Evaluation of 450mmØ Driven Pile Bearing Capacity in Keluang Residual Soil

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ABSTRACT

The allowable bearing capacity is the maximum bearing stress that can be applied to the foundation such that it is safe against instability due to shear failure and the maximum tolerable settlement is not exceeded. In order to assess the value of bearing capacity, predictions and actual measurements are made. This paper describes a study done on the ultimate bearing capacity of 450mmØ driven spun pile in Kluang Residual Soil. Comparison between the predictions value of bearing capacity using Meyerhof's Equation, Chin's Method and also with the Pile Dynamic Analyzer (PDA) measurement on site were made. It can be concluded from the study that Meyerhof's Equation provided lower bearing capacity while Chin's Method and PDA provided comparable result.

Figure 1: General site location in relation to the state of Johor

1.0 INTRODUCTION

Foundation is an element that transfers the load from a structure to the soil underneath. The selection of the foundation system will largely depend on the soil condition and column load of the building. To cover all the uncertainties, a safety factor needs to be incorporated in the design. The ability of the soil to sustain the load from the structure can be predicted in many ways, and the most accepted will be the one closest to the actual condition. This is always a challenging problem in geotechnical engineering due to the existence of varying formation, the lack of understanding of the soil-pile interaction and the inexact quality of soil information. In foundation engineering practice, the predicted results of pile design analysis are normally compared with the actual measurements of the static or dynamic response of a pile to an applied load.

1.1 SOIL PROFILE

A study on pile bearing capacity was conducted at the Kluang site in Johor (refer to Figure 1), which covers an area of approximately 40 acres of palm oil plantation.

In this study, only data for end bearing piles was taken, which was set at a depth of below 18m within the hard stratum of very dense sand. The soil above this layer is generally soft to stiff silt or loose to dense sand.

2.0 BEARING CAPACITY

This study provided a comparison between the allowable bearing capacity based on:

a) Meyerhof's Equation (prediction)
b) Chin's Method (actual), and
c) Pile Dynamic Analyzer test done on the driven piles (actual in situ test)

2.1 MEYERHOF'S EQUATION

The number of blow count, N, of the standard penetration test is used to calculate the bearing capacity of a pile. Meyerhof (1976) compiled and rationalised some of the wealth of experience available and recommended that the ultimate bearing capacity, Q_u be a function of the N, which can be predicted from the total of shaft resistance, Q_s and base resistance, Q_b. Based on the soil profile during the driven piles, the coefficient of skin friction, k_1 and end bearing pile, k_2 of 2 and 400 were used respectively for sand in order to calculate Q_u. Table 1 tabulates the value of k_1 and k_2 for silt and clay soil.

Table 1: Coefficient of Pile

	Sand	Silt	Clay
k_1 =	2	1.7	αCu
k_2 =	400	250	100

The standard penetration test is subjected to many errors and care must be taken when using the test results. For this reason, a minimum factor of safety of 3 is applied.

2.2 PROFESSOR CHIN FUNG KEE'S METHOD

A method proposed by Chin (1970, 1971) for piles (in applying the general work of Kondner, 1963) can be presented in the form of a graph (refer to Figure 2). In order to apply the Chin-Kondner method, each pile head settlement, δ has to be divided with its corresponding load and the results against the settlement is plotted. After some initial variation, the plotted values fall into a straight line. The inverse slope of this line is the Chin's Extrapolation of the ultimate load.

$$Q_u = \frac{1}{C_1} \qquad \text{Equation 1}$$

where

Q_u = capacity or ultimate load
C_1 = slope of the straight line

The criterion determines the load-movement curve for which the Professor Chin plot is a straight line throughout. The equation for this 'ideal' curve is shown as a dashed line in Figure 2 and Equation 2 gives the relation for the curve:

$$Q = \frac{\delta}{C_1\delta + C_2} \qquad \text{Equation 2}$$

where
Q = applied load
δ = pile head settlement
C_1 = slope of the straight line
C_2 = y-intercept of the straight line.

2.3 PILE DRIVING ANALYZER (PDA)

The PDA test is commonly used to predict pile load carrying capacity. It is performed by impacting the top of the pile with a mass that provides sufficient energy to mobilise the end bearing capacity of the pile. The test was used to find the ultimate bearing capacity of the driven piles in Keluang residual soil. It was performed by a Certified PDA Tester. A PDA tester is examined and certified by Foundation QA Pty Ltd which conducts the test in association with Deep Foundation Institute (DFI).

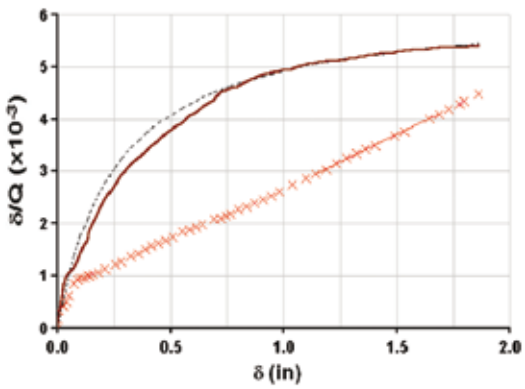

Figure 2: Chin-Kondner Extrapolation Method

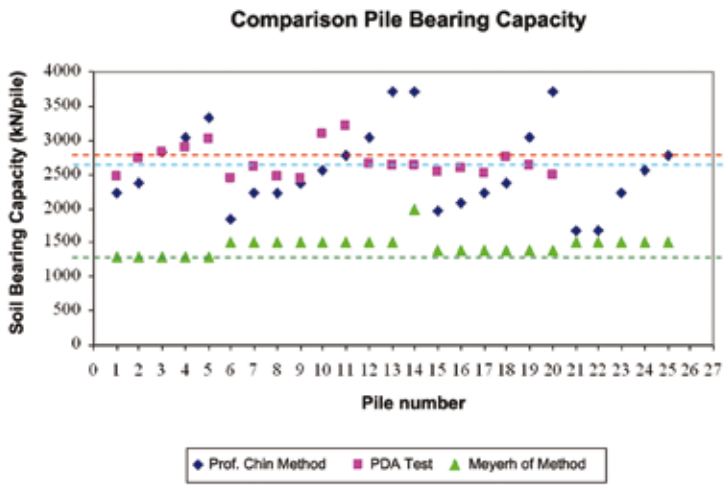

Figure 3: Comparison for pile size 450mmØ

3.0 RESULTS AND DISCUSSION

A total of 25 borehole and static load test records together with 20 PDA tests were collected from the site. The borehole results were used to calculate the predicted allowable bearing capacity by using Meyerhof's Equation. The static load test results were used to calculate the actual bearing capacity.

The results were presented in Figure 3 below. This comparison is done to demonstrate the overall results of pile bearing capacity obtained from a pile size measuring 450mmØ using the three different methods:

The graph for the 450mmØ pile size shows that Meyerhof's predicted capacities are between 1300kN to 1500kN. Chin's showed values are between 1600kN and 3700kN. PDA results are between 2400kN and 3200kN. The percentage difference between Chin's method and Meyerhof's Equation is 41%, Chin's method with the PDA test is 3.7% and Meyerhof's Equation with PDA is 43%.

From the results obtained, Chin's Method and the PDA test results show a very minimum percentage difference of 3.7%. This is similar to the results obtained by Hanif and Ng (2007) in their study. Likins and Raushe (2004) had also stated that the ultimate capacity measured from static load test and Dynamic (PDA Test) can provide a good correlation. Therefore, Dynamic Test (PDA test) could be considered as an alternative to static loading test for driven piles, particularly when static loading test cannot be carried out due to site constraint. As mentioned by Fellenius, et.al (2004), Meyerhof's

predictions always underestimate the capacity of driven piles.

4.0 CONCLUSION

Based on the study, it can be concluded that the predicted pile bearing capacity based on Meyerhof's Equation is lower than the actual value obtained from Chin's method. A higher actual bearing capacity of 41% is possible.

The PDA test conducted by an experienced and certified tester provided results which are almost similar to the calculated actual result. This study has shown that the PDA test can be used to determine the bearing capacity. However, due to the variation in soil and other input during the PDA test, initial static load test as a comparison to PDA is advised to ensure that correct interpretation of the PDA has been made. ■

REFERENCES

[1] A.A.Hanif and A.K.Ng (2007). High Strength Dynamic Pile Test Prediction Event at Johor Bahru Sentral. *16th South East Asian Geotechnical conference*, Kuala Lumpur.

[2] Chin F.K. (1970), "Estimation of the Ultimate Load of Piles from Tests not Carried to Failure", *Proceeding of 2nd Southeast Asia Conference on Soil Engineering*, Singapore, pp.81 – 90.

[3] Chin F.K. (1971). Discussion on pile test. Arkansa River Project. American Society of Civil Engineers. *ASCE Journal for Soil Mechanics and Foundation Engineering*, Vol. 97, SM6, pp. 930 – 932.

[4] Fellenius, B.H, Santos, J.A and Antiona V. (2004). Analysis of piles in a residual soil – *The 2nd International Conference on Site Characterization (ISC'2) Prediction*.

[5] Likins, G. E. and Rausche, F., (2004). "Correlation of CAPWAP with Static Load Tests". *Proceedings of the Seventh International Conference on the Application of Stresswave Theory to Piles 2004*: Petaling Jaya, Selangor, Malaysia; 153 – 165.

[6] Meyerhof, G.G., (1976). Bearing capacity and settlement of pile foundations. The Eleventh Terzaghi Lecture, November 5, 1975. *ASCE Journal of Geotechnical Engineering*, Vol. 102, GT3, pp. 195 – 228.

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