AMR Accelerating Market Readiness

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

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 Virginia ISTD field demonstration was performed on a barge in the Nottoway River.

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 research initiative for improving the accuracy of future bridge scour estimates.

BACKGROUND

The Virginia Department of Transportation (VDOT) hosted the ninth ISTD field demonstration at the bridge carrying Route 671 over the Nottoway River, located 4 mi southwest of the town of Franklin, VA. VDOT planned to replace the aging bridge structure and had questions about the scour depths calculated assuming a sand subsurface profile. The calculated scour depth based on these assumptions appeared to be greater than expected based on observations of the performance of the existing structure. VDOT believed that including the clay layers encountered at the site could potentially reduce the calculated scour depths.

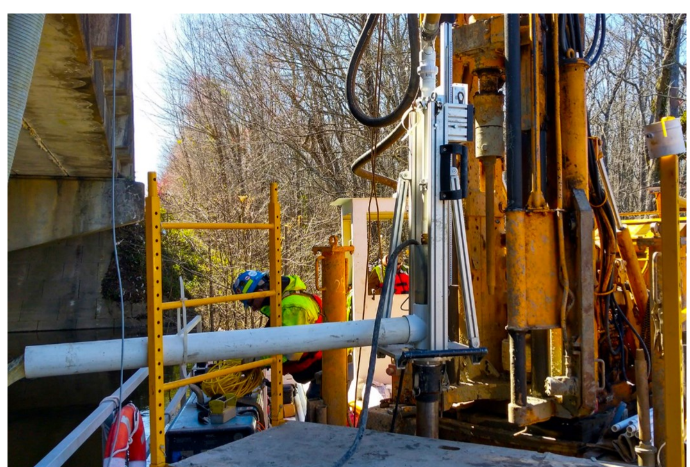
Prior ISTD field demonstrations were typically performed at an abutment or in the floodplain, but for this site, the test was conducted adjacent to the proposed pier in the main channel, which required conducting the ISTD test on a barge on the river. This setup required careful coordination with VDOT and its subcontractors and more advanced planning than at previous sites.

The subsurface soil profile was initially determined from boring logs taken from across the site in 2012. Those borings showed a 10-ft-thick layer of gray, soft, sandy lean-to-fat clay. The clay layer was located beneath a 14-ft-thick layer of sand that started at the channel bed. On the morning of the demonstration, the drillers performed a continuous standard penetration test (SPT) from the barge to confirm the soil properties. They found that the clay layer was about 8 ft beneath the sand layer, and it was about 8-ft thick with SPT blow counts (i.e. N-values) ranging from 2–4. The clay layer starting at 8 ft was selected as the targeted testing layer for the ISTD.

TEST PROCEDURE

The demonstration took place on March 27, 2019. One of the major challenges with conducting an ISTD test on the barge was the placement of the pump because of the limited space on the barge platform. To save room, FHWA and VDOT decided to position the pump in a closed lane of the bridge deck and run the hoses down to the barge. In preliminary meetings, the distance from the deck to the water surface was estimated to be only 10 ft, but it was between 15–20 ft. The researchers were uncertain if the pump would be powerful enough to supply the range of desired flows with that height differential.

A second major challenge was the use of mud rotary drilling instead of hollow stem augers because mud rotary is more adept at drilling in water and sand. The drillers utilized a bentonite slurry as the drilling fluid. When the hydraulics team tried inserting the erosion head and polyvinyl chloride (PVC) pipes into the borehole, they encountered excessive resistance as the bentonite mixture struggled to flow through the narrow channels of the erosion head. When the pump was started, it was completely unable to circulate the bentonite mixture through the system. The erosion head was removed, and the drillers then flushed the bentonite mixture from the casing with a tri-cone bit. When the erosion head was reinserted, the pump was finally able to circulate water through the system, but the flow meter indicated the flow was oscillating at amplitudes up to 0.03 ft^3/s. The hydraulics team relocated the hoses, gauges, and flow meter to the bridge deck, which helped steady the pulsating flow, along with operating the pump at higher flow rates.



The ISTD equipment assembled in front of the drill rig on the barge.

Source: FHWA.

At this point, the hydraulics team was able to successfully run several ISTD erosion tests and collect data.

RESULTS

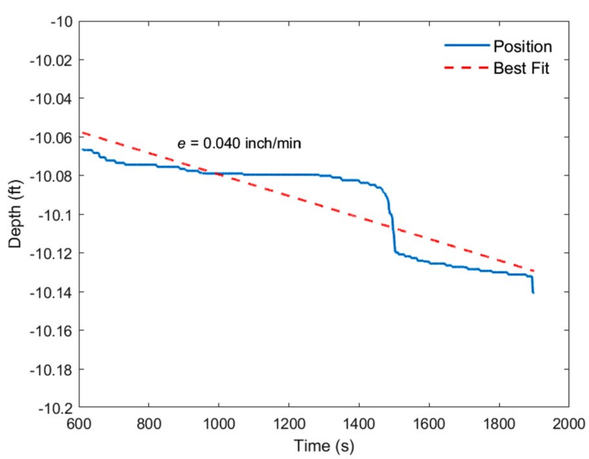
Over the course of the testing, the hydraulics team collected about 2 h of erosion data, captured in two test runs. They tested 1.5 ft of soil with 4 different flow rates ranging from 0.121 to 0.270 ft^3/s.

The two test runs produced varied results. It is unknown how the pulsating flow affected the erosion. At a few points, suspended sand in the water might have interfered with the sensors. Despite these uncertainties, four 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 four data points are detailed in the Summary of Results table. The erosion rates are plotted against flow rates, which show the correlation between the two values. With more data points, a nonlinear power curve can be fitted to the data to extract the critical flow rate.

Due to the presence of low erosion rates during testing, this ISTD demonstration revealed that the clay layer could potentially provide the required erosion resistance. However, additional testing would be needed to confirm that result and produce more consistent data.

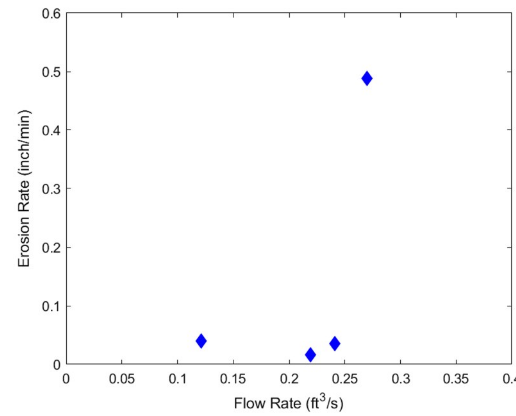
Summary of Results

Depth (ft)	Duration (min)	Flow Rate (ft^3/s)	Erosion Rate (inch/min)
10.07	21:30	0.121	0.040
10.15	23:10	0.219	0.016
10.61	14:05	0.241	0.035
10.67	26:35	0.270	0.488



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 Franklin 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)	11–11.5
Water content (%)	29
Liquid limit (%)	32
Plasticity index (%)	12
Clay fraction (%)	19
Percent fines (%)	56
Soil classification (USCS)	CL
Soil classification (AASHTO)	A-6(4)
Unconfined compressive strength (psi)	5.05

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

Recommended citation: Federal Highway Administration, *In-Situ Scour Testing Device (ISTD), State Demonstrations of Field Soil Tests, Franklin, VA* (Washington, DC: 2022) https://doi.org/10.21949/1521950.