Depth Effects and Texas Cone Penetrometer

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Abstract: Influence of depth on the undrained shear strength of clay soils and Texas Cone Penetrometer (TCP) blow count was investigated. Over 3500 data collected during the past decade in the Houston area was used in this study (1 and 2). Based on the analysis, a new relationship was developed to relate the TCP to undrained shear strength of soil.

1 Introduction

The variation in soil properties can be attributed to various geologic, environmental, mineralogical, and chemical processes that take place during the formation of soil deposits (3). Hence, the use of generalized correlations to predict soil properties like shear strength for soils of all geologic formations is not always possible and should be dealt with caution. Where applicable, the use of local calibrations is preferred over broader and generalized correlations. For this reason, in the present research, an attempt has been made to develop new correlations considering depth effect on N_{TCP} and S_u for Houston area soils.

2 Objectives

The objective of this study was to investigate the depth effect on the undrained shear strength of soil and TCP blow count and to develop a new correlations predicting undrained shear strength (S_u) from TCP blow count for soils in Houston area.

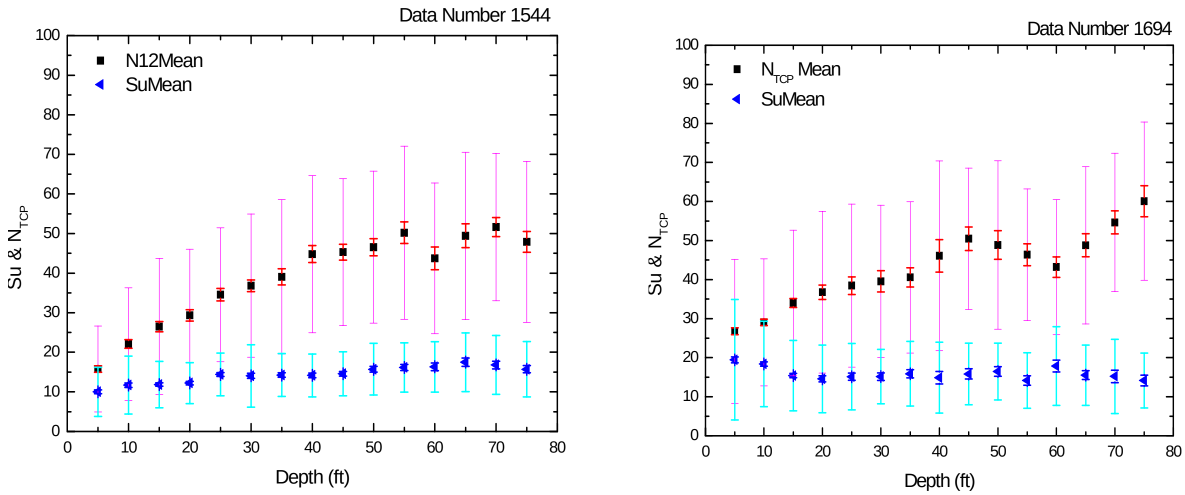
3 Model Analysis (Depth Effect)

The data set of N_{TCP} and S_u at 5 ft. intervals up to 75 ft. were collected for this analysis. At 5 ft. intervals, the mean and two standard deviation values of the N_{TCP} and S_u for CL and CH soils were determined. The relationships between mean N_{TCP} ($\bar{N}_{TCP}$) and mean S_u ($\bar{S}_u$) with depth (Z) were investigated.

4 Data Analysis and Results

The variation of mean, two standard deviation values and standard error of the mean of the N_{TCP} and S_u for the Houston CH and CL soils with depth are shown in Fig. 1. Based on the slope of the linear relationship, $\bar{N}_{TCP}$ showed greater dependence on depth than $\bar{S}_u$. Based on the trends observed with the available data, linear relationships were used to relate the variations with depth (Table 1 and 2).

The prediction of the new models is compared to current TxDOT relationships (M1) in Fig. 2 and the results are summarized in Table 3. New model (M2) had the lowest standard error of 0.67 and 1.64 for CH and CL soils respectively.



(a) CH Soils (b) CL Soils

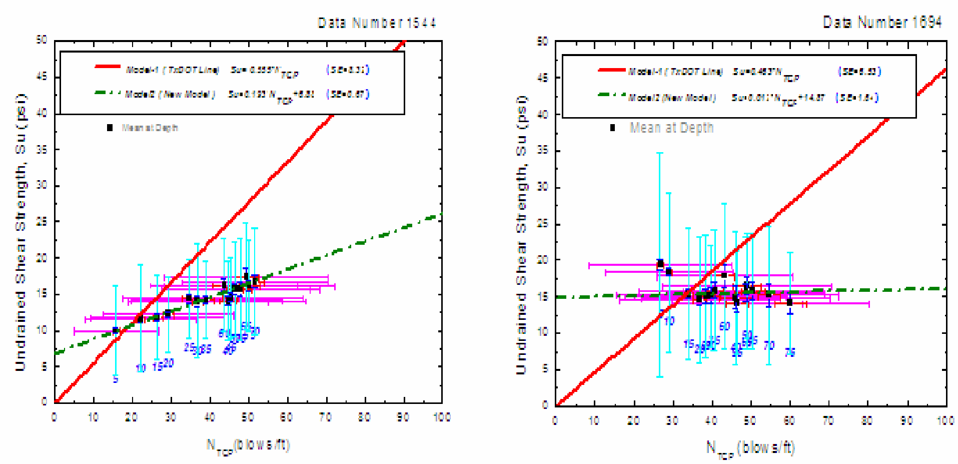
Figure 1 Relationship between mean N_{TCP} and mean S_u for the Houston CH and CL Soils

Table 1 Concept of New Model

$\overline{N}_{TCP}$ *and* $\overline{S}_u$ *vs. depth (Z)*	$\overline{N}_{TCP}$ *vs.* $\overline{S}_u$ (M2)	*Where,*
$\overline{S}_u = a \cdot Z + b$ $\overline{N}_{TCP} = c \cdot Z + d$	$\overline{S}_u = \frac{a}{c} \cdot \overline{N}_{TCP} + (b - \frac{a}{c} \cdot d)$	$\overline{S}_u$ *: Mean of undrained shear strength (psi)* $\overline{N}_{TCP}$ *: Mean of TCP blow counts (blows/ft)* Z *: Depth in feet*

Table 2 Model Study

	CH Soil	*CL Soil*
$\overline{S}_u$ *vs. Depth*	$\overline{S}_u = 0.089 \cdot Z + 10.813$ (R=0.93)	$\overline{S}_u = 0.004 \cdot Z + 15.219$ (R=0.08)
$\overline{N}_{TCP}$ *vs. Depth*	$\overline{N}_{TCP} = 0.462 \cdot Z + 20.411$ (R=0.93)	$\overline{N}_{TCP} = 0.344 \cdot Z + 29.750$ (R=0.90)
$\overline{S}_u$ vs. $\overline{N}_{TCP}$ M1 (TxDOT)	$\overline{S}_u = 0.555 \cdot \overline{N}_{TCP} = \frac{1.425}{N_c}\overline{N}_{TCP}\ psi = \frac{\overline{N}_{TCP}}{25}\ tsf$ $(N_c = 2.567)$	$\overline{S}_u = 0.463 \cdot \overline{N}_{TCP} = \frac{1.673}{N_c}\overline{N}_{TCP}\ psi = \frac{\overline{N}_{TCP}}{30}\ tsf$ $(N_c = 3.613)$
$\overline{S}_u$ vs. $\overline{N}_{TCP}$ M2 (New Model)	$\overline{S}_u = 0.193 \cdot \overline{N}_{TCP} + 6.881\ psi = 0.014 \cdot \overline{N}_{TCP} + 0.495\ tsf$	$\overline{S}_u = 0.012 \cdot \overline{N}_{TCP} + 14.873\ psi = 0.0009 \cdot \overline{N}_{TCP} + 1.071\ tsf$



(a) CH Soils (b) CL Soils

Figure 2 Variation of the $\overline{N}_{TCP}$ and $\overline{S}_u$ with depth for the Houston CH and CL Soils

Table 3 Model Comparisons for Houston Soil Data

	CH Soil		CL Soil	
	M1	M2	M1	M2
Total Data Set	1554		1694	
Total Mean Data Set	15		15	
Standard Error	8.32	0.67	6.53	1.64
Amount of Data Set Over Predicted	14	9	13	7
Percentage of Data Set Over Predicted (%)	93	60	87	47

5 Conclusions

The TCP blow count (N_{TCP}) showed greater variation with depth (Z) than the undrained shear strength (S_u) of soil. A model has been developed to predict the mean undrained shear strength ($\bar{S}_u$) from mean TCP blow count ($\bar{N}_{TCP}$).

6 Acknowledgement

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7 References

[1] Kim, Minsu and Vipulanandan, C. (2005), “Texas Cone Penetrometer (TCP) N-value and Shear Strength of Houston CL Soils”, CIGMAT Conference 2005, Houston, TX.

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