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

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 ISTD demonstration site on State Route 396.

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 system 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 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 Nevada Department of Transportation (NDOT) hosted the 10th ISTD field demonstration on State Route 396 at the bridge over the Humboldt River, located 2 mi north of Lovelock, which is about 90 mi northeast of Reno, NV. The demonstration was held on the south shoulder of the road at the west abutment. NDOT had scheduled the bridge for replacement due to its poor condition.

The subsurface soil profile was initially determined from boring logs taken in August and October 2018, which NDOT used to compile a subsurface fence diagram for the site. The geotechnical investigation revealed alternating layers of low- and high-plasticity clay down to 35–40 ft. The day before the demonstration, the drillers performed a continuous standard penetration test (SPT) from 10–20.5 ft and found a layer of light brown, moist clay, with trace sands, varying between high and low plasticity. The clay was very stiff in the initial 3 ft but dropped to an N-value of 10 at 13 ft and further weakened to values of 5–6 from 14.5–19 ft. The water table was measured at 12.5 ft. To avoid the initial stiff soil layer and conduct the test in groundwater, FHWA selected 12.5 ft as the targeted starting depth for the ISTD test.

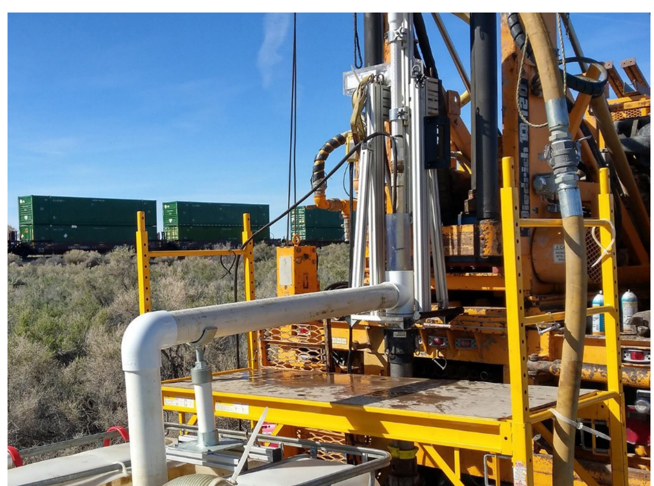
TEST PROCEDURE

The demonstration took place on April 17, 2019, but the drill crew and the hydraulics team arrived a day in advance to perform the SPTs and conduct as much ISTD field testing as possible in the two-day span. Because the test was held on the shoulder of an active roadway, NDOT organized traffic control to close the adjacent lane of traffic. The lane closure increased safety for the demonstration but reduced the available time to conduct testing. In addition, the rental pump was delivered from California and arrived without the proper adapter to connect the suction hose. Fortunately, an NDOT engineer found the correct adapter at a local construction site on an impromptu scouting trip, which saved a half-day of testing. The hydraulics team made a note to purchase a spare adapter to prevent future delays in a similar scenario. After mounting the adapter to the suction hose, the hydraulics team finished assembling the remaining equipment, including the linear drive, water tank, hoses, piping, and laptop. Having previously augered to a depth of 13 ft, the drill team lowered in the casing and pushed the Shelby tube 13 inches into the clay. The hydraulics team inserted the erosion head, connected all the equipment, and began the first test.

RESULTS

Over the course of the testing, the hydraulics team collected more than 3 h of erosion data, captured in five separate test runs of 20–75 min. The hydraulics team tested almost 4 ft of soil in 2 boreholes with 11 flow rates ranging from 0.139–0.281 ft^3/s.

From the data, FHWA identified 13 different segments and extracted erosion rates using a best-fit line through each dataset. The corresponding mean flow rates were also



The ISTD equipment assembled in front of the drill rig.

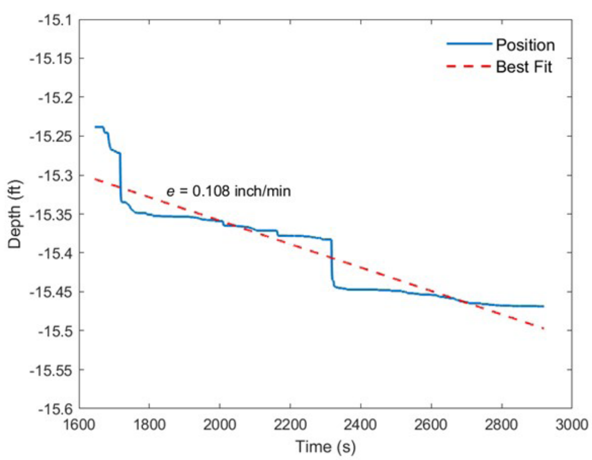
Source: FHWA

calculated for each segment. The clay at this site tended to erode in jumps, and on two occasions, a large segment of clay spanning the entire width of the tube broke off, driving all the sensors to nearly zero. These segments eventually disintegrated and washed out but did affect the data collection. The 13 data points are detailed in the Summary of Results table. The erosion rates are plotted against flow rates that 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, the ISTD demonstration revealed that this location could potentially have a clay layer with significant erosion resistance. However, additional testing would be needed to confirm that result and produce more consistent data.

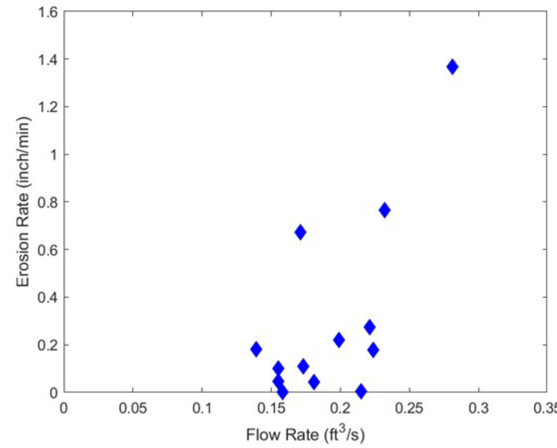
Summary of Results

Depth (ft)	Duration (min)	Flow Rate (ft^3/s)	Erosion Rate (inch/min)
12.55	11:42	0.215	0.004
12.80	13:05	0.232	0.766
13.37	0:55	0.281	1.369
12.97	11:40	0.224	0.177
13.40	6:15	0.158	0.001
13.44	28:45	0.155	0.100
13.75	13:05	0.181	0.042
14.06	11:30	0.171	0.673
15.10	12:50	0.139	0.180
15.23	2:15	0.155	0.045
15.24	21:15	0.173	0.108
15.47	12:25	0.199	0.220
15.92	5:10	0.221	0.274



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 Lovelock 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)	14.5–17
Water content (%)	35
Liquid limit (%)	43
Plasticity index (%)	19
Clay fraction (%)	52
Percent fines (%)	96
Soil classification (USCS)	CL
Soil classification (AASHTO)	A-7-6(21)
Unconfined compressive strength (psi)	5.71

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://transportation.org/design/wp-content/uploads/sites/31/2023/05/Hydrolink-Issue-16.pdf

NextScour Journal Paper:
https://doi.org/10.1680/jfoen.20.00017

For additional information, please contact:

Daniel Alzamora
Senior Geotechnical Engineer
FHWA Resource Center
720-963-3214
daniel.alzamora@dot.gov

James Pagenkopf
Research Hydraulic Engineer
FHWA Hydraulics Laboratory
202-493-7080
james.pagenkopf@dot.gov

U.S. Department of Transportation
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https://highways.dot.gov/laboratories/hydraulics-research-laboratory/hydraulics-research-laboratory-overview

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