SUSTAINABLE SLOW MAINTAINED PILE LOAD TEST

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DEDICATION

This thesis is dedicated to my loving family and friends especially my late father.
For their endless love, support and encouragement.

"When a man dies, his acts come to an end, except in three cases: an ongoing charity, knowledge from which people continue to benefit, and a righteous child who prays for him."

(Prophet Muhammad S.A.W)

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ABSTRACT

Slow maintained load test is widely used by contractors in Malaysia to ensure the driven pile could accommodate the design load of the structure. Slow maintained load test is a test to determine load-settlement curve and pile capacity for a period of time using conventional load test. Conventional static pile load test equipment is large in size thus making it heavier and takes a long time to install. In addition, it consumes a lot of space which causes congestion at construction sites. Therefore, the objective of this thesis is to conduct a conventional load test by replacing the pile kentledge load with anchorage and reaction pile. Preparations of ten designs comprising six commercial designs were reviewed. In addition, four proposed designs were suggested for the setup. Final design was produced based on its safety factors and criteria referred via literature review. The test frame consists of reaction frame with four reaction helical pile with two helixes per reaction pile. The deformation shapes, safety factor, stress, and strain of the design and finite element of the model has been analysed with the use of SolidWorks and Plaxis 3D software. SolidWorks software emphasizes on the model load-deflection relationship while Plaxis 3D ensures a correlation of reaction between pile uplift force and soil. Then, the model was tested on site to determine the relationship between physical load-deflection and pile-soil uplift force. The results of uplift force and displacement for numerical and physical test were nearly identical which increment of load-displacement graph pattern. The higher the uplift force, the higher the displacement obtained. In conclusion, the result obtained and the design may be considered as a guideline for future application of sustainable slow maintained pile load test.

ABSTRAK

Ujian pengekalan bebanan cerucuk secara perlahan telah digunakan secara meluas oleh kontraktor di Malaysia bagi memastikan cerucuk mampu menampung bebanan struktur. Ia merupakan ujian untuk menentukan carta lengkungan beban-penurunan serta kapasiti cerucuk pada tempoh masa tertentu dengan menggunakan perlatan pengekalan bebanan cerucuk. Peralatan ujian pengekalan bebanan cerucuk secara konvensional mempunyai saiz yang besar yakni menjadikannya lebih berat dan mengambil masa yang lama untuk dipasang. Tambahan pula, ia menggunakan ruang yang banyak dan menyebabkan kesesakan di tapak pembinaan. Oleh itu, objektif kajian ini adalah mengendalikan ujian bebanan cerucuk secara konvensional dengan menggantikan berat bebanan cerucuk kepada reaksi kerangka dan cerucuk sauh. Penyediaan sepuluh rekabentuk yang terdiri daripada enam reka bentuk komersial dan empat reka bentuk sendiri telah dikaji dan dirujuk melalui kajian literatur. Hanya satu reka bentuk sahaja dihasil berdasarkan faktor dan kriteria yang telah dirujuk kajian literatur. Reka bentuk dihasilkan adalah kerangka yang menggunakan empat sauh dan setiap sauh mempunyai dua lingkar. Reka bentuk dan 'finite element' model tersebut telah dikenalpasti dengan penggunaan perisian SolidWorks dan Plaxis 3D. SolidWorks mememastikan hubungan beban-pesongan model manakala Plaxis 3D memastikan hubungan reaksi diantara daya penarikan model cerucuk dan tanah. Kemudian, model tersebut telah diuji di tapak bagi mendapatkan hubungan fizikal di antara beban-pesongan model yang baru dan hubungan penarikan model cerucuk-tanah. Keputusan dan hasil diantara ujian fizikal dan perisian mengenai penarikan model cerucuk dan tanah telah di bandingkan. Keputusan tersebut mendapati corak graf diantara kedua-dua ujian adalah hampir sama iaitu corak graf beban-anjakan secara menaik. Hasil dan keputusan reka bentuk yang diperoleh boleh dijadikan sebagai garis panduan kepada pengguna kaedah ujian pengekalan bebanan cerucuk pada masa hadapan.

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LIST OF SYMBOLS AND ABBREVIATIONS

RECESS	-	Research Centre For Soft Soil
SM tests	-	Maintain Load Test
CRP tests	-	Constant Rate Of Penetration Test
QM tests	-	Quick Maintained Load Test
SM test	-	Slow Maintained Pile Load Test
LRFD	-	Resistance Factor Designs
ASD	-	Allowable Stress Designs
SL	-	Shrinkage Limit.
PL	-	Plastic Limit
CAD	-	Computer Aided Design
SS	-	Steel Sheet

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Slow maintained load test is widely used especially in Malaysia to ensure the driven pile could take the design load of the structure. Normally, pile would be loaded up twice of the working load (Geotechnical Engineering Bureau, 2007). Due to the huge equipment and material used, the danger of the workers and surrounding are relatively high. In addition, it takes time to install the test due to its weight, size, and transportation of the equipment's handling. Therefore, it is important to investigate an alternative solution to overcome these issues.

Sustainable is defined as the orientation of technological development to enhance current and future potential in human needs and aspirations. Sustainable slow maintained load has been proposed for this research to overcome such difficulties. A pile that consists of helixes which increases tension and compression capacity than normal conventional pile, helical pile was proposed as reaction pile as well. In other words, the proposed test has different concept compared to normal conventional tests which can be sustain in terms of size, safety, and installation. The normal slow maintained load test accommodates an amount of massive load during maintain load test. However, sustainable slow maintain pile load used a smaller counterweight as compared to the conventional setup. Thus, it reduces on the work space, improves worker safety and easy to install.

1.2 Problem Statement

Conventional static pile load test uses tons of weight for pile testing. This caused access to site becomes strenuous. Congestion area such as Kuala Lumpur, Bukit Bintang, or Bangsar has made the transportation of site material more difficult which caused delay. In addition, the setup will takes more time to complete. On the other hand, the safety of staff is low because serviceability or deformation limits are exceeded (Likins, 2004). Conventional static pile load test is big in size thus making the test becomes very heavy and uses a lot of space at construction site. Thus, an alternative method of static load test has been tested on pile load-deflection relationship to overcome these limitations. Helical Pile was used as reaction pile due to helical pile can reattached back after being installed than normal reaction pile which becomes permanent after installed.

1.3 Objective of Study

The study emphasizes on the following objectives:

1) To replace the conventional pile load test setup with a smaller pile load test using reaction frame and anchor pile instead of conventional kentledge load test setup.
2) To analyse finite element analysis of commercialized and proposed pile load test model by using SolidWorks and Plaxis 3D.
3) To compare physical uplift force behaviour by using numerical modelling and physical modelling in the pile-soil system.

1.4 Scope of Study

Slow maintained load test has been considered in this thesis because it is the most familiar test in Malaysia engineering industries. The study focused on minimizing a large counterweight used by conventional pile load test by using smaller test reaction frame. A combination of a reaction beam and anchor pile model has been proposed to be utilized in a laboratory scale condition. The test was conducted at Research Centre for Soft Soil (RECESS). The test was conducted on silty sand soil. Later the model was analysed using SolidWorks and Plaxis 3D software. Then, the model behaviour from numerical and physical test was compared in terms of physical uplift force.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, a literature review on types of pile load test, basic soil properties, properties of typical reaction pile load test, and software used to design the model pile load test were explained theoretically.

2.2 Pile Load Test

All piles are tested using pile load test to determine its bearing capacity (Das, 2010; Federation of Piling Specialist, 2006; Geotechnical Engineering Bureau (2007). Pile load tests are carried out during the pile foundation design stage. It is to prove the suitability of the piling system and to justify the design parameters obtained from site investigation (Comodromos, Anagnostopoulos, and Georgiadis, 2003). To carry out pile load test, safety measures must be considered. The risk of piling works varies and pile testing strategy must be done to reduce the risk (Federation of Piling Specialists, 2006). Table 2.1 shows the level of risk related to the characteristics of piling works.

Table 2.1: Level of risks related to the characteristics of piling works and pile testing strategy (Federation of Piling Specialists, 2006)

Characteristics of piling works	Risk level	Pile testing strategy
- Consistent ground conditions. - Previous pile test data is available. - Extensive experience of piling in similar ground.	Low	- Pile tests not essential. - If using pile tests either preliminary and/or working tests can be used. - 1 preliminary pile test per 500 piles. - 1 working pile test per 100 piles.
- Consistent ground conditions. - No previous pile test data. - New piling technique or very limited relevant experience.	Medium	- Pile tests essential. - Either preliminary and/or working pile tests can be used. - 1 preliminary pile test per 500 piles. - 1 working pile test per 100 piles.
- Complex or unknown ground conditions. - No previous pile test data. - New piling technique or very limited relevant experience.	High	-Both preliminary and working pile tests essential. - 1 preliminary pile test per 250 piles. - 1 working pile test per 100 piles.

2.3 Types of Pile Load Test

There are many piles testing method to determine the bearing capacity of pile foundation. The various available methods are best characterized by the duration of force applied to the pile and the strain induced in the pile (Federation of Piling Specialists, 2006). Nowadays, the frequently used types of pile load test are Slow Maintain Load Test (SM tests) and Constant Rate of Penetration Test (CRP tests) (Fellenius, 1975; Federation of Piling Specialists, 2006).

Other than that, Rapid Load Test, Dynamic Test (Federation of Piling Specialists, 2006), Quick Maintained Load Test (QM tests), and Swedish Cycle Test (SC) (Fellenius, 1975) are also considered as typical pile load test. Fellenius (1975) has described the comparison of required time and load-movement behaviour for SM tests, QM tests, CRP tests, and SC test methods in Figure 2.1 and Figure 2.2 respectively.

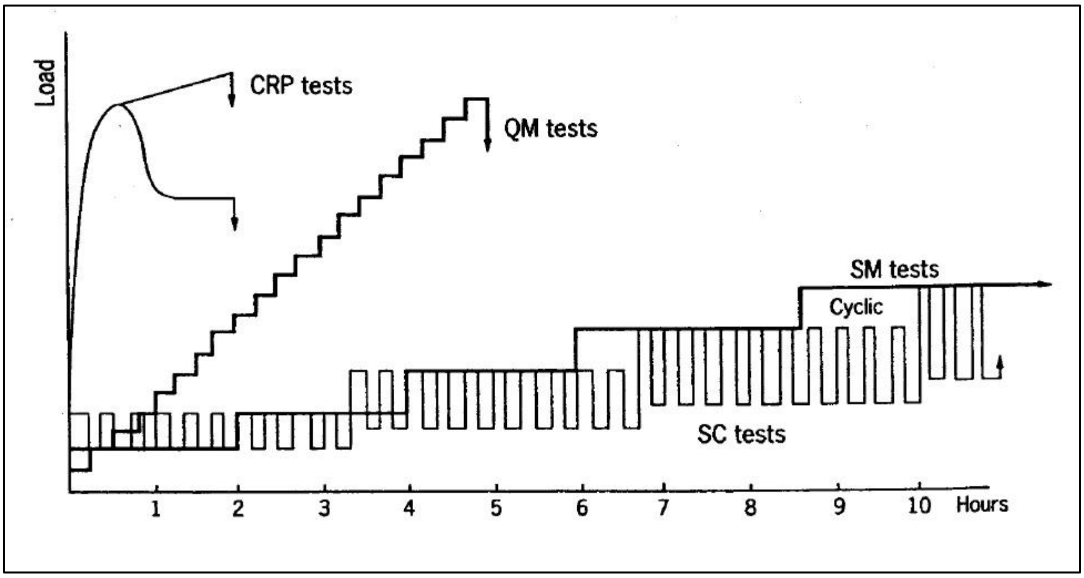

Figure 2.1: Comparison of required time for various test methods (Fellenius, 1975)

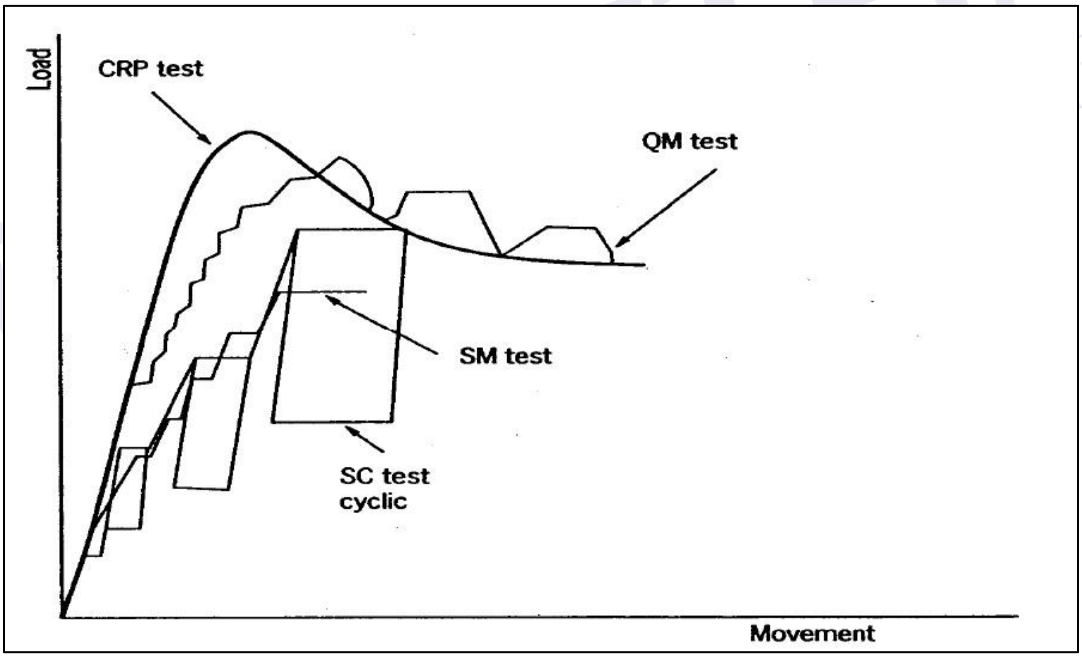

Figure 2.2: Comparison of load-movement behaviour for various test methods (Fellenius, 1975)

SM test is a test when load is applied to the pile in discrete increments thus resulting movement/settlement monitored. The test normally last between 24 and 48 hours (Federation of Piling Specialists, 2006). CRP test requires load for pile to penetrate into the ground at constant rate until maximum specified test load achieved or fail occur for pile. It takes less than 24 hours for the test to complete (Federation of Piling Specialists, 2006).

Rapid load test uses a combustion chamber to provide a rapid load application to the pile head. However the creep effects an pore water dissipation influences the results to a slightly lesser extent due to low loading rate (Federation of Piling Specialists, 2006).

Finally, Dynamic test are based on monitoring the response of a pile subjected to hammer blows applied at the pile head. Based on wave theory, the measured response parameter are analysed to predict soil resistance that would be mobilised by pile via static load condition (Federation of Piling Specialists, 2006). Table 2.2 summarised the SM, CRP, Rapid Load, and Dynamic test.

Table 2.2 : Summary for SM test, CRP test, Rapid Load test, and Dynamic test (Federation of Piling Specialists, 2006)

Test Type	Reaction System	Maximum Test Load	Advantages	Disadvantages
Slow Maintained Test (SM test)	-Reaction piles (Rock anchors may provide an alternative reaction system for piles and bearing in rock) -Kentledge -Bi-directional load cell	-30MN (generally) -3MN (generally) in both cases higher test loads are possible -27MN per cell	-Suits all soil conditions and pile types. -Manual and automated systems available. Piles can be instrumented. Tension and lateral testing possible. -Very high test loads achievable. -No reaction system required.	-Reaction piles/ kentledge and frame are required. -Kentledge tests are relatively expensive. Setting up and dismantling the test equipment involves operatives working at height. -Long duration. -Sophisticated pile instrumentation and analysis. -Suits bored piles only. -Relatively expensive and long duration.

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