

BACK ANALYSES ON PREFABRICATED VERTICAL DRAIN TREATED
GROUND USING PLAXIS 2D

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ABSTRACT

By increasing the industrial developments in Malaysia, there are many construction projects has been carried out. With the development of construction project, it can cause reducing the construction area. Many of the construction nowadays need to be constructed on the soft ground due to the limitation area and it gives the problem of soil settlement and the construction cost directly become double. Prefabricated vertical drains PVD is one of the most commonly used techniques to reduce the time of settlement substantially. The purpose of this study is to study the performance of prefabricated vertical drain (PVD) as treated ground method. This paper presents a case study of the field data associated to settlement of treated soft soil using PVD by comparing with numerical simulation for embankment constructed along highway. This study involved two methods which are field settlement recorded and prediction of settlement using Finite Element Method. PLAXIS 2D analysis showed that the preloading is important to reduce the post construction settlement. Result from the case study indicates the settlement predicted from Finite Element Modelling is slightly higher compare to an actual field settlement. Drain spacing was analysed to evaluate the factor affecting the performance of prefabricated vertical drain. The rate of settlement was increase by decreasing of drain spacing. The installation of PVD at spacing 1.0m gives the optimum rate of settlement followed by spacing 1.4 m, 1.8 m and 2.0 m respectively. In terms of excess pore water pressure, the result showed the pore water pressure were significantly higher and dissipated slowly due to increasing of prefabricated vertical drain spacing. Based on the series of simulation conducted, it was found that the prefabricated vertical drain is effective pre-construction countermeasure for increasing ground stability.

ABSTRAK

Dengan peningkatan perkembangan perindustrian di Malaysia, terdapat banyak projek pembinaan telah dijalankan. Dengan adanya perkembangan projek pembinaan ini, ianya boleh menyebabkan pengurangan kawasan pembinaan. Banyak pembinaan pada masa kini perlu dibina di atas tanah lembut kerana kawasan yang terhad dan ia memberi masalah kepada enapan tanah dan kos pembinaan secara langsung berganda. Saliran tegak pra-fabrikasi (PVD), adalah salah satu teknik yang paling biasa digunakan untuk mengurangkan masa enapan dengan ketara. Tujuan kajian ini adalah untuk mengkaji prestasi saliran tegak pra-fabrikasi (PVD) sebagai kaedah rawatan tanah. Kertas kerja ini membentangkan kajian kes data lapangan yang berkaitan dengan enapan tanah lembut yang dirawat menggunakan PVD dengan membandingkannya dengan simulasi berangka untuk tambak yang dibina di sepanjang lebuhraya. Kajian ini melibatkan dua kaedah iaitu merekod enapan di tapak dan ramalan enapan menggunakan Kaedah Unsur Terhingga. Analisis PLAXIS 2D menunjukkan bahawa pra-beban adalah penting untuk mengurangkan enapan selepas pembinaan. Keputusan daripada kajian kes menunjukkan enapan yang diramalkan dari model Unsur Terhingga adalah lebih tinggi sedikit berbanding dengan enapan sebenar ditapak. Jarak saliran dianalisis untuk menilai faktor yang menjejaskan prestasi saliran tegak pra-fabrikasi. Kadar enapan meningkat dengan pengurangan jarak saliran. Pemasangan PVD pada jarak 1.0m memberikan kadar enapan optimum diikuti dengan jarak 1.4 m, 1.8 m dan 2.0 m. Dari segi lebihan tekanan air liang, hasil menunjukkan tekanan air liang adalah lebih tinggi dan hilang perlahan-lahan dengan peningkatan jarak saliran menegak pra-fabrikasi. Berdasarkan siri simulasi yang dijalankan, ia menunjukkan bahawa saliran tegak pra-fabrikasi adalah langkah pra-pembinaan yang berkesan untuk meningkatkan kestabilan tanah

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CHAPTER 1

INTRODUCTION

1.1 Background of the Problem

There are many construction projects has been carried out by growing the industrial expansion in Malaysia. Based on the study by the Fauziah *et al.* (2013) the causes of reducing the construction area is due to the development of construction project. Nowadays, many of the construction required to be constructed on the soft ground due to the constrain area and it create the problem of settlement and the construction cost directly become double. They construct the embankment to manage the settlement of the soil but, the settlement still appears during and after filling the embankment.

Based on Buddhima Indraratna *et al.* (2016), prefabricated vertical drain, PVD is the world-wide method practice for ground improvement for improving the mechanical properties of the soft clay deposits. The usage of Vertical drains is to accelerate the dissipation of excess pore pressure under embankments and a Prefabricated Vertical Drain (PVD) is the most applicable method (Hansbo 1997, Bergado *et al.* 2002, Yan and Chu 2005, Chai *et al.* 2010, Mesri and Khan, 2012, Long *et al.* 2013, Indraratna 2010). The radial drainage paths facilitated by PVDs stabilize the soft ground due to increasing the shear strength and reducing the construction settlement. Study by Jae-Hong Kim *et al.* (2015), the researcher stated that series of construction management are conducted in the ground improvement site to investigate the final settlement and they are combined with the Prefabricated Vertical Drain (PVD). Based on the measured settlement data, they are also used to

correct the predicted settlement at the design stage. This is because there is a difference between the settlement prediction during design and actual settlement. The factors of discrepancy such as the determination problems of soil parameters used for analysis, the limit of theoretical solution and the variability of construction condition.

Finite Element Modelling code PLAXIS 2D was performed to design embankment model with vertical drain. The prediction of their performance based on Terzaghi's average degree of vertical consolidation. The design of Prefabricated Vertical Drain (PVD) required the prediction of the degree of consolidation in a given time for any given drain and for a specific ground condition. Previous researched by Branner and Phebaharan, (1983) stated that the performance of Prefabricated Vertical Drain (PVD) both in the laboratory and in the field was investigated by using finite element method. It simplified assumption whereby all strain within the soil occurs only in the vertical direction. The performance of prefabricated vertical drain (PVD) was successfully predicted using Finite Element Method.

1.2 Statement of the Problem

Generally, geotechnical problem during pre-construction and post-construction is embankment built on very soft soil may cause a settlement, lateral deformation and global and local instability. Geotechnical design is focused to certify the stability and maintain the settlement within allowable limit. Prefabricated Vertical Drain (PVD) proved the effective result in acceleration soil consolidation and strengthens the shear strength of soil. As the previous researched on the test of embankment, the design through Finite Element Modelling (FEM) showed the prediction of the excessive settlement. The analysis of drainage condition with automatic mesh generation and update mesh analysis was released in 1999 by code PLAXIS version 7. The mode means that there is no compressive pore water pressures occur, there are no water movements relative to the soil solid. (poodt *et al.*, 2003).

Therefore, the mechanical properties of the embankment were widely known after an analysis by a Finite Element Modelling (FEM) for a relevant soil profile. The analysis of the problem considered by using PLAXIS 2D used to determine the performance of Prefabricated Vertical Drain (PVD) on site. From the back analysis using Finite Element Modelling (FEM) of the fully instrumented embankment, the performance of the ground treatment is evaluate and verified.

The study is important and significant both from the theoretical and practical view point. The rationale and motivation for this study are:

- i. The result obtained from the prediction by using Finite Element Modelling (FEM) can be determined the performance of ground treatment by Using Prefabricated Vertical Drain (PVD).
- ii. This study can helps future improvement on design the parameter of soft soil treatment using Prefabricated Vertical Drain (PVD) for road construction.
- iii. This study can predict the most effective drain spacing of prefabricated vertical drain

1.3 Objectives of the Study

The objectives of this study are as follow:

1. To compare the settlement of embankment on soft soil treated with prefabricated vertical drain (PVD) between predicted from Finite Element Modelling (FEM) and field observed vertical displacement data.
2. To evaluate the performance of degree of consolidation of soft ground treated with prefabricated vertical drain (PVD) and without PVD using the Finite Element Method.
3. To analyse the factor affecting the performance of prefabricated vertical drain at different drain spacing.

1.4 Scope of the Study

The scope of this research limited to the study of the road development of soft soil area at Lebuhraya Pantai Timur 2, Terengganu.

- The study will focus on evaluating the performance of ground treatment along highway by referring to the field data recorded.
- Predict the factor affecting the performance of prefabricated vertical drain at different spacing using PLAXIS 2D
- The performance measure of the evaluation based on the degree of consolidation.

1.5 Organization of the Project report

Chapter 1 in this project report is the early part in conducting the project of research. Chapter 1 will guide on the focus of the flow of project within the scopes. This introduction will give an overview on the background of the geotechnical problem during construction of embankment on soft soil until the significant of the study. The objective is based on two difference section which is the settlement result from the observation data and the numerical simulation analysis. Chapter 1 discussed the aim of this study which is to determine the settlement of the construction embankment by predicting the vertical drain at different length of installation. Besides, the prediction also was tested for normal embankment with no PVD installation. The Design of Experiment has been conducted in order to determine the factors affecting the performance of prefabricated vertical drain. All the data represented on the graph is to explain the PVD performance by replacing it with 1.0 m, 1.4m, 1.8m and 2.0 m drain spacing. Both of this section will be compared as to achieve the research objective and findings.

Chapter 2 provides the previous works and research on the back analyses on prefabricated vertical drain treated ground using PLAXIS 2D. Through this section, it will specify on overview of this study to be carried out effectively. Study from other researcher is important to desire a conclusion based on the previous finding.

Chapter 3 describe the methodology design in this research. It begins with carried out the data collecting from soil investigation report. The data obtained contain of field test and laboratory test. Important field data test such as atterberg limit, moisture content, bulk density, dry density and one dimensional consolidation test were used in this study. Flowchart outline is drawn in order to detail each of the processes. This would give a detail view on how this study is being conducted to accomplish its objectives. The result and findings of this project report will be discussed in Chapter 4 and Chapter 5 will conclude this study.

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