Statistical Assessment of Pile Capacity Prediction Using CPT

Aram M. Raheem, C. Vipulanandan and A. Ayoub
Center for Innovative Grouting Material and Technology (CIGMAT)
Department of Civil and Environmental Engineering
University of Houston, Houston, Texas 77204-4003
Tel: 713-822-3838: E-mail: engaram@yahoo.com

Abstract: In this study, five methods of predicting the pile capacity using the cone penetration test were compared using four statistical methods. The statistical methods were sensitive to the methods of pile capacity prediction and identified the best and worst prediction models.

1. Introduction

Several Methods have been used to estimate the axial capacity of piles in which cone penetration test, CPT, one of the popular in situ test methods. Cone penetration test has been used for more than 40 years and it basically depends on pushing a cone at the end of series of steel rods at a constant rate into the soil. The measurement of mobilized resistance to penetration in the soil is continuously monitored during the pushing of the cone and it includes two main records: resistance to penetration of the cone tip (q_c), and resistance of advancing the friction sleeve (f_s).

Four statistical methods have been used to assess five of the popular methods that are used to estimate the pile capacity through CPT in different soil conditions. In which, those methods were ranked according to their efficiency in estimating the capacity.

2. Objectives

The objective of this study was to investigate the effectiveness of predicting pile capacity using the CPT. The CPT predictions were statistically analyzed to rank based on the pile capacity.

3. Methods:

(a) CPT methods: Five CPT methods were mentioned with methodology of each of those methods can be seen in table (1).

Table 1. CPT methods for Pile Capacity Predictions

Method	Details
(1) Bustamante and Gianeeselli (1982) or LCPC	The shaft resistance and end bearing were obtained from empirical equations. Tip resistance was calculated based on the average of cone resistance over the influence zone extending 1.5 Dp above the pile tip and 1.5 Dp below the tip
(2) De Ruiterand Beringer (1979) method	Skin friction and end bearing was calculated based on undrained shear strength calculated from the cone tip resistance for clay.In sand, end bearing is calculated in the same range as the Schmertmann method, and skin friction was obtained by an empirical relationship with CPT values.
(3)CPTu method (Eslami and Fellenius 1997)	This method was developed based on the piezocone. The cone tip resistance is transferred to effective cone resistance by subtracting the measured pore pressure from the measured cone resistance. Tip resistance is calculated based on the average cone resistance over the influence zone of 2Dp to 8Dp above pile tip and 4Dp below the pile tip.
(4)Schmertmann (1978) method	Skin friction was calculated based on sleeve friction time reduction factor. Tip resistance is calculated based on the average cone resistance over the influence zone extending from 6 Dp to 8 Dp above the pile and 0.7Dp to 4Dp below the pile tip.
(5)Egyptian Code (2001)	This method is assumed that unit toe capacity depends on coefficient (α) which depends on the ratio of cone to pile diameter and other factors. It estimates the cone resistance over a length extends 6Dp above to 3Dp below the pile toe.

(b)Statistical assessment for CPT procedures: The CPT methods in Table 1 evaluated 32 full-scale concrete piles load tests that were obtained from literature and ranked through four statistical methods as Table 2.In which, the piles are varying in shape and their capacity ranges from 39.10 kPa-41500 kPa.

Table 2, Statistical assessment for CPT Methods

Method	Regression Analysis			Statistical Analysis		Cumulative Probability Function		Overall Evaluation	
	R^2	Equation between Qup, and Qum (MN)	r_1 rank	Mean of T	r_2 rank	T at P_{50}	r_3 rank	r_g gross rank	E
1	0.91	$Q_{up} = 0.68Q_{um} + 0.27$	1	0.90	1	0.85	1	3	1
2	0.54	$Q_{up} = 0.92Q_{um} + 0.77$	3	1.62	5	1.61	5	13	5
3	0.80	$Q_{up} = 1.04Q_{um} + 0.49$	2	1.40	4	1.31	4	10	3
4	0.39	$Q_{up} = 0.44Q_{um} + 0.95$	4	1.25	2	1.21	2	8	2
5	0.39	$Q_{up} = 0.67Q_{um} + 0.85$	5	1.30	3	1.30	3	11	4

Qup = predicted ultimate axial capacity, Qum=ultimate measured axial capacity.

4. Conclusions

Based on the statistical results, method (1) had the highest efficiency of predicating the pile capacity while the method (2) was the worst one due to wide range of assumptions.

5. Acknowledgements

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6. References

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