DESIGN VERIFICATION OF DRIVEN PILES IN SOFT GROUND USING MAINTAIN LOAD TEST AND HIGH STRAIN DYNAMIC LOAD TEST

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To the people I love

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ABSTRACT

In Malaysia, piling activities are very active due to the numerous development projects that are on-going now. Types of piles used for these development projects can broadly be divided into displacement and replacement piles. Given many uncertainties inherent in the design and construction of piles, it is difficult to predict the performance of a pile. In order to mitigate and prevent such occurrence, a comprehensive pile-testing program must be conducted. Load testing can be carried out on preliminary piles to confirm the pile data and design. Although pile load tests add to the cost of foundation, the saving can be substantial in the event that the improvement of the foundation design can be materialized. Pile test can be generally be divided into three (3) main categories, which are Static Load Test such as Maintain Load Test, Dynamic Load Test such as High Strain Dynamic Load Test and Statnamic Load Test which is the combination of the latter. For pile foundation projects, it is usually necessary to confirm the capacity and to verify the behavior of the piles agrees with the assumptions of the design. The foundations design requires a good knowledge of the soil behavior, the methods of pile testing and the analysis of piles used. In this study, the methods employed for Maintain Load Test are such as Davisson's Method, Chin's Method, Mazurkiewicz's Method and De Beer's Method. Meanwhile, CAPWAP analysis is employed for High Strain Dynamic Load Test. Based from the comparison it was found that De Beer's Method provide best capability to predict ultimate pile capacity. From the CAPWAP analysis, it shows that the mobilised capacity is approximately 30% to 60% higher than the ultimate pile capacity from Maintain Load Test.

ABSTRAK

Di Malaysia misalnya, aktiviti pembangunan yang pesat menyebabkan peningkatan terhadap aktiviti kerja-kerja cerucuk. Jenis cerucuk yang biasanya digunakan untuk projek-projek pembangunan secara umumnya boleh dikategorikan kepada dua bahagian iaitu cerucuk anjakan dan cerucuk gantian. Memandangkan banyak ketidaktentuan yang wujud dalam rekabentuk, adalah sukar untuk meramal ketepatan prestasi sesebuah cerucuk. Dalam usaha untuk mengurangkan risiko ketidaktepatan, maka program ujian beban yang komprehensif perlu dilaksanakan. Ujian beban yang dijalankan pada cerucuk awalan adalah untuk mengesahkan data dan kaedah reka bentuk cerucuk. Walaupun ujian beban cerucuk meningkatkan kos asas, penjimatan boleh berlaku sekiranya rekabentuk asas boleh diperbaiki. Ujian cerucuk secara umumnya boleh dibahagikan kepada tiga (3) kategori utama iaitu Ujian Beban Statik seperti Ujian Beban Tetap (MLT), Ujian Beban Dinamik seperti "High Strain Dynamic Load Test" (HSDLT) dan Ujian Beban "Statnamic" iaitu gabungan ujian-ujian sebelumnya. Bagi projek-projek yang melibatkan cerucuk, kapasiti cerucuk perlu ditentu sahkan bagi memastikan kelakuan cerucuk tersebut supaya selari dengan reka bentuk. Reka bentuk asas cerucuk memerlukan satu pengetahuan yang sangat baik tentang keadaan dan tingkah laku tanah. Kaedah ujian cerucuk. Kaedah ujian cerucuk dan analisa yang digunakan untuk MLT dalam kajian ini adalah seperti Kaedah Davisson, Kaedah Chin, Kaedah Mazurkiewicz dan Kaedah De Beer. Manakala, analisa CAPWAP digunakan untuk HSDLT. Berdasarkan kepada analisis yang telah dijalankan, Kaedah De Beer memberi hasil keputusan ramalan yang hampir sama dengan kapasiti dari Ujian Beban Statik (MLT). Manakala daripada analisa CAPWAP, ianya menunjukkan bahawa kapasiti cerucuk adalah 30% hingga 60% lebih tinggi daripada kapasiti cerucuk yang diperolehi dari Ujian Beban Statik (MLT).

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LIST OF SYMBOLS

Q	-	Applied load
L	-	Length of pile
A	-	Cross section area of pile
E	-	Modulus elasticity of pile
D	-	Diameter of pile
Q_u	-	Ultimate failure load
S_u	-	Ultimate settlement
C	-	Slope gradient
S	-	Settlement

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Since structure began rising above the ground, there are needs of foundation. The use of foundation is to transmit the loads directly to the underlying soil or rock and play an important role to interact favorably with the soil to carry components of a structure to the ground. Generally, there are two types of foundation which is deep foundation and shallow foundation. Different type of foundations have its own usage. Based on Neoh C.A., the choice of the foundation designs are based on loads per column, bearing type, bearing layer, type of intermediate layer and location of water level.

In the cases of heavy construction, it is not practical and economical to use shallow foundation carrying heavy and variable column loads in structure. Hence, deep foundation is more suitable to be used to such extend of depth of soil to achieve adequate shearing strength. In addition, pile foundation is also used to resist vertical, lateral and uplift load. Therefore, this study will focus to the design of pile foundation.

In the past, numerous studies have been conducted on the procedure of pile foundation design, i.e. from site investigation, selecting the type of pile foundation, design of pile foundation, driving criteria and load test. The studies show that choosing various options in each step as mentioned above will affect the ultimate bearing capacity of the piles. For example, different method in pile driven, different formula used in pile foundation design, type of pile used give different results in pile bearing capacity.

However, these findings are not enough to find the most conservative way in the method use in pile foundation design in different type of soil condition. Therefore, more in-depth studies need to be carried out. In this study, the relationship between methods used in pile foundation design and ultimate bearing capacity will be investigated.

1.2 Statement of Problem

As a geotechnical engineer, it is his/her responsibility to design the foundation according to the stipulated criteria and achieve the target performance with the reasonable cost. The design of every foundation presents a unique challenge to the engineer.

“Pile technology is probably as old as human existence” (L. Mastikian, 1974). As the time move forward, there are rapid develop in pile foundation engineering. Of note are the advent of new methods in pile foundation design, the maturity of the concept of soil-structure interaction, the development in the technical in pile driven and others.

Nowadays, a number of n equations develop in pile foundation design to include parameters dependent on soil properties. However, according to Casagrande (1964) state that the risk is always involved in geotechnical engineering because of inability to get real information about behavior of soil. In addition, Peck (1967) addressed the source of failure of foundations include the theory used in the design may be wrong or may not apply and the soil conditions used in the design may differ from the actual soil condition.

Because of the non-availability of consistent procedures for accessing the load transfer mechanisms between piles and surrounding soil, the full-scale load tests are conducted. By estimating the ultimate capacity of pile when it is driven into the ground, it will result in equations where none of the equation is consistently dependable. Therefore, to solve this problem, the best resolution in predicting the pile capacity is by dynamic means consist in driving a pile, recording the driving history and load testing the pile as described by Bowles (1997).

The number of activities involving piling in a country normally corresponds with the development of that particular country. In Malaysia, piling activities are currently active all around the country due to the numerous development projects that are on-going. Types of piles used for these development projects can broadly divided into displacement and replacement piles.

Given the many uncertainties inherent in the design and construction of piles, it is difficult to predict with accuracy the performance of a pile. In order to mitigate and prevent such occurrence, a comprehensive pile testing program must be conducted. Load testing can be carried out on preliminary piles to confirm the pile design on working as a proof of loading test.

Although pile load test add to the cost of foundation, the savings can be substantial in the event that improvement to the foundation design can be

materialized. Pile test can generally be divided into two (2) main categories, which are static load test, such as Maintain Load Test (MLT) and dynamic load test, such as High Strain Dynamic Load Test (HSDLT).

1.3 Objectives of Study

The objectives of the study are:

i. To determine the ultimate capacity of pile foundation using Maintain Load Test (MLT).
ii. To determine the ultimate capacity of pile foundation using High Strain Dynamic Load Test (HSDLT).
iii. To compare the ultimate capacity of pile from Maintain Load Test (MLT) and High Strain Dynamic Load Test (HSDLT).

1.4 Scope of Study

The scope of works and the limitation in this study will only deploy Maintain Load Test (MLT) and High Strain Dynamic Load Test (HSDLT) results. This includes the testing procedure. The scope is limited to the analysis of pile load test data for axially loaded piles. Pile load test give the load settlement behavior up to some pre-assigned load or load up to failure.

For Maintain Load Test (MLT), the method for analyzing the settlement is by using the graphical or semi-empirical methods available such as Davisson’s Method, Chin’s Method, De Beer’s Method and Mazurkiewicz’s Method. Meanwhile,

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