COMPARISON OF ULTIMATE BEARING CAPACITY OBTAINED BY PILE DRIVING ANALYZER AND MAINTAINED LOAD TEST

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DEDICATION

To my beloved parents, family and friends

I am where I am because of all of you

Please continue to give me your support and encouragement

My humblest thanks and gratitude to all

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Firstly, my salutations and adoration to God for keeping me in good health and supplying me with the required knowledge and information to complete this thesis.

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ABSTRACT

In Malaysia, Maintained Load Test (MLT) is the most common static load test used for testing of driven reinforced concrete (RC) piles, while Pile Driving Analyzer (PDA) is currently the most popular dynamic test method. MLT provides relatively accurate information on ultimate pile capacity and settlement but is costly, time consuming and difficult to carry out. PDA is much more timesaving, less expensive and can be carried out with relative ease, but the results are subject to uncertainties and interpretations of wave stress propagation theories. Results of pile load tests at a hypermarket development were studied and analysed to create a comparison between MLT and PDA. From the study, ultimate pile capacities derived from analysis of PDA were consistently higher than results from MLT. Comparison of pile settlement results for MLT and PDA was observed to be inconsistent. The study also recognises that Davisson's Method is used to obtain ultimate pile capacity from MLT as it is more conservative compared with other calculation methods. PDA results were observed to be satisfactory in determining ultimate pile capacity, but a coefficient of 0.9 or a 10% reduction is suggested to be applied to values derived from PDA. For future pile testing programs, there is a potential for an increase of PDA tests to be carried out. However, a limited number of MLT must also be carried out to determine accuracy of parameters and soil models used in PDA tests.

ABSTRAK

Di Malaysia, Maintained Load Test (MLT) merupakan kaedah ujian statik yang paling biasa digunakan ke atas cerucuk konkrit bertetulang manakala Pile Driving Analyzer (PDA) adalah kaedah ujian dinamik yang paling popular. MLT mampu memberi maklumat yang tepat mengenai keupayaan maksima cerucuk dan enapan yang dialami, namun ia melibatkan kos dan masa yang banyak, dan sangat susah dijalankan. PDA lebih senang dijalankan serta melibatkan kos dan masa yang kurang, namun keputusan ujian dipengaruhi oleh ketidakpastian dan tafsiran berkaitan teori "wave stress propagation". Keputusan ujian bebanan untuk satu projek pasaraya besar telah dikaji dan dianalisa untuk mendapatkan perbandingan di antara keputusan MLT dengan PDA. Daripada kajian, didapati keupayaan maksima cerucuk daripada PDA adalah lebih tinggi berbanding dengan MLT untuk semua cerucuk yang dianalisa. Bagi perbandingan enapan cerucuk pula, didapati bahawa keputusan daripada MLT dan PDA adalad tidak tetap. Kajian juga menyokong kaedah Davisson digunakan untuk mendapatkan keupayaan maksima cerucuk kerana kaedah ini memberikan hasil yang lebih konservatif berbanding kaedah-kaedah lain. Keputusan keupayaan maksima cerucuk daripada PDA didapati memuaskan, namun sedikit pengurangan sebanyak 0.9 atau 10% dicadangkan untuk keputusan PDA . Untuk program pengujian cerucuk yang bakal dilakukan pada masa hadapan, terdapat potensi untuk menambahkan bilangan ujian PDA yang dilakukan. Namun, MLT perlu juga dijalankan pada kadar yang minima untuk mendapatkan kepastian mengenai parameter and model tanah yang digunakan dalam ujian PDA.

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A	-	Cross section Area of the pile
B	-	Diameter of pile
β	-	Ratio of impedance before and after section considered
c	-	Wave speed
D	-	Embedment depth of pile
E	-	Modulus of Elasticity of the pile material
F	-	Compression force
f_{cu}	-	Compressive strength of concrete at 28 days age
i	-	Incident (velocity)
P	-	Test load
R	-	Soil resistance
R	-	Reflected velocity

s_e	-	Elastic settlement of the pile
s_{net}	-	Net settlement
s_t	-	Total settlement
v	-	Velocity
z	-	Impedance

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CHAPTER 1

INTRODUCTION

1.1 Background

The magnitude 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 ongoing, funded by both the Government and the private sector. Types of piles used for these development projects can broadly be divided into displacement and replacement piles. Driven reinforced concrete (RC) pile is type of displacement pile that transmits loads from structures into the soil stratum through shaft friction and end bearing capacity of the pile.

Construction of foundations using RC piles is popular and widespread in Malaysia, especially for buildings that are of limited height. Construction of driven RC piles foundation is commonly chosen by developers as it is relatively time saving with a flexible construction schedule, the RC piles are normally readily available and construction methodology is straightforward and not complicated.

However, if driving is not carried out properly, it will result in piles that have not adequately set. Set criteria for driven RC piles are pre-determined by calculation before pile-driving activity begins. If the set criterion for a certain pile is not achieved, excessive settlement of the particular pile may be encountered and this will eventually affect the stability and integrity of the supported structure or building.

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 occurrences, and comprehensive pile-testing program must be incorporated in every project. Loading tests can be carried out on preliminary piles to confirm the pile design or on working piles as a proof loading tests. Although pile load tests add to the cost of foundation, the saving can be substantial in the event that improvement of to the foundation design can be materialized. Pile tests can generally be divided into two main categories, which are static and dynamic tests. An example of static testing is the Maintained Load Test (MLT) while Pile Driving Analyzer (PDA) is a type of dynamic test.

MLT has been traditionally used to test piles in static condition. Most projects require a certain number of driven RC piles to be selected and tested by the MLT method. The MLT test method is well known to be cumbersome due to the test set and testing process. It is a very costly test method and the long duration required for testing makes it undesirable. Unfortunately, the MLT is one of the most direct methods of testing driven RC piles and if procedures are strictly followed, the results are extremely reliable and the settlement of driven RC piles can be accurately determined.

Testing using PDA has gained popularity in recent years due to it being relatively cost-efficient, timesaving and easy to perform. Due to its cost which is much less compared to MLT, PDA can be performed on more driven RC piles thus providing a bigger sample of tested piles.

However, accuracy of data from PDA testing can sometimes be in doubt due to the uncertainties in the energy transmitted to the pile during testing and wave stress propagation theories.

As both of the methods have their own advantages and disadvantages, a combination of data obtained from MLT and PDA testing is proposed to provide a clear picture of the driven RC pile bearing capacity and expected settlement.

1.2 Problem Statement

At present, not many comparisons have been made between PDA and MLT testing for driven RC piles, specifically for cohesive soil in Malaysia. Accurate and detailed studies showing attempted calibration between PDA and MLT in order to gauge the effectiveness of PDA is not normally carried out. By comparing the results of ultimate pile capacity using both PDA and MLT, it is envisaged that eventually, the number of MLT can be reduced and substituted by conducting more PDA tests instead. Thus, by comparing the results from PDA and MLT, the Engineer will gain the confidence and reliability of using numerous PDA with limited MLT tests.

1.3 Objectives

The main objectives of this research are:

a) To determine the most appropriate calculation method for obtaining pile capacity from MLT.
b) To determine the ultimate capacity of driven RC piles in cohesive soil utilizing data from MLT and PDA respectively.

c) To compare results and data obtained from MLT and PDA. The correlation is to be used for future testing programs for cohesive soil whereby the number of MLT can be reduced and replaced with more PDA tests

1.4 Scope and Limitations

For the purposes of this research, only driven RC piles in cohesive soil will be considered. This limitation is necessitated by the available data, which involves driving of RC piles in mainly cohesive soil.