EFFECT OF PILE EMBEDDED IN SAND ON LOAD CARRYING CAPACITY AND SERVICEABILITY LIMITS USING NEW INSTALLATION METHOD

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ABSTRACT

Due to heavy works at construction sites, method of pile installation is considered as one of the factors that can affect the progress of a project. Well known methods such as jacking, dropping weight, vibration and explosion have been used at sites. It was observed to have some drawbacks during the installation process such as high resistance due to friction and high settlements that can cause failure to the structure. This study is aimed to determine the performance of pile behaviour using a common and a new method of pile installation and to determine its effects on the load-carrying capacity from the axial working load. The rotary-jacking technique is a new technology of installation where jacking and rotating movements happen simultaneously during the process. A stainless steel 25 mm circular pile, a 50 mm circular pile and a screw pile were fabricated as tested piles in this study. A laboratory model setup is used as a physical model to compare with the existing theoretical values calculated using Meyerhof's theory. This study was administered in two phases where the initial phase is the installation of piles by using two different methods namely jacking and jacking and rotary method. The second phase involves carrying out static load tests for obtaining the ultimate pile capacity. From the results, when 25 mm circular pile is used, it was discovered that the jacking and rotary method requires less loading compare to jacking method during installation when 0.300 kN of loading which is smaller than 0.600 kN due to the change in direction and magnitude of the base and the pile shaft resistance. Load carrying capacity has proven that new method of installation is best chosen when 50 mm circular pile was used, and this was shown in the result of 0.491 kN, which is near to the designed pile load (0.424 kN). For future studies, bigger sized piles are advised to be utilized to reduce load settlement. In

conclusion, the jacking and rotary method can be used as alternative practised to be chosen for construction in the future.

ABSTRAK

Disebabkan kebanyakan kerja yang dijalankan di tapak pembinaan adalah yang berisiko tinggi, kaedah pemasangan cerucuk telah diambil kira sebagai salah satu faktor yang dapat mempengaruhi kemajuan pencapaian projek. Kaedah yang sering digunakan seperti sistem cerucuk jek, penukul jatuh bebas, ayunan dan letupan dikenal pasti mempunyai masalah semasa proses pemasangan cerucuk seperti rintangan tinggi kerana geseran dan berlaku kadar pemendapan yang tinggi yang menyebabkan kegagalan pada struktur bangunan. Kajian ini bertujuan untuk mengetahui prestasi cerucuk apabila menggunakan kaedah pemasangan yang biasa dan juga kaedah baru, juga mengetahui kesannya terhadap daya bawa muatan dari beban kerja paksi. Teknik putaran dan jek adalah teknologi pemasangan baru diperkenalkan di mana pergerakan yang dilakukan seperti putaran dan jek tersebut berlaku secara serentak. Cerucuk keluli tahan karat berbentuk bulat berdiamater 25 mm, 50 mm dan cerucuk skru diuji dalam kajian ini. Penyediaan model makmal digunakan sebagai model fizikal untuk dibandingkan dengan nilai teori yang dikira menggunakan teori Mayerhof. Kajian ini dilaksanakan dalam dua fasa di mana fasa pertama adalah pemasangan cerucuk dengan menggunakan dua kaedah yang berbeza, iaitu sistem cerucuk jek dan putaran dan jek. Fasa kedua melibatkan ujian beban statik untuk mendapatkan kapasiti bebanan cerucuk. Hasil kajian mendapati bahawa kaedah putaran dan jek memerlukan bebanan yang lebih kecil berbanding dengan sistem cerucuk jek dan rintangan yang lebih sedikit iaitu 0.300 kN berbanding dengan 0.600 kN kerana berlaku perubahan arah dan juga magnitud ke atas rintangan asas dan poros cerucuk. Beban daya muatan cerucuk membuktikan kaedah pemasangan baru perlu dipilih apabila apabila cerucuk berdiamater 50 mm yang digunakan menunjukkan bacaan kapasiti bebanan sebanyak 0.491 kN hampir sama dengan bacaan bagi rekaan bebanan cerucuk (0.424 kN). Untuk

kajian yang akan datang, saiz cerucuk yang lebih besar disarankan untuk digunakan bagi mengurangkan mendapan beban. Kesimpulannya, kaedah putaran dan jek boleh digunakan sebagai alternatif untuk dipraktikkan bagi pembinaan pada masa akan datang.

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APPROVAL

The Examination Committee has met on **05th May 2021** to conduct the final examination of **Nor Syamira Binti Hassan** on his degree thesis entitled **'Effect of Pile Embedded in Sand on Load Carrying Capacity and Serviceability Limits using New Installation Method'**

The committee recommends that the student be awarded the Master of Science (Civil Engineering).

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This thesis was submitted to the Senate of Universiti Pertahanan Nasional Malaysia and has been accepted as fulfilment of the requirement for the degree of **Master of Science (Civil Engineering).** The members of the Supervisory Committee were as follows.

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Academic Session : 2020/2021

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LIST OF ABBREVIATI ONS

BS	-	British Standard
EN	-	Eurocode
ASTM	-	American Society for Testing Materials
SPT	-	Standard Penetration Test
CPT	-	Cone Penetration Test
FOS	-	Factor of Safety
Qu	-	Ultimate Bearing Capacity

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CHAPTER 1

INTRODUCTION

1.1 Background

Pile foundations are used to transfer load of the structure from the surface of the ground to below ground. There are two components of foundations which are piles and pile caps. Piles are basically long and slender structures that are buried into the ground to take the weight deep underground to support and transfer load from the structure to the deeper part of the ground. Piles are placed in the ground, and often touch rocks and solid ground. Load transferring and pile materials used in the project are dependent on the types of soil at the site.

Pile driving is one of the main tasks of constructing a building. It is one of the main elements in the construction process as it will ensure that the structure has enough strength to withstand the load. Installing and driving piles into the ground can be performed by using pile driving methods for displacement piles and boring methods for piles replacement. Normally, pile driving methods such as jacking would use static hydraulic force to install displacement piles. By using hydraulic rams, the static jacking force is used to eliminate ground vibration and noise in nearby construction areas.

Choosing a suitable pile type for the structure is considered the most important step to ensure that the structure is strong enough. The type of piles selected depends on a broad range of variables, such as soil type, erosion, local availability and cost, the manpower and the foundation's load-bearing requirements (Adejumo & Boiko, 2012). Piles can be classified into two types: driven or displacement piles, and bored or replacement piles.

In this project, a new concept of pile installation was introduced. When penetrating the piles into the ground, the piles are rotated and jacked directly into the ground. When the piles are rotating, jacking resistance decreases due to the change of directions and the magnitude of the base and shaft resist towards the piles. This new technique can help the piles to drive into the sand with less time taken, and less resistance occurring between the surface of the pile, and the sand medium.

1.2 Problem Statement

Pile installation is commonly related to pile resistance. This is due to the resistance that exists between the pile surface and sand when the pile is driven into the sand medium. Previous research by Norkus & Martinkus (2019) stated that, at the loading points, the ground resistance of the single pile is evaluated by stress distribution under pile base and the piles skin surface. The resistance from the piles will increase when friction between both surfaces is slightly increase. Resistance will decrease when the pile is driven in smoothly with less friction. Since piles are installed using static analysis methods and the real pile resistance is tested during construction phase, achieving the pile resistance assumed in design presents some challenges (Ng

& Sritharan, 2014). It is understood that, the chemical effects created from bonding of sand and pile surface can increase the stiffness and changes in stress surrounding the piles for a long-term period. This may cause stress on pile shaft to increase and this may be the possible reason to the increase of resistance and pile capacity in sand (Chow et al, 1998).

The timeline of a project is important to ensure that the work in progress is completed within the time given. Time taken to install the piles is one of the main factors that has to be considered when choosing the method of installing the piles. Previous researches have proven that the hammering method takes longer time to finish during pile installation. This situation will leave an impact on the timeline of a project and the cost of the project will gradually increase. According to a previous study by Chen et al (1999), the changes in pile capacity is observed with the time taken during the pile installation due to the excess pore water pressure after installation of pile was completed in few hours. However, the increase in pile capacity in sand has three possible reasons which can lead to these conditions. These are the chemical effects that can cause the bonding between sand particle and pile surface, stress that occurs surrounding the pile surface for a long term changes and effects of soil aging that can increase dilation stiffness and strength.

Pile settlement is one of important part to be observed during the installation phase because it can cause major problem to the structure. The settlement can be achieved by sum of pile heel settlement and elastic deformation of pile (Gabrielaitis et al., 2013). The conclusive criteria for any design should be investigated whether the pile settlements at working loads are within the reasonable limits of the supported