PREFABRICATED VERTICAL DRAIN IN MARINE CLAY SOIL USING PLAXIS 2D

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A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Geotechnics)

School of Civil Engineering
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JANUARY 2020

DEDICATION

This project report is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

ACKNOWLEDGEMENT

In preparing this thesis, I was in contact with many people, researchers, academicians, and practitioners. They have contributed towards my understanding and thoughts. In particular, I wish to express my sincere appreciation to my supervisor, Professor Dr Nor Zurairahetty Mohd Yunus, for your patience, guidance, and knowledge. I am very thankful to my friends around me, Syahrul Nazrain Abdul Rahman, Nurul Nisya Amran and my classmates who always help me when needed. I am also indebted to Universiti Teknologi Malaysia (UTM) and all its staffs for being very supportive. My sincere appreciation also extends to all my colleagues and others who have provided assistance at various occasions. Their views and tips are useful indeed. Unfortunately, it is not possible to list all of them in this limited space. I am grateful to all my family member.

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ABSTRACT

Due to the rapid development in Malaysia, area that can be considered as suitable soil which has high resistance to support the structure naturally has becoming increasingly rare. This phenomenon has force engineers to works in soft ground with high compressibility layer. The main risk for development on soft soil is settlement. There are many researches that have been conducted in order to overcome this problem. Prefabricated Vertical Drain (PVD) is one of the methods used to accelerate the settlement, hence made it more suitable for development. This study aims to presents a case study of field data associated to settlement of treated marine clay soil using PVD with different spacing with finite element analysis. Data obtained from site instrumentation will be analysed by Asoaka method and shall be compared with PLAXIS 2D simulation analysis. The result shows that PVD was able to accelerate the consolidation process and suitable to be used as soft ground improvement technique. The rate of settlement was inversely proportional with the drain spacing. Based on the series of modelling it was proved that the prefabricated vertical drain is an effective method for increasing ground stability by accelerate the consolidation process thus suitable to be used as soft ground improvement technique and different PVD spacing affect the soil settlements analysis in term of settlement rate and excess pore water pressure.

ABSTRAK

Disebabkan perkembangan pesat di Malaysia, kawasan yang boleh dianggap sebagai tanah yang sesuai yang mana mempunyai ketahanan yang tinggi untuk menyokong struktur secara semulajadi telah menjadi terhad. Fenomena ini telah memaksa jurutera untuk bekerja di tanah lembut dengan lapisan mampatan yang tinggi. Risiko utama untuk pembangunan pada tanah lembut ialah mendapan. Terdapat banyak penyelidikan yang telah dilakukan untuk mengatasi masalah ini. Prefabricated Vertical Drain (PVD) adalah salah satu kaedah yang digunakan untuk mempercepatkan mendapan, dengan itu menjadikannya lebih sesuai untuk pembangunan. Kajian ini bertujuan untuk membentangkan kajian kes data lapangan yang berkaitan dengan masalah mendapan di tanah lembut terawat dengan menggunakan PVD dengan jarak yang berbeza dengan analisis unsur terhingga. Data yang diperoleh dari instrumentasi tapak akan dianalisis dengan kaedah Asoaka dan akan dibandingkan dengan analisis simulasi PLAXIS 2D. Hasilnya menunjukkan bahawa PVD dapat mempercepatkan proses mendapan dan sesuai untuk digunakan sebagai teknik pembaikan tanah lembut. Kadar mendapan adalah berkadar songsang dengan jarak saliran. Berdasarkan siri pemodelan, terbukti bahawa longkang menegak prefabrikasi merupakan kaedah yang berkesan untuk meningkatkan kestabilan tanah dengan mempercepatkan proses mendapan supaya sesuai digunakan sebagai teknik pembaikan tanah lembut dan jarak PVD yang berbeza mempengaruhi mendapan tanah dari segi kadar mendapan dan tekanan air liang yang berlebihan.

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CHAPTER 1

INTRODUCTION

1.1 Problem Background

Development on soft ground with high compressible layer is somehow most civil engineer would like to avoid. Ground stability and settlement is the two main factors when it comes to construction on soft ground. In order to tackle both of these problems, the ground shall be treated or improve so that it is suitable to bear the structure load.

The easiest way to improve the soil stability is by using pre-loading with surcharge method to achieve allowable required settlement. However, when it comes to construction, time is of the essence. For this purpose, prefabricated vertical drains (PVD) are the solution as it can accelerate the consolidation process. (Hansbo 1997, Bergado et al. 2002, Yan and Chu 2005, Chai et al. 2010, Mesri and Khan, 2012, Long et al. 2013, Indraratna 2010).

PVD system will reduce the drainage path of the pore water from a low permeable layer to free water surface or to pre-installed drainage layer of granular material, thereby accelerating the rate of primary consolidation or the settlement.

The effects of PVD in soft ground has been analysed based on various method such as analytical method, numerical analysis and field observation data. Numerical analysis will produce the most non-restrictive analyses compared to other methods. It also can imitate the actual construction condition because of the possibilities to incorporated effects of reinforcement and staged construction. (Hird, et al., 1992).

The data from monitoring instrumentation and finite element analysis would assist engineers to accomplish better understanding in regards of actual soil attributes; in contrast with the modelling of finite element. Thus, this study is done to establish the effects of prefabricated vertical drain modelling in soft soil by using finite element method.

This project is based on a mix development project at Bandar Bukit Raja, Klang. The area is formerly a palm oil plantation. The developer decided to developed the land in 2015. The overall area is around 1120 acres, which is developed into residential, industry and mixed development area. It also comprises of public amenities such as masjid, hospital, school, police station, market, parks and infrastructures such as roads, drains, pond, open area, etc.

Generally, the proposed development is located on the northern part of Jalan Sg. Puloh, neighbouring to Aman Perdana residential area on the western side stretching to Jalan Meru on the eastern side. A part of the proposed BBR 2 is also neighbouring Petaling Garden development and also stretches up to Jalan Hj. Abdul Manan on the northern side. The proposed Section 5 of Western Corridor Expressway (WCE) cuts through the middle of this development area.

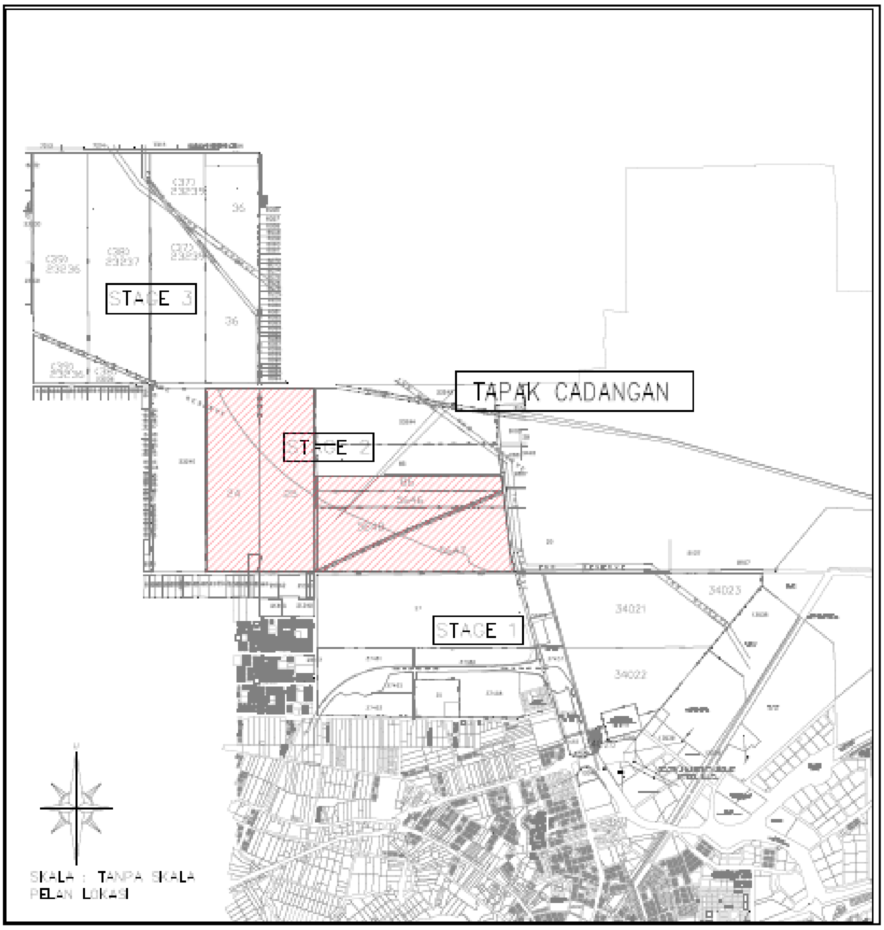

Figure 1.1 : Site Location

Today the use of numerical calculation method particularly those focused on the finite element method becomes more common. In this research, therefore, numerical analysis which is PLAXIS 2D is used in this study to establish the PVD model and to analyse the efficacy of PVD installation in marine clay soil on settlements. Finding of the soil settlement through field measurements and numerical analysis are being compared and discussed.

1.2 Problem Statement

The risk that will be faced when constructing on soft soil is stability and settlement. It is crucial for geotechnical design to ensure the stability of the structure and to control the settlement within the acceptable limit. Marine clay by nature has very low permeability and will consume a lot of time before it reaches the ideal settlement if it is only affected by preloading.

In Peninsular Malaysia, marine clay can be widely found especially in the coastal area. Hence, there are high possibility that engineer encounter this type of soil during construction. The characteristics and conditions of marine clay are very poor that exhibits instability, poor properties, high compressibility and low unconfined compressive strength. From the initial site investigation results, the developer came to a decision to choose prefabricated vertical drain as the ground improvement method.

Hence, this study aims to analyse the effectiveness of PVD installation on marine clay soil and also to come up with predictions based on the monitoring instrumentation data and numerical analysis of the soil settlement. The finding of this study can be use as guidance for understanding the settlement effect of PVD installation as ground improvement in marine clay soil.

This intention of this study is to conduct out a soil settlement assessment due to the effectiveness of PVD system on the former oil palm plantation with marine clay soil. Subsequently, established some predictions based on the field measurement and numerical analysis of the soil settlement.

The finding of this study will lead to the benefit of society in understanding the impact of PVD as ground improvement. Therefore, regarding ground improvement design, the engineers can apply or considering the finding as guideline.

1.3 Project objectives

The aim of this project is to study the effectiveness of PVD installation in the marine clay soil by using Plaxis 2D for the settlement analysis. The objectives of the project are:

(a) To conduct Finite Element Method (FEM) for PVD installation in marine clay by using PLAXIS 2D.

(b) To measure variance between field measurements and numerical analysis on soil settlement in marine clay.

(c) To determine the settlement of PVD at different spacing for the field measurement and PLAXIS 2D.

1.4 Project scope

The proposed development covers an area of 1120 acre. This development is located at the north of Jalan Sg. Puloh which divides the BBR Stage 1 and Stage 2 development, neighbouring Aman Perdana area on the western side stretching to Jalan Meru on the eastern side. A part of the proposed BBR 2 is also neighbouring Petaling Garden development and also stretches up to Jalan Hj. Abdul Manan on the northern side. The proposed Section 5 of Western Corridor Expressway (WCE) cuts through the middle of this development area. Sg. Parit Bt. Enam also flows on the eastern part of the development until it joins Sg. Batu Enam. This development is generally on flat ground with elevation varying between Level +3.00 to +3.50. The original condition of the proposed site is made of palm plantation with a flat terrain with elevation ranging from Level +3.00 to +3.50 above mean sea level. Earthworks cover filling up to elevation +3.85 for open areas, up to +4.50 for building platforms and +4.30 for road platforms.

Based on Figure 1.2, from 1120 acres of the proposed for residential development, only plot area (red colour) are being considered in this study. Each plot has PVD with different spacing.

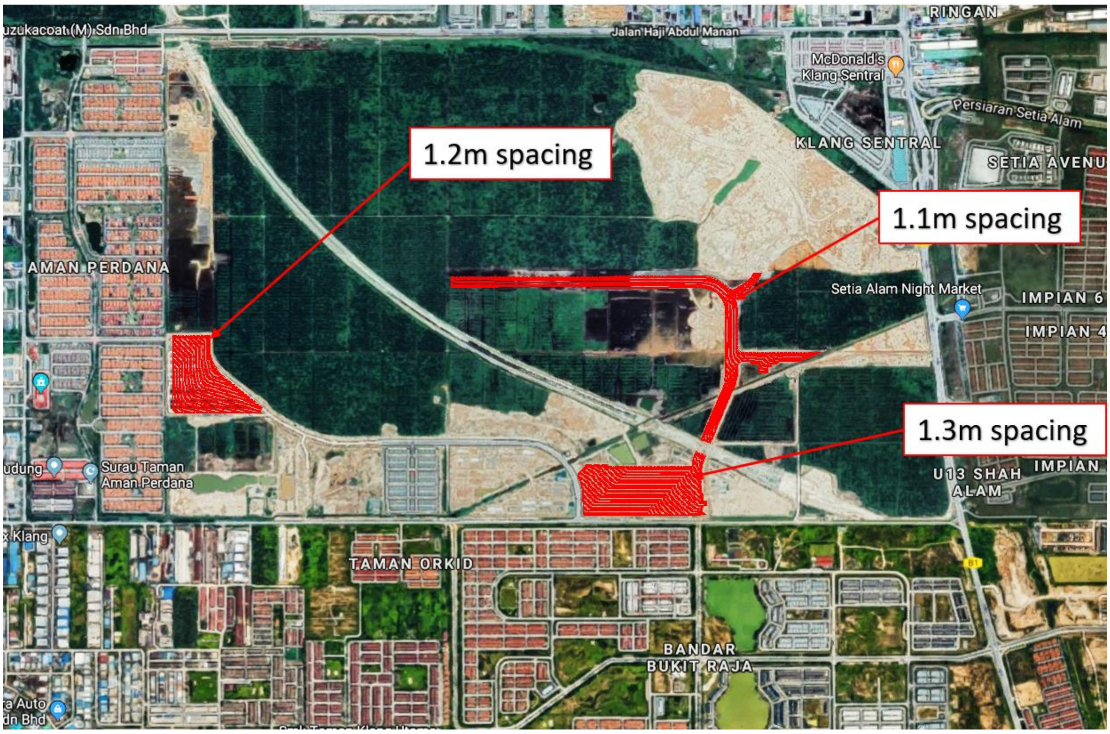

Figure 1.2 : Layout plan of PVD installation.

Data collected from the site investigation report have 30 number of boreholes which are executed to investigate the sub-surface condition and to determine their engineering parameter for designing work purposes. Soil settlement readings are recorded along the construction period using settlement gauges.

The performance assessment was done based on the settlement monitoring data such as settlement gauge and piezometer. PLAXIS 2D v8, a commercial 2D program are choose for doing FEM analysis.

The basic soil models that are used in this study are restricted to Mohr-Coulomb (MC) models under PLAXIS 2D v8. The modelling of permeability is utilised in this study to obtain the comparability between the vertical drain axisymmetric behaviour to the condition of plain strain in plaxis software modelling.

Asoaka's method was choose to predict the final settlement of the settlement data which would be obtained from finite element analysis and monitoring instrumentation. The comparison carried out in between finite element analysis and field instrumentation monitoring to get the time required for 90% consolidation succession.

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