Project Summary

Texas Department of Transportation

0-5825: Influence of Verification Cores on Point Bearing Capacity of Drilled Shafts

Background

Verification cores are important tools in ascertaining the condition and properties of the bedrock at the bottom of drilled shafts. However, the influence of verification core holes on the point bearing capacity of drilled shafts is unknown. This research addressed two key issues:

1) Will verification core holes fill during concrete backfilling? If so, what are the mechanical properties of the filling material? What is the effect of these properties on the point bearing capacity of the drilled shaft?
2) When drilling in materials such as shales that are susceptible to degradation, does this degradation occur, and if so, does it affect point-bearing capacity of the drilled shaft?

What the Researchers Did

The work plan, completed in two years, comprised eight tasks as follows:

1) review of the existing literature,
2) lab tests and scale lab tests of the core samples and core holes at the bottom of the shaft,
3) large degradation tests on moisture sensitive materials,
4) tests on concrete filling,
5) numerical modeling of the detrimental effect of coring,
6) remedial actions that could be taken to lessen the impact of verification holes,
7) report writing, and
8) meetings with the project monitoring committee.

Tasks 1 through 4 were meant to provide the data to proceed with numerical modeling of the detrimental effect of coring at the base of a drilled shaft.

Research Performed by:

Center for Transportation Research (CTR), The University of Texas at Austin

Research Supervisor:
Fulvio Tonon, CTR

Researchers:
David W. Fowler, CTR
Robert B. Gilbert, CTR
Hugh T. Kelly, CTR
Anay P. Raibagkar, CTR
Heejung Youn, CTR

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What They Found

Concrete flow into verification core holes: In order to simulate the flow of concrete into the verification core hole, the drilled shaft and core hole were replicated in a specially built steel apparatus above ground. The apparatus consisted of a steel pipe 3 feet in diameter and 13 feet in length resting vertically on a steel frame. The bottom of the steel pipe was closed with a steel lid that could be used to attach a 6-inch or 12-inch diameter clear PVC (Polyvinyl Chloride) pipe 5 feet in length, and concentric to the shaft, used to simulate the verification core hole. Concrete was poured from a concrete pump with a 30-foot, 70-foot, and 100-foot drop in both dry and wet conditions.

1) In dry conditions, the verification core hole always completely filled with concrete. In wet conditions, the verification core hole was completely filled, however, the quality and type of infill material was dependent on the method of concrete delivery (see 3) and 4) below).
2) In dry conditions, the compressive strength of the concrete in the core hole matched the concrete strength of the drilled shaft. The concrete recovered in the 12-inch core hole was better consolidated and had a higher compressive strength than that for the 6-inch core hole.
3) Under wet conditions, the verification core holes fill with concrete only if the tremie or pump pipe used to place the concrete is inserted to the bottom of the core hole.
4) Under wet conditions, if the tremie or pump pipe used for placing the concrete is not at the bottom of the core hole the bottom half of the core hole fills with a non-cemented gravel-sand mixture ($\varphi = 52°$), while the upper half of the core hole fills with weakly cemented material ($V_p = 2000$ fps).

Degradation of clay shales: The degraded engineering properties of clay shales were estimated from laboratory tests such as multi-stage triaxial tests (after one cycle of drying and wetting), slake durability tests, and jar slake tests.
1) The principal stress difference of Del Rio Clay and Eagle Ford Shale is not affected by drying-duration but is related to water content.
2) The principal stress difference of Taylor Marl and Navarro Shale decreases considerably as drying-duration increases.
3) The elastic modulus of all four clay shales drops significantly when clay shales are dried and wetted.
4) The slake durability index (SDI) tends to increase at low water content.
5) The engineering properties of Edwards Limestone and Austin Chalk are not affected by one cycle of drying and wetting.
6) Severe slaking of Del Rio Clay, Taylor Marl, and Navarro Shale (Eagle Ford Shale) occurs after 4 (8) hours of air drying and wetting.

From full-scale degradation tests, the maximum thickness of the degraded zone around the verification core hole was found to be equal to 12.7 cm (5 inches).

What This Means

Overall effect of verification hole on tip capacity: The effect of the verification core hole on the point bearing capacity of drilled shafts was investigated using the PLAXIS finite element method (FEM) software. The load-displacement curves at the shaft base were created from PLAXIS analyses, and the point bearing capacity was obtained at 5%D and 10%D displacement from the load-displacement curves:
1) When shales are first dried and then rewetted and concrete is poured in the wet, the verification core reduces the tip capacity by a maximum of 10% (14% for Taylor Marl).
2) In all other cases, the verification core does not decrease the tip capacity.

TxDOT should consider modifying the construction practice in shales where verification cores are used by limiting the stand up time between completion of the drilled shaft and placement of concrete. If this modification is not adopted, TxDOT should consider a reduction in point bearing capacity.

For More Information:
Research Engineer - German Claros, TxDOT, 512-465-7403
Project Director - Marcus Galvan, TxDOT, 512-416-2224
Research Supervisor - Fulvio Tonon, CTR, 512-471-4929

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Texas Department of Transportation
Research and Technology Implementation Office
P.O. Box 5080
Austin, Texas 78763-5080
512-465-7403

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