SOFT GROUND IMPROVEMENT BY PREFABRICATED VERTICAL DRAIN (PVD)

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DEDICATION

This thesis 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.

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ABSTRACT

Soft soil improvement in the project requires the consideration of the preloading programme. This method long track record of success and may be a unexpected time delay. Then one of the solutions is to use surcharge that fill must extend horizontally at certain depth beyond the perimeter of the planned construction. Surcharge must remain in place for months or years, thus delaying construction. Since this project needs to be completed within 2 years and the time given to increase the soil strength is 6 months only. Based on that reason, Prefabricated Vertical Drain (PVD) was added to expedite this process. It decreases the overall time required for completion of primary consolidation and also decreases the amount of surcharge load required to achieve the same desired amount of consolidation over a given period of time.At BH 9 and BH10, without surcharge the untreated ground would required about 2.5 year time to eliminate most of settlement. To achieve 99.3% and 99.2 % degree of consolidation the estimated time required is about 1.5 year. PVD was adopted to expedite the consolidation settlement. The consolidation degree 99.3 % were required to ensure that anticipated consolidation settlement of 895mm and 901mm due to permanent fill alone and compensation settlement permanent fill are completely eliminated and no excess pore water pressure left in the soil for BH9 and 860.56mm and 868.066mm for BH10. With the introduction of PVD and surcharge fill of 1m, the required degree of consolidation, Ureq of 99.3% (borehole 9) and 99.2% (borehole 10) was expected to be expedited within a designed rest perod of 6 months. However the evaluation against settlement monitoring results indicated that the corresponding achieved degree of consolidation over 6 months time was about or more than 90% but less than 99.3%

ABSTRAK

Penambahbaikan tanah lembut dalam projek memerlukan pertimbangan program preloading. Kaedah ini mencatat rekod kejayaan yang panjang dan mungkin merupakan kelewatan masa yang tidak dijangka. Kemudian salah satu daripada penyelesaiannya adalah dengan menggunakan Surcharge yang mengisi mesti horizontal consolidation pada kedalaman tertentu di luar perimeter pembinaan yang dirancang. Surcharge harus tetap di tempat selama berbulan atau tahun, sekali gus melambatkan pembinaan. Oleh kerana projek ini perlu disiapkan dalam masa 2 tahun dan masa yang diberikan untuk meningkatkan kekuatan tanah adalah hanya 6 bulan. Berdasarkan sebab itu, Prefabricated Vertical Drain (PVD) telah ditambah untuk mempercepat proses ini. Ia mengurangkan masa keseluruhan yang diperlukan untuk menyelesaikan penyatuan utama dan juga mengurangkan jumlah beban Surcharge yang diperlukan untuk mencapai jumlah pemampatan yang diinginkan yang sama sepanjang tempoh tertentu. Pada BH 9 dan BH10, tanpa surcharge tanah yang tidak dirawat memerlukan sekurang-kurangnya 2.5 tahun untuk menghapuskan kebanyakan penyelesaian. Untuk mencapai tahap penyatuan 99.3% dan 99.2%, anggaran masa yang diperlukan ialah 1.5 tahun. PVD telah digunakan untuk mempercepat penyelesaian penyatuan. Penyatuan 99.3% diperlukan untuk memastikan bahawa penyelesaian konsolidasi yang dijangkakan dari 895mm dan 901mm disebabkan oleh pemanggilan tetap dan penyelesaian pemendapan kekal sepenuhnya dihapuskan dan tiada tekanan air liang berlebihan yang tersisa di dalam tanah untuk BH9 dan 860.56mm dan 868.066mm untuk BH10 . Dengan pengenalan PVD dan Surcharge mengisi 1m, tahap penyatuan yang diperlukan, Ureq 99.3% (BH9) dan 99.2% (BH10) dijangka dipercepatkan dalam perod istirehat yang dirancang selama 6 bulan. Walau bagaimanapun penilaian terhadap keputusan pemantauan penyelesaian menunjukkan bahawa tahap penyatuan yang sama yang dicapai dalam tempoh 6 bulan adalah kira-kira atau lebih daripada 90% tetapi kurang daripada 99.3%.

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LIST OF ABBREVIATIONS

Cc	-	Compression Index
Ch	-	Horizontal coefficient of consolidation
CR	-	Compression ratio
Cr	-	Recompression Index
Cv	-	Vertical coefficient of consolidation
De	-	Diameter of equivalent cylinder of soil
dm	-	Diameter of mandrel
ds	-	Diameter of smear zone
dw	-	Equivalent well diameter
eo	-	Initial void ratio
F	-	Factor considering three compenet
F(n)	-	Drain spacing factor
F(r)	-	Well resstance factor
F (s)	-	Smear effect factor
H	-	Thickness of compressible layer
Hd	-	length of drainage path
Ho	-	initial thickness of compressible soil layer
Kh	-	Hotrizontal permeability coefficient
Ks	-	Reduced permeability coefficient in the smear zone
Kv	-	Vertical permeability coefficient
Ldrain	-	Length of vertical drain
N	-	Spacing ratio
OCR	-	Over consolidation ratio
P'c	-	Preconsolidation pressure
P'o	-	Initial effective stress
Qw	-	Discharge capacity of drain
S	-	Drain or well spacing
S	-	Smear ratio
Sc	-	Primary consolidation settlement
Sn	-	Settlement at specific time
Sp	-	Final primary settlement
St	-	Magnitude of settlement at specific time
Sult	-	Ultimate primary settlement
F	-	Time or duration
Th	-	Horizontal time factor
Tv	-	Vertical time factor

Uav	-	Average or overall degree of consolidation
Uh	-	Degree of horizontal consolidation
Ureq	-	Required cegree of consolidation
Uv	-	Degree of vertical consolidation
Uw	-	Pore water pressure
σt	-	Total vertical stress
$\gamma bulk$	-	Bulk density
Pcp	-	Primary consolidation settlement due to permanent embankment load
Pc(p+f)-	-	Primary consolidation settlement due to surcharge preloading

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CHAPTER 1

INTRODUCTION

1.1 Problem Background

Ground Improvement Technology may be utilized as a treatment for the unacceptable subsurface conditions specially in soft clay. Soft ground improvement is for soft soil that have low bearing capacity and high compressibility of these deposits affect the long term stability of major infrastructure such highway embankment. Therefore it is imperative to stabilize these soil before commencing construction to prevent unacceptable settlement. One of oldest and simplest methods is removal and replacement simply to remove and replace the soil. Soils that will have to be replaced include contaminated soils or organic soils this method is usually practical only above the groundwater table.

In the past, various method was use for the ground improvement. Its categorizes into two which is by chemical stabilization and mechanical stabilization. For the Chemical Stabilization. The method include the Lime Stabilization, Cement Stabilization and Fly Ash Stabilization. For the Mechanical Stabilization, its include vibroflotation, Dynamic Compaction, Blasting, Precompression and Sand Drain. Well known that compressibility and shear strength of soil can be greatly improved if water content in soil can be significantly reduced. One common method improving soft soil is to be reduce the water content of soil through consolidation. For consolidation to occur it must be an increases the effective stress. This can be achieve by increase the total stress or reduce pore water pressure. Some recent development of soft soil consolidation and soft soil improvement are review. Over the year preloading have been use to more conventional the original compacted sand drain.

According to soil classification system, soil improvement through consolidation or preloading belong to the category of ground improvement without admixture in cohesive soil. Preloading is best suited for soft, fine-grained soils that will experience excessive settlement under a structure's load. Fill soil utilized for preloading is typically delivered to the area with dump trucks. Dozers are then used to push the soil into a mound. The mound's height depends on the pressure required to achieved desired improvement. In very soft sites, piezometers and inclinometers may be required to avoid the abrupt placement of fill.

However, depending how preloading is applied, this method can be subdivided into preloading using fill, preloading using fill, preloading using vacuum pressure and combination between combined fill and vacuum preloading method. Because of the min risk of damage to utilities from lateral ground movement and significant reduction in the price of flexible, the combination between combined fill and vacuum preloading method has been choosen. Since most compressible low-lying soils have very low permeability and are often thick, a length time period is usually needed to achieved the desired primary degree of consolidation. One drawback of this surcharge technique is that not suitable to be applied for a sufficiently long period which may at time become impractical due to stringent construction schedule and deadlines. From that reason combination of preloading and surcharge h When surcharge pressure is applied which is to increase the effective stress is depends on the dissipitation of pore water. Their installation can significantly reduce the preloading period Once sufficient consolidation has occurred, the fill can be removed and construction process takes place. The surcharging method places soil fill on-site to pre-consolidate existing soil prior to construction. Combination preloading and surcharge is one of the most successful technique for improving shear strength of low-lying area because it load the ground surface to induce a greater part of ultimate settlement t. In order to control the development of excess pore pressure a surcharge is usually raised as a multi-stage exercise with rest period between the loading stage. In this instances, the height of surcharge can be excessive for an economic perspective and stability consolidation. Since soft soils have low

permeability, the desired consolidation takes very long time to occur, even with very high surcharge load. Therefore with tight construction schedules, combination of preloading and surcharge may not be a feasible solution. Hence, sand or vertical drains may be used to accelerate consolidation process by reducing the drainage paths length.

Therefore Prefabricated Vertical Drain (PVD) become part of these core technologies. Prefabricated Vertical Drain (PVD) have been used successfully in many soil improvement and highway embankment in the world. Design and construction method for soft soil improvement . Prefabricated Vertical Drain (PVD) have also been used for some other relatively new method such as dynamic consolidation for clay. In both case the main purpose of using Prefabricated Vertical Drain (PVD) is apply drainage part that the time taken for the consolidation of soft soil or dissipitation of excess pore-water pressure can be substantially reduced. Prefabricated Vertical Drain (PVD) can be install quicker with min environmental implication and quarrying requirements. Prefabricated Vertical Drain (PVD) also known as wick drains consist of channeled synthetics core wrapped in geotextile fabric. They are flexible, durable, inexpensive and have an advantage over sand drains is that they don't need drilling. as been applied to shorten the time period.

1.2 Problem Statement

At sites where an inadequately performing subsurface material may negatively impact the stability, function or construction system. Ground Improvement Technology serves to improve or stabilize the subsurface material's performance or to improve the load conditions applied to the unsatisfactory subsurface material. Soft soil improvement in the project requires the consideration of the preloading programme. This method long track record of success and may be a unexpected time delay. Then one of the solutions is to use surcharge that fill must extend horizontally at certain depth beyond the perimeter of the planned construction. Surcharge must remain in place for months or years, thus delaying construction. Since this project needs to be completed within 2 years and the time given to increase the soil strength is 6 months only. Based on that reason, Prefabricated Vertical Drain (PVD) was added to expedite this process. It decreases the overall time required for completion of primary consolidation and also decreases the amount of surcharge load required to achieve the same desired amount of consolidation over a given period of time. More than that it increases the rate of strength gain due to consolidation of soft soils when short-term stability is of concern.

1.2.1 Research Objectives

The objectives of the research are :

1. Interprete borelog from the site investigation about the soil conditions for design purposes.
2. Calculate settlement due to preloading.
3. Calculate settlement due to preloading surcharge and prefabricated vertical drain (PVD)

1.3 SCOPE OF STUDY

This study is based on soil investigation work from Lahad Datu, Sabah, Malaysia. The sample collected consist three (3) number of borehole that can be interprete about the type of soil and the depth of soft clay. These data are listed to determine soil profile. The scope of analysis and discussion are limited to the objective of study which is the settlement value correlation with the time from variation condition of ground improvement either by preloading, combination preloading surcharge and preloading surcharge combined with Prefabricated Vertical Drain (PVD). Instrumentation Prefabricated Vertical Drain (PVD) was selected in the field is desirable as it provided insight to the consolidation distribution development with depth. Calculation and analysis for the design criteria were carrying out by applying manual calculation and misrosoft excel that will come out with the graph settlement vs time and degree of consolidation vs time.

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