EVALUATION OF BEARING CAPACITY DUE TO RADIAL EXPANSION USING EXPANDING PILES

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ABSTRACT

The engineering community is familiar with different techniques to improve the bearing capacity and settlement characteristics of weak cohesive soils. Preload piers or expanding piles are newly invented method for improving soft soils by means of radial compression. These piers are inserted in the soil and expanded about three times their original cross-sectional area. Due to this expansion, the surrounding soil will be radially stressed, which results in consolidation and general stiffening. The main objective of this research was to investigate improvement in the bearing capacity and settlement changes in a soft clay (Kaolinite) due to applying a preload pier. To gain this goal, soil samples of Kaolinite with undrained shear strength of 15 kPa was prepared in cubic boxes. Then two concrete piles were casted in these soil samples; first one in a cavity expanded by an expanding pile to reach 6 cm diameter and the other one casted in a bored cavity with the same diameter(without expansion). Then piles were tested by loading them until failure. Load testing of the piles yielded a load settlement graph. Based on the graph applying a preload pier improved bearing capacity of the soil up to 12 percent. Settlement of the pile decreased by 11 percent.

ABSTRAK

Komuniti kejuruteraan biasa dengan teknik-teknik yang berbeza untuk meningkatkan keupayaan galas dan ciri-ciri pemendapan tanah jelekit yang lemah. Tiang pra-muat atau cerucuk berkembang adalah kaedah yang baru dicipta untuk menambah baik tanah lembut dengan cara mampatan jejarian. Tiang-tiang ini dimasukkan ke dalam tanah dan mengembang kira-kira tiga kali ganda luas keratan rentas asal. Disebabkan perkembangan itu, tanah sekitarnya akan tertekan berjejarian, dimana ia mengakibatkan pengukuhan dan pengerasan umum. Objektif utama kajian ini adalah untuk menyiasat penambahbaikan dari segi keupayaan galas dan pemendapan tanah liat lembut (Kaolinit) disebabkan oleh penggunaan tiang pra-muat. Untuk mencapai matlamat ini, sampel tanah Kaolinit dengan kekuatan ricih tak tersalir, 15kPa telah disediakan dalam kotak kubik. Kemudian, dua cerucuk konkrit di acukan ke dalam sampel tanah; yang pertama dalam ruang yang dikembangkan dengan cerucuk berkembang untuk mencapai 6 cm garis pusat dan satu lagi di acukan dalam ruang digerudi dengan garis pusat yang sama (tanpa pengembangan). Kemudian cerucuk-cerucuk telah diuji dengan mengenakan beban sehingga gagal. Ujian beban cerucuk menghasilkan graf pemendapan beban. Berdasarkan kepada graf, penggunan tiang pra-muat, keupayaan galas tanah meningkat sehingga 12 peratus. Pemendapan cerucuk pula telah dikurangkan sebanyak 11 peratus.

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LIST OF ABBREVIATIONS

FEM	-	Finite Element Method
ASCE	-	American Society of Civil Engineers
ASTM	-	American Society for Testing and Materials
BS	-	British Standard
LVDT	-	Linear Variable Differential Transformer
LL	-	Liquid Limit
PL	-	Plastic Limit
PI	-	Plastic Index

LIST OF SYMBOLS

c'	-	Effective cohesion
u		Pore pressure
ϕ'	-	Effective friction angle
γ	-	Unit weight
γ_w	-	Unit weight of water
σ	-	Total normal stress
k	-	Permeability
D	-	Diameter
t	-	Time (second)

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Construction on soft soils remains a trouble making foundation engineering challenge as usually a significant load is imposed by the new structure and the available shear strength of the soft clay is low thus applying a method for improving of soil characteristics seems to be necessary. The engineering community is familiar with different techniques to improve the bearing capacity and settlement characteristics of weak cohesive soils. Some of the in situ techniques to improve the properties of soft ground (e.g. soft clays) prior to placement of foundations are preloading, deep cement/lime mixing, stone columns, grouting (Henn, 1996; Moseley, 1993).

Besides these better known methods, a novel approach has recently been proposed to achieve soft ground improvement by means of applying radial compression using Preload Piers. Preload Piers can be performed as pre-treatment or site improvement before a structure or embankment is built. They are intended especially for soft ground construction and can be placed anywhere between ground surface to 15 m depth at relatively close spacing (about 2 m on center). Preload piers can be utilized to stiffen soil at a cost which is significantly less than that encountered in using aggregate piers or other soil reinforcing systems.

1.2 Mechanisms Of Improvement By Preload Piers

The idea behind the Preload Piers is densification in the radial direction due to consolidation of the soil. The improvement would result in an increase in the stiffness of the soil which enables to solve the problems raised by soft soils. The preload pier method includes the boring a cavity in the section of ground and applying at least one elongate expandable member which can be distended from normal to expanded configuration, which will provide densified soil adjacent to expandable member.

Preload pier technique could be applied in soft clays in two main functions. First method is to place piers directly under foundation, thus each of them assist load bearing capacity duo to an increment in side friction. Second, is to install preload piers as a group, so they improve the surrounding soil by densification and radial consolidation and will result in a pier-soil composite with enhanced stiffness and strength, which is capable of bearing loads without exceeding settlement limitations.

1.3 Research Motivation

A search of the literature review has indicated that researches have done mostly on load capacity of vertically loaded piles. Seed and Reese (1957) investigated the influence of adjacent soil on the load capacity of a pile by focusing on the improved skin friction, but not on the stiffness improvement of the soil. Moseley (1993) studied influences of preloading on the stiffness of the soil by focusing on soils which are preloaded vertically but a theoretical approach which provides prediction in vertical stiffness changes in response to radial preloading is not investigated so much. One of the few researches around vertical stress and strain changes in soils due to preloading has done by Biringen (2006). This research investigated improvement in vertical stress-strain-strength properties of a normally consolidated soft clay in response to preloading in radial direction.

In summary, going through literature has shown that an investigating of changes in bearing capacity of a soft soil due to Preload Pier application and consequent improvement in bearing capacity adjacent to pile is a soil mechanics problem has received little or no attention. Also, it is not clear how much bearing capacity improvement can be expected due to stress changes caused by a radially expanding pier. Thus my research will focus on investigating influences of installing expanding piers on bearing capacity of adjacent soft clay.

1.4 Objectives

In this study, I will investigate influence of applying preload pier in a soft soil. Focus of this study will be on monitoring changes in the soil duo to radial expansion of a pier. The main objectives of this study are:

i. To determine ultimate bearing capacity of the soft soil adjacent preload piers
ii. To investigate settlement in the soft soil due to installation of expanding piers
iii. Modeling a preload pier in expanded and non-expanded status, and comparing the results.

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