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

AMR Accelerating Market Readiness

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 Colorado Department of Transportation (CDOT) hosted the sixth ISTD field demonstration at the Box Elder Creek Bridge, which is located about 15 mi east of Denver on U.S. Route 36. The demonstration was held in the sandy floodplain south of the east abutment. This bridge was replaced in 2005, so CDOT had detailed geotechnical data from the site. FHWA agreed it would be a good candidate to demonstrate the technology.

The subsurface soil profile was initially determined from boring logs taken in 2004 that showed a 20-ft layer of soft, sandy clay, starting at a depth of 19 ft. Approximately 1 month before the demonstration, a cone penetration test (CPT) was conducted in close proximity to the planned borehole location to provide an updated profile. The CPT confirmed the clay layer, but found it started further down, from 26 to 36 ft. On the day before the demonstration, the drillers performed a continuous standard penetration test (SPT) through that entire layer, beginning at 23 ft. Starting at 26 ft, they found a layer of soft, brown, sandy clay with N values ranging from 4 to 7. This layer was selected as the targeted testing layer for the ISTD.

TEST PROCEDURE

The demonstration took place on October 18, 2018. The drill crew and the hydraulics team arrived 1 day in advance to perform the SPTs and get a head start on assembling the ISTD equipment to conduct trial runs. This demonstration was the first to incorporate new accessories, including quick-snap cam and groove couplings for the hoses and new brass gate, lever, and pressure-relief valves to help control the water flow. These items needed to be fully tested before the CDOT engineers arrived. Another adjustment was made to the tank by cutting out a large rectangular access area in the top to allow for more flexibility to set up the water outlet pipe from the linear drive. A new custom outlet pipe support was also introduced. After the SPTs were conducted, the drill crew then augered to 27 ft in a new borehole and lowered in the Shelby tube and casings. The hydraulics team could then assemble the ISTD equipment, including the linear drive, water tank, hoses, and piping to conduct the erosion tests.

RESULTS

Over the course of the testing, the hydraulics team collected almost 4 h of erosion data, captured in four separate test runs ranging from 40 to 80 min per run. They tested roughly 4 ft of soil with nine different flow rates ranging from 0.106 to 0.259 ft^3/s.

Compared with the clay from the previous sites, this clay produced more consistent erosion curves recorded during field testing. There were not many sudden drops of the erosion head, which can occur when a large segment of clay quickly washes out during testing. The soil surface also eroded consistently, which was noted by the high percentage of contact between all four sensors with the

The ISTD equipment assembled in the field.

Source: FHWA.

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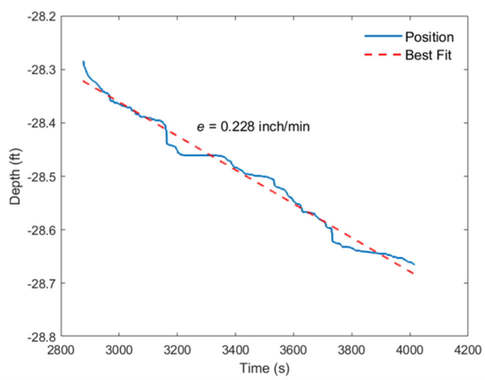
surface, compared with the testing at the other sites. From the data, 12 different segments were identified, and the erosion rates were extracted by using a best-fit line through each set of data. The corresponding mean flow rates were also calculated for each segment. The 12 data points are detailed in the Summary of Results table. With enough data points, a nonlinear power curve can be fitted to the data to determine the critical flow rate of the soil, which can be correlated to the shear stress. The plot shows the cloud of data points beginning to form, but more points are needed to confidently calculate the curve.

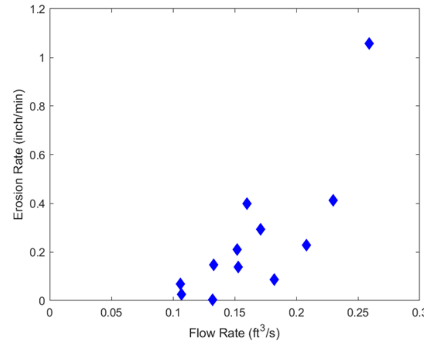
The ISTD demonstration revealed that this location contained soils that were easily erodible and could potentially have a clay layer with weak erosion resistance. However, additional testing would be needed to confirm that result and produce more consistent data.



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)**
27.96	29:30	0.107	0.026
28.05	15:45	0.153	0.138
28.29	19:00	0.208	0.228
28.73	23:47	0.182	0.087
28.94	13:45	0.230	0.413
29.36	2:50	0.259	1.058
30.73	26:10	0.133	0.147
31.05	8:57	0.171	0.294
31.36	20:00	0.106	0.069
31.47	13:40	0.160	0.399
31.93	18:55	0.132	0.004
31.95	18:55	0.152	0.210



Source: FHWA.

Erosion rate versus flow rate for the Watkins 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)	27-30
Water content (%)	30
Liquid limit (%)	62
Plasticity index (%)	42
Clay faction (%)	57
Percent fines (%)	95
Soil classification (USCS)	CH
Soil classification (AASHTO)	A-7-6(44)
Unconfined compressive strength (psi)	9.58

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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Federal Highway Administration

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

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