Correlation between Texas Cone Penetration (TCP) Values and Compressive Strength of Clay Shale in Texas

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Abstract

Designing of deep foundations, ACIP piles and similar foundations in clay shale require knowledge of the compressive strength and modulus of the rock. However, jointing at many sites prohibits the recovery of samples of sufficient length and integrity to test rock cores in either unconfined or triaxial compression. Since design procedures require values of compressive strength, testing methods must be employed to estimate the compressive strength of the rock. An testing method considered here is the TxDOT dynamic penetrometer test (in which a 76-mm-diameter solid steel cone is driven into rock at the bottom of a borehole in much the same way as a split spoon is driven during testing of a standard penetration test in cohesionless soil). A correlation between TCP and compression strengths of clay shale cores from these formations is provided in the paper. The correlations are formation-dependent, most likely through the degree of cementation present in the geomaterial. The reliable correlation was between compressive strength and the TxDOT cone penetration test, although separate correlations were observed in limestone and in clay shale.

1. Introduction

The design of drilled foundations, footings and rafts in soft rock requires quantification of the strength properties of the rock in order to be rational. When rocks are massive, cores can be recovered and tested in the laboratory to ascertain compressive strength. However, at many locations rock cores are recovered in fragments if the soft rock has a strong closed joint structure or contains open joints or joints with gouge. The core fragments are therefore often too short for the performance of compression tests. When such conditions occur, the foundation engineer is faced with the question of how to quantify geomaterial strength, which can conceivably be accomplished by performing *in situ* tests.

Texas cone penetrometer test, which is a dynamic penetration test that is used routinely for foundation design by the Texas Department of Transportation, was quantified with the compressive strength, q_u, of soft rock by direct comparison of the results of such alternative test with compression tests in two soft rock formations in Texas.

2. Objective

The objective of this research was to develop a correlation between TCP and q_u for clay shale.

3. Sampling and Testing

Clay shale samples were collected from Dallas sites. Two continuous cores were recovered at each of the test sites. A third core hole was made in which TxDOT cone penetration tests were conducted. Cores were recovered with a double-walled core barrel (52.3 mm ID). In the laboratory, the core segments were trimmed and subjected to the compression testing [UU triaxial testing for samples of clay shale; unconfined testing for samples of limestone]. TxDOT cone penetrometer tests are peformed as illustrated in the schematic in Fig. 1. The penetrometer is a steel cone. It is driven with approximately the same energy per blow as is used in the standard penetration test. The solid cone is used in preference to the split spoon because of its robustness.

After seating, the penetrometer is struck 100 blows, and the penetration is recorded. One such reading was made every 0.76 m of depth for this study.

4. Test Results

The best estimates of the variation of soft rock strength with depth at the test sites are considered to be the profiles of q_u for purposes of this paper. The mean compressive strengths range from about 1500 kPa at Hampton Road and Lone Star Park to 2000 kPa at Denton Tap and Belt Line Road (clay shale). At the Denton Tap and Lone Star Park sites, some carbonate seams were visible in the cores, which yielded much higher compressive strengths than cores without visible carbonate cementation.

A correlation between the TCP (mm / 100 blows) and q_u (kPa) was made for clay shale as shown in Fig. 2 and equations of the correlations are as follows;

q_u (kPa) = 6331.2 [TCP (mm)]$^{-0.1}$ Clay shale with Carbonate Cementation

q_u (kPa) = 7500.2 [TCP (mm)]$^{-0.4}$ for Uncemented Clay Shale with Occasional Sandstone Seams

5. Conclusions

A nonlinear relationship between TCP and q_u for clay shale with the presence of cementations has been developed.

7. Acknowledgments

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8. References

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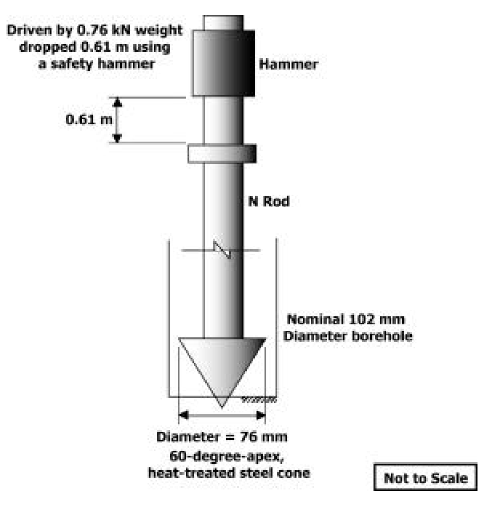

Fig. 1. The Texas Cone Penetrometer

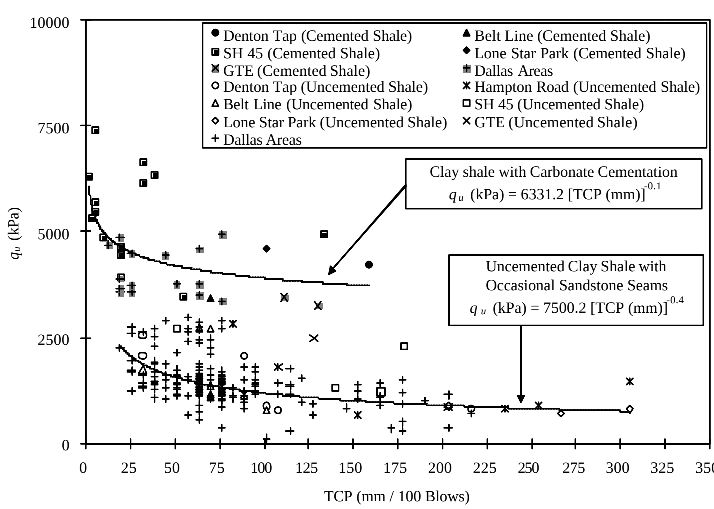

Fig. 2. Correlations between TCP and q_u of Clay Shale