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

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 device 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 measurements are 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) NextScour research initiative for improving the accuracy of future bridge scour estimates.

BACKGROUND

The Maine Department of Transportation (MaineDOT) hosted the 13th ISTD field demonstration at a MaineDOT maintenance lot in Scarborough, ME. The site location was roughly 0.5 mi from a recently replaced bridge on Route 1 over the Dunstan River. Although the bridge was already constructed, MaineDOT was interested in the ISTD technology for future projects and suggested conducting a demonstration at the lot because it expected a similar subsurface soil profile compared to the bridge site, which had clay layers.

MaineDOT conducted a soil boring in the lot in June 2019, one month before the demonstration. The investigation found brown/olive, wet, medium-stiff clayey silt and silty clay, with trace sand from depths of 0 to 12.5 ft. At 12.5 ft, the soil transitioned to a gray, wet, soft, silty clay to a final boring depth of 41 ft. Two weeks before the demo, a geoengineering contractor conducted a cone penetration test (CPT) at the site that confirmed the soil profile. The day before the demonstration, the drill crew collected several Shelby tube samples for additional soil erosion and geotechnical testing. Sand lenses were found between 13 and 19 ft, so the researchers selected 20–29 ft as the testing depth for the ISTD.

TEST PROCEDURE

The demonstration took place on July 17, 2019, but the drill crew and the hydraulics team arrived a day earlier to collect Shelby samples and conduct as much ISTD field testing as possible in the two-day span. After collecting samples, the drill crew augered a new boring to a depth of 20 ft for the initial ISTD test. The clay at this site was very soft and weak, and after inserting the casing and Shelby tube for the erosion test, the measured depths did not match the expected depths. The depth difference indicated that disturbed soil was rising up into the casing. The drill crew tried to flush out the material with a tricone bit and the erosion head, but the effort was unsuccessful.

The next day, the drill team drilled a new boring and took extra care inserting the casing and Shelby tube. The weight of the casing easily enabled the Shelby tube to penetrate the soil without additional force. The hydraulics team assembled the remaining equipment, including the water tank, pump, piping, hoses, linear drive, and laptop and conducted the first test. The hydraulics team also brought a newly fabricated subframe assembly that supported the Shelby tube and modified the test setup so the ISTD could conduct erosion testing at ground level. The modified test setup became known as the portable scour testing device (PSTD). Soil at this site was too weak to sample in the 3.5-inch Shelby tube, so the team conducted only a mock PSTD test to validate the range of flow velocities with the new portable fire pump.

The ISTD equipment assembled in front of the drill rig.

Source: FHWA.

RESULTS

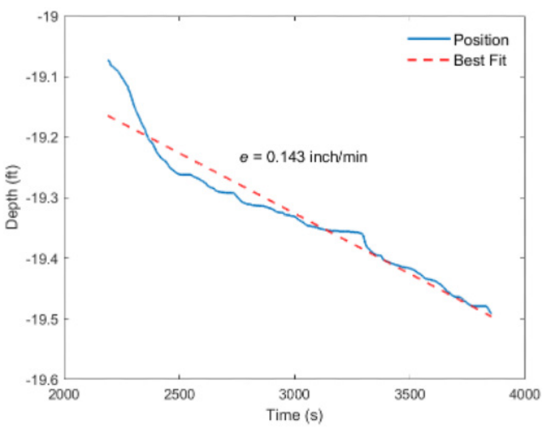
Over the course of the testing, the hydraulics team collected 3.5 h of erosion data, captured in four test runs ranging between 13 and 80 min in length and tested about 6 ft of soil with 10 different flow rates, ranging from 0.101 to 0.196 ft^3/s.

Of all the field demonstrations conducted for this study, this site produced some of the steadiest erosion data, likely due to the soft, easily erodible clay material. With this data, FHWA identified 10 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 10 data points are detailed in the Summary of Results table. The erosion rates plotted against flow rates on the related graph show the correlation between the two values. With additional data points, a nonlinear power curve can be fit to the data to extract the critical flow rate.

This ISTD demonstration revealed that this location has a clay layer with potential low erosion resistance. However, additional testing is needed to confirm this result.

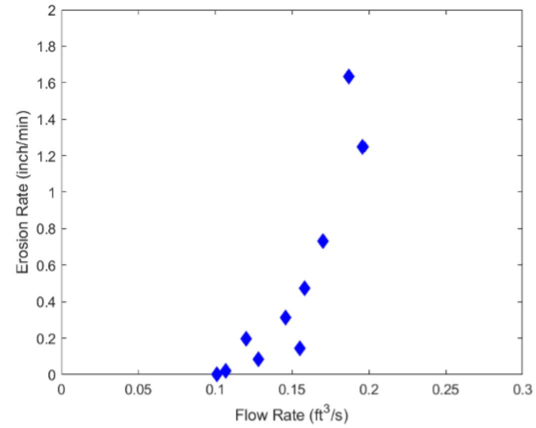
Summary of Results

Depth (ft)	Duration (min)	Flow Rate (ft^3/s)	Erosion Rate (inch/min)
18.97	34:15	0.107	0.022
19.07	27:45	0.155	0.143
19.53	3:05	0.196	1.248
19.91	16:35	0.101	0.003
19.92	25:45	0.128	0.083
20.10	20:05	0.146	0.311
20.73	8:45	0.170	0.732
21.16	9:45	0.187	1.635
22.47	20:40	0.120	0.197
22.72	19:25	0.158	0.475



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 Scarborough ISTD demonstration. With additional 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)	20.25
Water content (%)	43.9
Liquid limit (%)	76.7
Plasticity index (%)	15.0
Clay fraction (%)	69.2
Percent fines (%)	98.0
Soil classification (USCS)	CL
Soil classification (AASHTO)	A-7-6(18)
Unconfined compressive strength (psi)	3.2

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

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

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