Estimation of drained shear strength parameters (c’ and f’) of Beaumont Over-Consolidated Clay from piezocone data (CPTU).

E.A. Sellountou, C. Vipulanandan, and M.W. O’ Neill

CIGMAT-Department of Civil and Environmental Engineering
University of Houston, Houston, TX77204-4003
Phone: 713-743-4291 email: eselloun@bayou.uh.edu

Abstract

In this study, a Cone Penetration Test with Pore Pressure Measurements (CPTU) was performed at Beaumont over-consolidated (OC) clay. CPTU data are used for the determination of effective strength parameters of OC Beaumont clay. The effective strength parameters obtained from CPTU interpretations are compared with effective strength parameters measured from conventional triaxial tests on the same soil. CPTU interpretations gave reasonable estimations of effective strength parameters of over-consolidated clay soils.

1. Introduction

The effective shear strength parameters c’, ϕ’, are important factors of the geotechnical design. Consolidated Drained (CD) triaxial tests or Consolidated Undrained with Pore Pressure Measurements triaxial tests (CU) are common methods for their experimental estimation. Today it is possible to estimate these parameters from interpretation of Piezocone data. The use of Cone Penetration Test with Pore Pressure Measurements (CPTU), allowed pore pressures (u), developed during penetration, to be measured together with the cone end resistance (q_c) and frictional resistance (f_s) of soil. Therefore, attempts of applying an effective stress interpretation of CPTU data have been made, and methods for the estimation of effective strength parameters from CPTU tests have been proposed [1,2].

The CPTU test is an in-situ test, which in contrary to the triaxial tests, provide with **continuous** measurements of parameters (q_c, f_s, u), **rapidly** and without the need of boreholes.

However, the interpretation of piezocone data in order to estimate effective strength parameters of fine grained soils is questionable especially for over-consolidated (OC) clays, where the distribution of total stresses and pore pressures around the cone is complex and have not been adequately modeled yet [3].

2. Objective

The objective of this study was to determine the shear strength parameters of Beaumont OC clay using CPTU test data.

3. Description

According to the methods [1,2] attraction “a” needs to be calculated first. Figure 1 illustrates the determination of attraction “a”, from the plot $q_n=q_t-p$(corrected end bearing-total overburden) vs. p’ (effective overburden). Attraction “a” is the negative intercept of axis p’.

The calculation of two dimensionless parameters N_m(cone resistance number) and B_q(pore pressure ratio) that involves the attraction "a" follows. Parameters N_m and B_q are calculated as shown below:

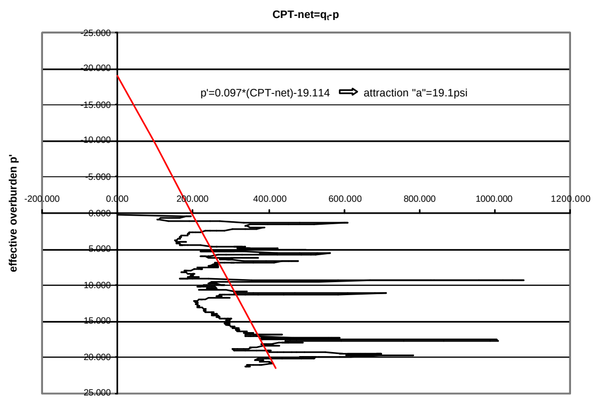

Figure 1 Evaluation of attraction "a" from data of a CPTU test on Beaumont OC Clay

$$N_m = \frac{q_t - p}{p' + a}$$

$q_t = q_c + (1 - \text{a})u$, (where q_c = end cone resistance, a = effective area ratio, and u = total pore pressure)

p = total overburden

p' = effective overburden

a = attraction

$$B_q = \frac{u - u_o}{q_t - p}$$

u, q_t, p = as previously

u_o = initial in-situ steady state pore pressure

An interpretation diagram between tanϕ', and dimensionless parameters N_m and B_q is needed for the determination of ϕ'. This diagram differs for different types of soils.

Figure 2 shows an interpretation diagram constructed for Beaumont Clay, which is stiff OC clay and for which β-value (plastification angle) was assumed to be equal to -15^o (β-value is an indication of the shape of the plastified zone in an idealized failure pattern around the advancing cone in various soil types; e.g. for OC clays $-20^o<\beta<-10^o$).

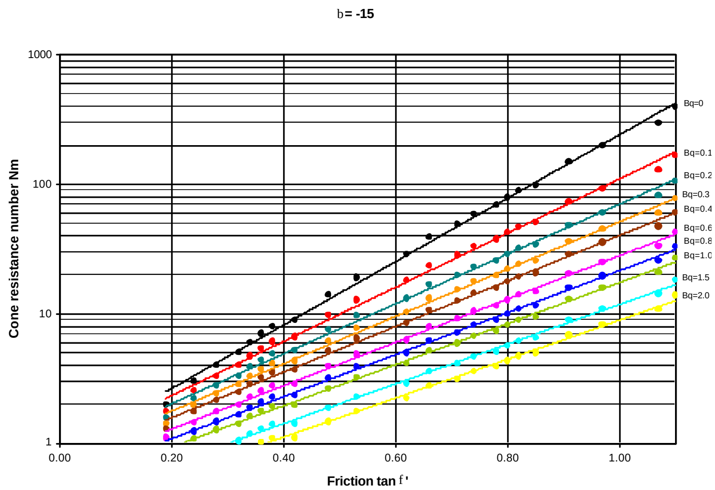

Figure 2: Interpretation diagram for determination of tan f ’ for b =-15°

A continuous calculation of N_m and B_q can be made along the entire depth. This will provide a continuous plot of effective friction angle vs. depth with the aid of Figure 2. Finally, the effective cohesion c’ can be calculated by c’=a*tanϕ’ continuously along the entire depth. In this study the average value of c’ and ϕ’ from 0-42ft is evaluated, using piezocone data, in order to be compared with the results from triaxial tests.

4. Results

Using the data of a CPTU test conducted in Beaumont OC clay, attraction “a” and values of effective friction angle ϕ’ and effective cohesion c’, were calculated from 0-42ft where stiff OC clay was encountered. The results are as follows:
Attraction “a”=19.1psi (Figure 1)
Average value of ϕ’ and c’ for a depth between 0 to 42 ft were:
$\phi'_{aver}=23.6^o$ (Figure 2) and $c'_{aver}=(a\tan\phi')_{aver}=8.3$psi

Conventional Triaxial tests (CU) were performed using soil samples of the same soil from depths of 8ft to 38 ft. The results are presented in Table 1.

Table 1 Results from 9 CU triaxial tests with pore pressure measurements in Beaumont OC clay samples

	f' (°)	c' (psi)	Confining stresses (psi)
	25.9	2.1	10, 32, 42
	31.3	1.7	18, 29, 36
	15.1	14.7	26, 36, 56
average	24.1	6.2	

5. Conclusions

The use of piezocone data (CPTU) gave reasonable estimation of the effective strength parameters (c’ and ϕ’) of the Beaumont OC clay.

6. Acknowledgements

The CPTU test was supported by Mr. Kenneth T and this study was supported by Texas Department of Transportation (TXDOT).

References:

1. Senneset, K., Janbu, N., and Svang G. (1982). "Strength and deformation parameters from Cone penetration tests" *Proc., 2nd European Symposium on Penetration Testing*, Amsterdam, 863-870.
2. Sandven, R., Senneset, K., and Janbu, N. (1988). "Interpretation of piezocone tests in Cohesive Soils", *International Symposium on Penetration Testing*, Balkema, Rotterdam, 939-953
3. Robertson, P., K., and Campanella R., G. (1983). "Interpretation of Cone Penetration Tests. Part II: Clay." *Canadian Geotechnical Journal*, Vol.20, 734-745