Texas Cone Penetrometer (TCP) N-value and Shear Strength of Houston CL Soils

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Abstract: Based on limited data collected from Houston, Texas on CL soils up to a depth of 25 feet, the relationship used by the Texas Department of Transportation for predicting the shear strength from the Texas Cone Penetration (TCP) N-value was investigated. The depth effect may have to be considered in predicting the shear strength of CL soils from TCP values.

1. Introduction

In foundation design, it is necessary to know the shear strength of soil. The Texas Department of Transportation (TxDOT) currently uses the Texas Cone Penetrometer (TCP) test to determine the shear strength and point bearing capacity for various types of soils (TxDOT (2000)). It is of interest to verify these relationships for shear strength of CL soils in Houston, Texas using recently collected data.

Researchers at the University of Houston, University of Texas at Arlington and Lamar University are developing a database on TCP and soil properties based on past 10 years of information collected by TxDOT. The information used in this abstract is only a subset of the database.

2. Objectives

The objective of this study was to verify the relationship used by TxDOT to determine the shear strength of CL soils in Houston, Texas and to consider the effect of depth (up to 25 feet) on the predictions.

3. Evaluation of Relationships

The data base was mined to collect data on CL soils in Houston area between 10 and 25 feet depth. Total of 167 data were used in these analyses. The top 10 feet of data was neglected because it is in the active zone and maximum depth was limited to 25 feet because it will be in the Beaumont formation and the amount of data available on CL soils decreased with depth.

Case 1: Once the soil is classified as CL soil, the following relationship can be used to determine the shear strength (c_u) of CL soils (TxDOT (2000)):

$$C_u = 2\left(N_{TCP}/60\right) tsf = N_{TCP}/30\, tsf = (0.463)\cdot N_{TCP}\, psi \qquad \text{--(1)}$$

In this linear relationship, it is assumed that all the factors that influence N_{TCP} will directly influence the shear strength of CL soils.

Case 2: In cohesive soils, the bearing capacity formula for deep foundations is as follows:

$$q_{ult} = cN_c + qN_q \qquad \text{--(2)}$$

Where N_c *and* N_q are called the bearing capacity factors and q is the overburden pressure (unit weight x height) $(=\gamma h)$ .Since, during driving undrained condition in the clay is assumed and hence $\phi = 0$, $c = c_u\ (>0)$ and $N_q = 1$. The ultimate capacity (Point Bearing Chart, TxDOT (2000)) for CL soils can be estimated as follows:

$$q_{ult} = 2 * Pb = 2\left(N_{TCP}/16.6\right) tsf = N_{TCP}/8.3\, tsf \ for < 100\, blows/ft \qquad \text{-------------------------------------(3)}$$

Substituting Eqn. (3) (convert to psi) into Eqn (2), will result in the relationship for c_u:

$$c_u = \frac{1.6733}{N_c^{TCP}(h)} N_{TCP} - \frac{q(h)}{N_c^{TCP}(h)} \qquad \text{-- (4)}$$

As compared to Eqn (1), Eqn. (4) has the depth effect. Also note that $c_u > 0$ for Eqn. (4) to be applicable for CL soils.

4. Analyses and Results

Total of 167 data on CL soils were used in this analyses to compare the predictions of Eqn (1) and (4). Soil unit weight of 127 pcf (0.073 pci) was used in the analyses. The predictions are compared in Fig. 1 and 2 for depths of 10 and 25 feet. At 10 feet depth the predictions were very close, but it was not the case at 25 feet. Linear regression analysis was performed to determine the parameter N_c (**Case 2**) at various depths and the variation with depth is shown in Fig. 3 and can be represented as follows:

$$N_c^{TCP}(h) = 0.26 \times h + 0.5 \;\; (10 ft \le h \le 25 ft) \qquad \text{--(5)}$$

Standard error calculations showed that, compared to Eqn. (1), Eqn (4) better predicted the shear strength of CL soils with depth.

5. Conclusions

Based on very limited data and analyses, it can be concluded that the depth effect may have to be considered in predicting the shear strength of CL soils using the TCP. This finding is limited and cannot be extended to other soil types or locations without further detailed investigation.

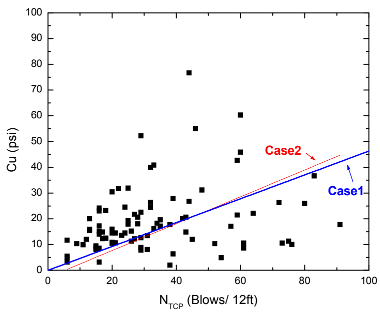

Figure 1 Correlation between Shear Strength **(**c_u**) and *the TCP N-value at 10 ft***

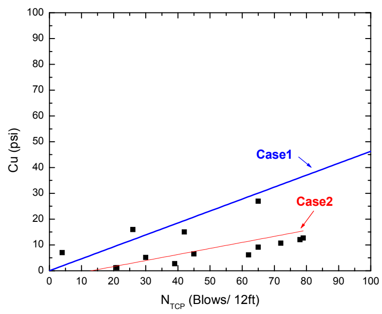

Figure 2 Correlation between Shear Strength **(**c_u**) and *the TCP N-value at 25 ft***

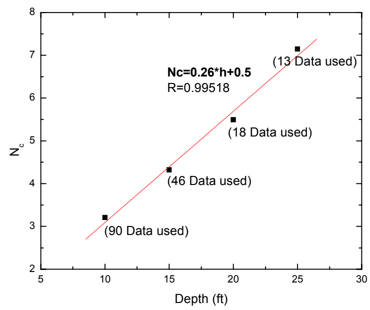

Figure 3. TCP Parameter Relation N_c ***versus Depth***

6. Acknowledgement:

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Table 1 Standard error for Case1 and Case 2 at various depth

Depth	Case 1 Standard Error	Case 2 Standard Error
10	14.055	14.784
15	12.790	12.137
20	16.640	11.433
25	17.262	7.493

7. References

[1] TxDOT Geotechnical Manual (2000) - Texas Department of Transportation (TxDOT), Austin, Texas.