# In-Situ Scour Testing Device (ISTD), State Demonstrations of Field Soil Tests, Grifton, NC

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

## BACKGROUND

The North Carolina Department of Transportation (NCDOT) hosted the eighth ISTD field demonstration on State Route 11 at the bridge over Contentnea Creek, located 1 mi west of the town of Grifton, NC. The demonstration was held in the median, north of the creek. The bridge was not scheduled for replacement, but NCDOT was interested in the technology, and the site was easily accessible.

The subsurface soil profile was initially determined from boring logs taken in 1993 for a scour investigation that showed a layer of clay among mostly silty sand at the site. A week before the demonstration, a cone penetration test (CPT) was conducted at the site to obtain detailed information about the soil profile. The CPT confirmed that beneath the sand was a layer of clay silt and silty clays beginning around 24 ft and continuing to 37 ft. The day before the demonstration, the drillers performed a continuous standard penetration test (SPT) between 23 and 34.5 ft and found a continuous layer of gray, silty, micaceous clay with blow counts (i.e. N-values) ranging from 9 to 13. The layer starting around 23 ft was chosen as the targeted testing layer for the ISTD.

## TEST PROCEDURE

The demonstration took place on March 20, 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. Unfortunately, unforeseen events, including equipment malfunctioning on the drill rig and issues with the commercial pump delivery, caused lengthy delays on the first day. The drill team was able to pull some samples to return to the laboratory, but most of the day was lost. After an early start on the second day, the drillers were quickly able to auger to a depth of 25 ft, then lowered in the casing and Shelby tube. Despite the stiff clay, the drillers successfully pushed the Shelby tube 14 inches with full recovery. The hydraulics team then assembled the remaining equipment, including the linear drive, water tank, piping, hoses, and laptop, and began the first test.

## RESULTS

Over the course of the testing, the hydraulics team collected almost 4 h of erosion data, captured in a single test run. They tested almost 1 ft of soil with eight different flow rates ranging from 0.174 to 0.424 $ft^3/s$.

The clay at this site was very stiff compared to the previous sites, which resulted in extremely slow erosion. The Shelby tube was only pushed once, and in 4 h of testing, less than

*The ISTD equipment assembled in front of the drill rig.*

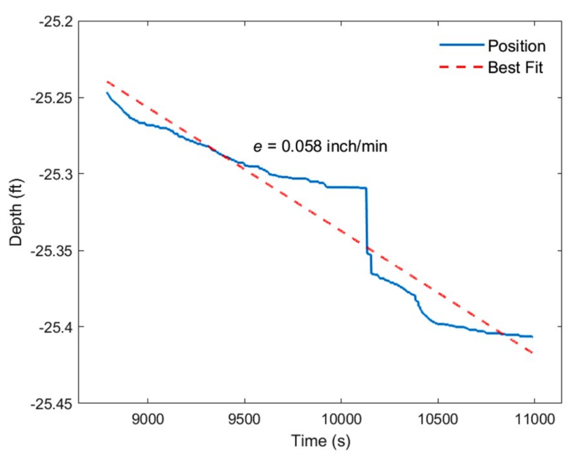
*Source: FHWA.*

9 inches of soil was eroded from the 14-inch sample. Due to deteriorating weather conditions, more testing was not possible. From the data, eight 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 eight 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 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.

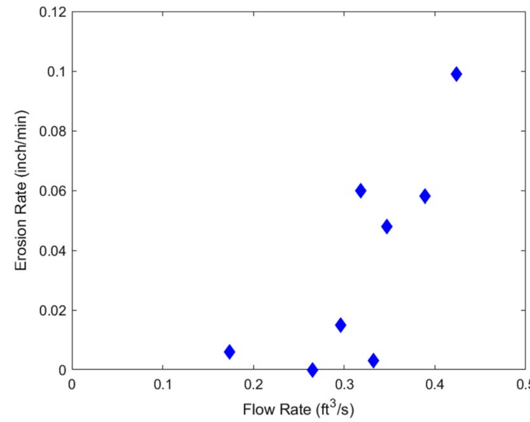
**Summary of Results**

| Depth (ft) | Duration (min) | Flow Rate ($ft^3/s$) | Erosion Rate (inch/min) |
|---|---|---|---|
| 24.79 | 19:10 | 0.174 | 0.006 |
| 24.80 | 29:30 | 0.296 | 0.015 |
| 24.84 | 48:20 | 0.347 | 0.048 |
| 25.09 | 36:50 | 0.318 | 0.060 |
| 25.25 | 36:40 | 0.389 | 0.058 |
| 25.41 | 21:20 | 0.265 | 0.000 |
| 25.41 | 26:25 | 0.332 | 0.003 |
| 25.42 | 14:30 | 0.424 | 0.099 |




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 Grifton 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) | 26.1–28.7 |
| Water content (%) | 33 |
| Liquid limit (%) | 76 |
| Plasticity index (%) | 50 |
| Clay fraction (%) | 57 |
| Percent fines (%) | 91 |
| Soil classification (USCS) | CH |
| Soil classification (AASHTO) | A-7-6(52) |
| Unconfined compressive strength (psi) | 60.44 |

*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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U.S. Department of Transportation
**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, Grifton, NC* (Washington, DC: 2022) https://doi.org/10.21949/1521951.