SITE INVESTIGATION, SAMPLING AND SLOPE STABILITY ANALYSIS AT KILOMETER 141 KL-KUANTAN HIGHWAY

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Recently, the public become more concern about slope failure and landslide. Beside that, the governments try to limit any construction at high risk slope area and enforce the construction at high risk slope to provide ground improvement and slope reinforcement. This response is due to the landslide problem that happened frequently in year 2008. In response to the rising problems, this study has been proposed for the Final Year Project. The objective of this Final Year Project is to determine the basic properties, shear strength and unit weight of slope which is located at kilometer 141 from KL-Kuantan Highway. The analysis then will determine the better option between soil nail and anchor reinforcement since these two methods are commonly used. Based on particle size distribution, the soil at three part of slope are dominant by sandy soil type. The moisture content result for the slope is range 22% to 26%. For plastic limit result, the range is 21% to 25% and for liquid limits results, the range is 43% to 50%. The range of dry unit weight is 11kN/m^3 to 12kN/m^3 with optimum moisture content is 13% to 18%. Based on this result, toe the slope is the most dense part since the dry unit weight is the highest and lowest optimum moisture content. The average shear strength for lower layer is higher than upper layer which is 93.49kPa for lower layer and 71.76kPa for the upper layer. By using slope/W software, the factor of safety (FOS) of existing slope is determined, which is 2.044. Beside that, analysis shows that soil nail reinforcement will give the higher FOS rather than using anchor reinforcement which is 2.940 for soil nail reinforcement and 2.847 for anchor reinforcement. This probably because the soil nails have a lower load requirement than tieback anchors, and are placed closer together.

ABSTRAK

Sejak kebelakangan ini, masyarakat mula memberikan perhatian terhadap kegagalan cerun dan tanah runtuh. Selain itu, pihak kerajaan juga mula menghadkan sebarang pembinaan di cerun yang berisiko tinggi dan memastikan pembinaan di cerun yang berisiko tinggi dilengkapi dengan penambahbaikan tanah dan pengukuhan cerun. Respon daripada masalah yang semakin meningkat ini, kajian ini telah dicadangkan sebagai Projek Tahun Akhir. Tujuan kajian ini adalah untuk mendapatkan kandungan lembapan, ciri-ciri asas tanah, kekuatan ricih dan berat unit cerun yang terletak di kilometer 141 Lebuhraya KL-Kuantan. Kajian ini seterusnya akan menentukan pilihan terbaik diantara kaedah pasak tanah dan pengukuhan jangkar dimana kedua-dua kaedah ini biasa digunakan. Melalui partikel taburan tanah, jenis tanah mewakili tiga bahagian cerun didominasi oleh tanah jenis pasir. Kandungan lembapan cerun kajian adalah diantara 22% hingga 26%. Untuk had plastik adalah diantara 21% hingga 25% dan untuk had cecair adalah diantara 43% hingga 50%. Berat unit cerun adalah diantara 11kN/m^3 hingga12kN/m^3 dengan kelembapan optimum diantara 13% hingga 18%. Berdasarkan keputusan ini, kaki cerun merupakan bahagian yang terpadat kerana mempunyai unit berat yang tertinggi dan kandungan lembapan optimum yang terendah. Purata kekuatan ricih bagi lapisan bawah lebih tinggi berbanding lapisan atas dimana 93.49kPa untuk lapisan bawah dan 71..76kPa untuk lapisan atas. Dengan menggunakan perisian slope/W, faktor selamat bagi cerun sediada adalah 2.044. Selain itu, kajian ini juga menunjukkan kaedah pasak tanah memberikan faktor selamat yang lebih tinggi berbanding kaedah jangkar dimana 2.940 untuk kaedah pasak tanah dan 2.847 untuk kaedah jangkar. Ini kerana kaedah pasak mempunyai keperluan nilai beban yang lebih rendah dan mempunyai rekabentuk susunan yang lebih rapat.

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S	-	Shear strength
c'	-	Effective stress cohesion intercept
Θ'	-	Effective stress angle of friction
w,	-	Moisture content
PL	-	Plastic limit
PI	-	Plasticity index
LL	-	Liquid limit
c_u	-	Shear strength

CHAPTER 1

INTRODUCTION

1.1 General

Malaysia lately was surprised by some natural disaster, especially involving soil structure. Latest cases, on 6th December 2008 five (5) people were killed buried in a landslide in Bukit Antarabangsa, Ulu Klang, near Kuala Lumpur. The landslide, which is believed to have buried 14 bungalows in Taman Bukit Mewah and Taman Bukit Utama, occurred at about 4am.

The government strictly forces the related parties to give extra observation on soil analysis. Beside that, the governments try to limit any construction at high risk slope area and enforce the construction at high risk slope to provide ground improvement and slope reinforcement. These cases make an impact to public where the awareness about slope failure becomes better. Related parties that involve in design, safety and maintenance of slope also start to give information about slope to the public.

There are several cases of landslide that involving highway in Malaysia. One of most tragic cases is Genting Sempah (Kuala Lumpur–Karak Highway) landslide. A landslide at Km 34 feeder road to Genting Highlands, Pahang on 30th June 1995, where 20 people were killed and 22 sustained injuries. Beside that, the slope failures that are involving highway and federal road are Gua Tempurung (PLUS Highway) landslide, Gua Musang-Lojing landslide at the 71st kilometer, and recently the Trans-Borneo Highway, a landslide at KM135 of the Jalan Sibu-Bintulu.

In response to the rising problems and the realization of the impacts of landslide hazards in the country, this study been proposed for this Final Year Project and hopefully will be able to solve the above problems. An increasing proportion of building development takes place on poor ground, which presents the geotechnical engineer with the challenge of providing satisfactory foundation performance at low cost. According to Charles (2002), ground behavior can be modified by ground treatment so that the ground properties are improved and heterogeneity is reduced. Ground improvement has developed largely as an experienced based technology.

There are various types of soil. Paramananthan (2006) has classified Malaysian soils under the United State of Department Agriculture (USDA) system, which is contain seven soil order, included basic information about the management requirements for each soil type. More than that, the soil description and soil classification is also important to geotechnical engineer. Soil descriptions include details of material and mass characteristic while in soil classification, soil is allocated to one (1) of a limited numbers of groups on the basis of materials characteristics (Craig, 2004). This study is made to study the ground improvement that are practical to be used in slope. Basically, a study of soil is important in determining the status of safety for each construction. In this study, the result will obtain from analyzed data and from site investigation.

1.2 Objectives

1) To determine basic properties of soil at slope between KL-Kuantan Highway.
2) To determine shear strength parameters and dry unit weight of soil at slope between KL-Kuantan Highway.
3) To compare the factor of safety (FOS) of existing slope design with a new proposed design by using slope/W.

1.3 Scope of Study

Basically, this study will collect all relevant data for ground improvement method. As we know, ground improvement method is applied for any type of construction to improved soil properties and for this study, focus will be in slope engineered slope.

Scope area of this study is along KL-Kuantan Highway. By experienced, East-Coast Highways have through a lot of mountainous topographical rather than north-south highway. Logically, there should have a lot of ground improvement that applied along KL-Kuantan highway. The study will discuss only two (2) ground improvement method to reinforce the slope.

In order to analyze the slope, site investigations will be done. Sampling will be taken for at least three (3) part of the slope. Then, this sample will proceed with laboratory testing to obtain its basic properties and shear strength. Properties obtain from laboratory testing then will be used in slope/W to analyze slope stability. Lastly, this study will obtain the best design of ground improvement method regarding the FOS from the analysis.

1.4 Background of Study

Historically the design of structures on soft compressible soils has created problems for civil engineers. Construction without some sort of soil treatment is usually impractical due to unpredictable long-term settlement. Although surcharging increases water pore pressure, settlement can take considerable time, often years, as the water lacks an easy path to leave the soil (Charles, 2002).

Regarding to this type of problems, ground improvement are one of the practical method. Ground Improvement in a broad sense is the alternative of any property of soil and treatment of ground so that the soil may be made to serve better for engineering purposes. The ground improvement technique is a combination of physical and chemical methods to improve the strength, bearing capacity and stability and to decrease the permeability and compressibility. These techniques have become very popular for more than 40 years (Das, 2002).

The development of technologies also gives some impact to the evolution of ground improvement method. Until now, there are various type of ground improvement method applied in worldwide country. The ground improvement methods are including: Grouting, Vertical Wick Drains, Soil Mixing, Stone Columns, Lightweight Fill Materials, Vibrocompaction, Dynamic Compaction, Soil Nailing, Mechanically Stabilized Earth Walls Reinforced Soil Slopes, Micropiles, and Geo-textile.

Technically, the objective doing all this types of methods are to reduce settlement of structures, to improve shear strength and bearing capacity of shallow foundations, to increase the FOS against possible slope failure of embankments and dams and to reduce shrinkage and swelling of soils.

1.5 Problem Statement

As stated before, there are various types of ground improvement method. Various type of method does not make any advantages if the methods applied are not suitable for soil properties. The selection of ground improvement method also important in order to fulfill the safety of construction with relevance cost of the project. Some of slope reinforcement also almost the same in external design and the system of work for example soil nail and anchor. In this study, the difference for both methods will be determined especially on efficiency of method regarding the FOS.

One of the problems regarding to improve soil strength in any construction is the selection of method used. Certain construction applied the most effective method, but the pay for ground improvement seems not relevance to the project cost. Cost of project also one of the main criteria in method selection. Where poor ground conditions make traditional forms of construction expensive, it may be economically viable to attempt to improve the engineering properties of the ground before building on it. This can be done by reducing the pore water pressure, by reducing the volume of voids in the soil, or by adding stronger materials (Kumar, 1994).

In order to achieve the objective that is to determine the best method of ground improvement, soil properties should be obtained and then will be analyzed by using slope/W software.

1.6 Significant of Study

In order to build a safe of structure or slope design, engineer should consider the properties and characteristic of soil at site. Therefore this project is carried out to study the soil properties of slope. This data of soil properties are important to update the exist data. Some data was obtain about past ten years ago and now, maybe the properties of soil are change due to external factor such as weather and flood disaster.

This study then will obtain the status of safety for the studied slope. For typical slope designs, the required FOS is usually in the 1.25 to 1.5 range. Higher factors may be required if there is a high risk of loss of life or uncertainty regarding the pertinent design parameters. The investigation of proving existing data is important because it can prevent the failure of soil, especially slope that can be classified crucial such as this study area, along the KL-Kuantan Highway.

Beside that, this project also covered the analysis of using reinforcement. The analysis result will be compared to the existing slope based on the factor of safety. For method of ground improvement, focused will be on soil nail and anchor method. The FOS for both methods also will be determined in order to get the most efficient ground improvement.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The construction of ground improvement over soft soil is increasing due to lack of suitable land for infrastructures and other developments. This typical problem also occurred in Great Britain. According to Charles (1997), high population density and a long history of industrial development have resulted in economical and environmental pressure to redevelop land with former industrial usage and to build on poor and marginal ground. Sites often contain poorly compacted fill deposits or soft natural clay soils which require special geotechnical consideration.

Beside that, the increasing of construction that involving slope also increases due to the same cause. When slope fails, it is usually not possible to pinpoint a single cause that acted alone and resulted in instability. For example, water influences the stability of slopes in many ways that it is impossible to isolate one (1) effect of water and identify it as a cause failure.

For slope, the increasing of construction mainly involved in type of engineered slopes. Engineered slopes may be considered in three (3) main categories, which are embankments, cut slope and retaining wall. For natural slope, Abramson (2002) said that many projects intersect ridges and valley, and these landscape features can be prone to slope stability problems. Natural slope that have been stable for many years may suddenly fail because of changes in topography, seismicity, groundwater flows, loss of strength, stress changes, and weathering.

Therefore ground improvement method should be one of the alternative processes in order to completing the construction which involving poor soil conditions. The treatment of these soils aims to provide adequate support for the structural loading and is usually designed to pre-consolidate or reinforce the soil or alternatively to transmit structural loads through the weak soils to a sound underlying stratum (Watts, 1997).

In choosing a ground improvement system it is first necessary to accurately characterize soil conditions at the site. Material types, stratigraphy and groundwater conditions must be determined above, below and in the treatment zone. Typical properties of importance in the treatment zone include gradation, plasticity, moisture content, organic content, strength and consolidation properties. Properties of the proposed structure including column loads, slab loads and tolerable total and differential settlements are also required in the analysis.

2.2 Ground Improvement

Mitchell (2000) defined of ground improvement which the controlled alteration of the state, nature or mass behavior of ground materials in order to achieve an intended satisfactory response to existing or projected environmental and engineering actions.

Andrew (2004) defined that ground improvement includes systems that use the ground or some modification of it to transfer or support loads. Ground improvement can increase soil strength and stiffness or reduce permeability. In many situations, ground improvement can be used to support new foundations or increase the capacity of existing foundations in place of bypass systems, such as piling, caissons, or remove and replace.

Ground improvement methods are often used to reduce settlements and increase bearing capacity for new construction. In most cases, the purpose is to allow the use of conventional spread footings which are typically the most economical foundation system (Allen, 2004). Some of the methods can also be used to improve the support of existing structures or to provide support for excavations. There are numerous ground improvement methods available, and selection of the best method depends on the properties of the soil at the site and other project specific factors.

2.3 Ground Improvement Methods

Various methods of ground treatment for soft ground can be broadly categorized into the structural and the geotechnical solutions based on various considerations, which included the height of fill, thickness and compressibility of the soil as well as time and cost (Tiwari, 2002). Following methods of ground treatment can be adopted for various poor ground conditions:

1) Vibratory surface compaction and deep vibro-compaction.
2) Preloading of existing soft/loose fill.
3) Preloading with vertical drains.
4) Dynamic replacement.
5) Stone column.
6) Geotextile.
7) Drainage.
8) Soil nailing.
9) Tie back anchor.

2.3.1 Geotextiles

Geotextiles are textiles in the traditional sense, however the fabrics are usually made from petroleum products such as polyster, polyethylene and polypropolyne. They may be also be made from fiberglass. Geotextiles are one of the term in geosynthetics. In general geosynthetics are fabriclike material made from polymer.

According to Tack (2005), the commonly used geotextiles today are either woven, non-woven or knitted geotextiles. Nonwoven geotextiles are manufactured from continuous filaments formed by extruding polymers through spinnerets or staples fibre while woven geotextiles are made from yarns knitted using various weave patterns such as plain twill, satin, or various combination of these (Budhu, 2007).

Geosynthetic soil reinforcement is another technique used to stabilize slopes, particularly after a failure has occurred. Geosynthetic also can improve compaction on the edge of a slope, thus decreasing the tendency for surface sloughing (Sharma, 2002). Design of geosynthetically reinforced slopes is based on modified versions of classical limit equilibrium slope stability methods. According to Das (2002), each type of geosynthetics performs one or more of the following five (5) major functions;

1) Separation.
2) Reinforcement.
3) Filtration.
4) Drainage.
5) Moisture barrier.

One (1) of the major functions of geotextile is filtration. For this purpose, water must be able to flow freely through the fabric of the geotextile. Hence, the cross plane hydraulic conductivity is an important parameter for design purpose (Das, 2002). It should be realized that geotextile fabrics are compressible, however their thickness may change depending on the effective normal stress to which they are being subjected. Figure 2.1 shows in-plane flow in geotextile. The change in thickness under normal stress also changes the cross-plane hydraulic conductivity of a geotextile, as shown in Figure 2.2. Geotextile currently available commercially have thickness that varies from about 0.25mm to 7.6mm. The mass per unit area of these geotextile ranges from about 150 to 700g/cm^2.

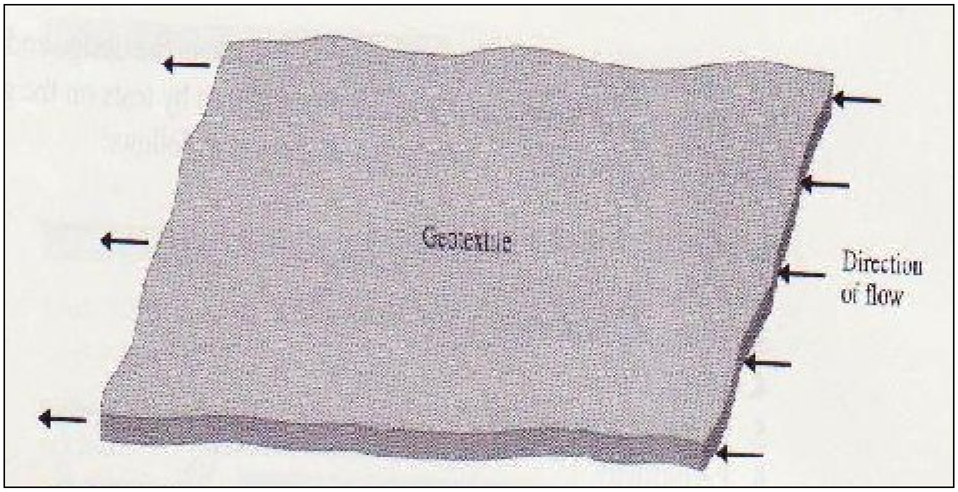

Figure 2.1: In-plane flow in geotextile (Das, 2002)

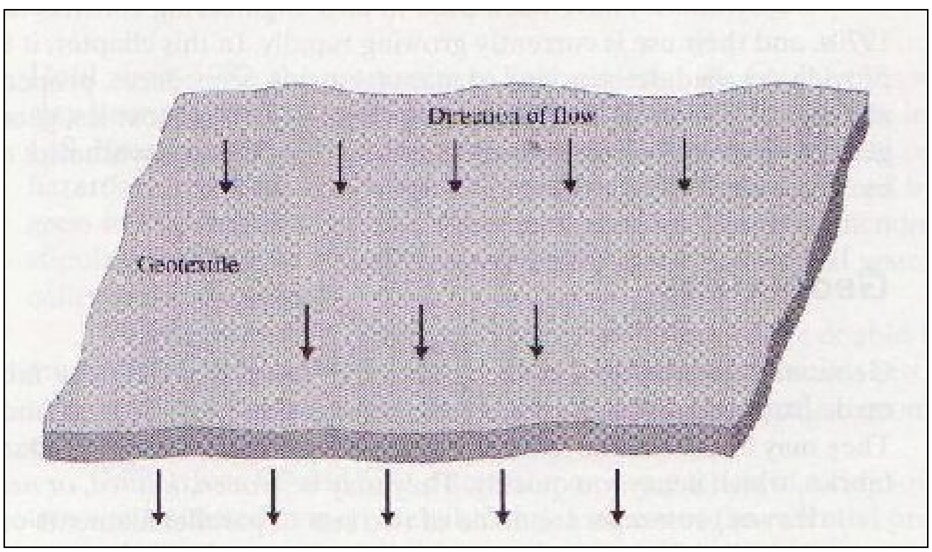

Figure 2.2: Cross-plane flow through geotextile (Das, 2002)

2.3.2 Densification of Soil

The densification of granular soil by compaction has been extensively carried out in earthwork construction and ground improvement (Saturo, 1997). Then the engineering properties of compacted granular soils that are most relevant to geotechnical engineers are shear strength, compressibility and permeability (Nobucha, 1997). According to Charles (2004), the utility of densification as a means of ground improvement method rests primarily on three (3) factors. There are;

1) An increase in the density of a soil generally results in improved ground behavior, such as increased stiffness and strength.
2) Many of hazards for buildings on untreated ground are associated with volumetric compression of the ground. Therefore appropriate ground treatment by densification can act as a type of inoculation by subjecting the ground to a form of the hazard before construction on the ground take places.
3) Soils are generally inelastic and strains are non-recoverable. Therefore once the ground has been densified by ground treatment it will remain densified, and subsequently vulnerability to volume compression will be greatly reduced.

According to Charles (2004), there are two (2) principle form if densification which is compaction and consolidation. Compaction may be more effective in reducing vulnerability to liquefaction, whereas consolidation may be more effective in reducing compressibility, because in both these cases the remedy closely resembles the problem. Thus, treatment by compaction is particularly effective in reducing subsequent susceptibility to self compaction due to vibration, and treatment by consolidation in reducing settlement due to subsequent loading.

2.3.3 Preloading

Preloading generally refers to the process of compressing the soil under applied vertical stress prior to construction and placement of the final construction load (Stapelfeldt, 1999). The two (2) common preloading techniques are conventional preloading, as shown in Figure 2.3. For example an embankment and vacuum induced preloading. Preloading reduces total settlement and may allow for economical selection of foundation system. Vertical drains speed up the process while preloading reduces the amount of post consolidation settlement (Hausmann, 1990).

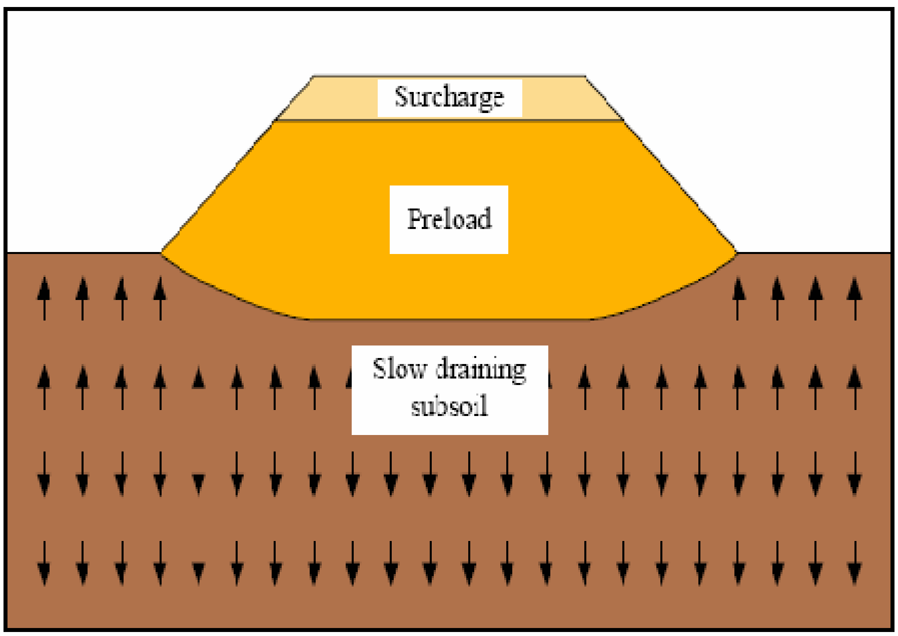

Figure 2.3: Conventional preloading schematic diagrams (Stapelfeldt, 1999)