In-Situ Scour Testing Device (ISTD), State Demonstrations of Field Soil Tests, Gulf Islands National Seashore, MS

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.

Hydraulics team assembling ISTD equipment at Gulf Islands National Seashore.

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 ISTD demonstration, hosted by Eastern Federal Lands (EFL) Highway Division, occurred in the Gulf Islands National Seashore National Park near Biloxi, MS. The main road in the park features a 250-foot-long elevated road embankment that carries it across a salt marsh on the way to the park's visitor center. EFL is exploring replacing the existing culvert in the embankment and constructing a parallel bike and pedestrian bridge across the marsh.

The subsurface soil profile of the site was determined from boring logs taken in September 2017. The upper layers of the soil contained very loose to medium-dense, gray, silty sand with traces of clay. Starting at 20 ft, the soil had a layer of soft, gray, silty clay with traces of sand, which was the targeted testing layer for the ISTD. This silty clay layer had a standard penetration test (SPT) N-value of 4 or less, which was softer than any soils previously tested with the ISTD.

TEST PROCEDURE

The demonstration took place on Wednesday, June 13, 2018. The drill crew drilled to a depth of 22.5 ft and retrieved a 2-foot-long soil sample to verify the soil properties before conducting the ISTD test. The crew then augered to a depth of 24.5 ft and the hydraulics team assembled the ISTD equipment, including the hoses, water tank, pump, piping, control box, and laptop. A Shelby tube was mounted to a series of casing segments and lowered into the borehole. Once the tube was resting on the soil surface, it was then pushed 14 inches into the clay, and the advanced linear drive was mounted on top. The erosion head was then lowered into the casings to prepare for the erosion test.

The advanced linear drive mounted on steel casings in front of the drill rig.

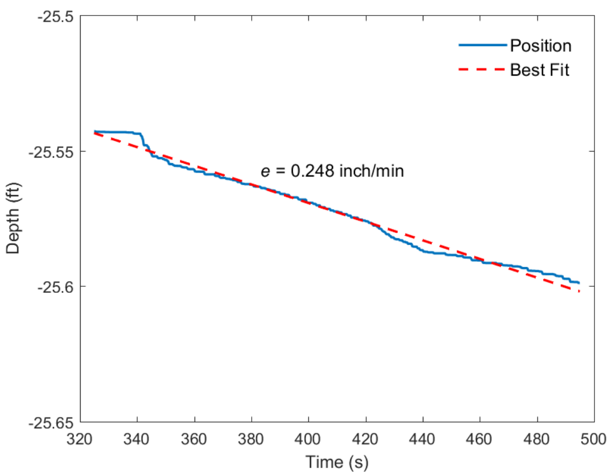
RESULTS

Over the course of the day, the hydraulics team collected a total of 60 min of erosion data, captured in four separate test runs ranging from 10 to 18 min per run. They tested roughly 35 inches of soil with seven different flow rates ranging from 0.072 to 0.247 ft^3/s.

The test site featured very soft, sandy clay that was easily eroded by the ISTD. On multiple occasions, the erosion head could not settle into the control loop, which maintains a constant gap during erosion testing. Unfortunately, large quantities of data had to be discarded because either the soil material washed out too quickly or the erosion head got stuck in the Shelby tube.

From the remaining data, four short, continuous segments, each corresponding to a specific flow rate, were identified as viable for extracting an erosion rate. A best-fit line was calculated through each segment to determine the resulting erosion rate. The four data points are detailed in the Summary of Results table. Ideally, a nonlinear power curve can be fitted to the data to determine the critical flow rate of the soil, but the range of data was too small to confidently extrapolate a curve. Additionally, these data points were considered low quality due to their duration, which was much shorter than the targeted value of 10 to 20 min for each segment.

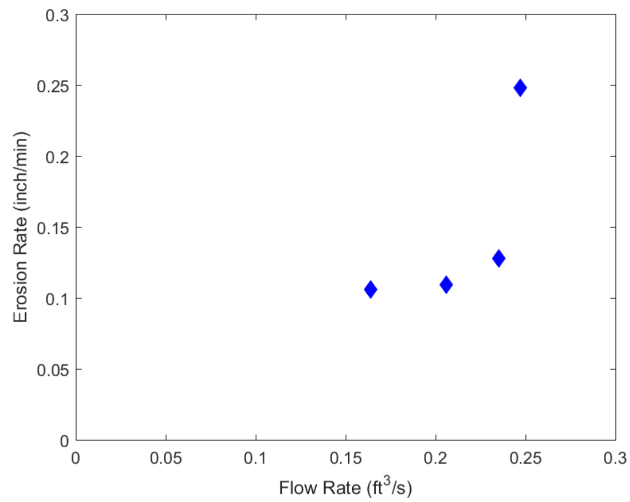
The ISTD test revealed that the soil at this site was highly erodible, and no significant soil-resistance layer was found.



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)**
25.27	3:12	0.164	0.106
25.44	2:15	0.235	0.128
25.54	2:50	0.247	0.248
27.09	3:40	0.206	0.109



Source: FHWA.

Erosion rate versus flow rate for the Gulf Islands ISTD demonstration. With more data points, a nonlinear fitted power curve could be used to extract the critical flow rate where erosion begins.

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

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