psi)	3.4

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

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

Recommended citation: Federal Highway Administration, *In-Situ Scour Testing Device (ISTD), State Demonstrations of Field Soil Tests, Lowndesboro, AL* (Washington, DC: 2021) https://doi.org/10.21949/1521693.