SHORT TERM PERFORMANCE EVALUATION OF A RURAL ROAD EMBANKMENT WITH DIFFERENT REINFORCEMENT CONSTRUCTED ON SOFT SOIL PERTAINING TO VERTICAL SETTLEMENT

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Specially dedicated to my beloved mother and father, family and friends. Thanks for all the patience and love. May The Almighty Allah SWT bless you all always.

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ABSTRAK

Pembinaan jalan raya di kawasan tanah lembut merupakaj suatu kebiasaan di selatan Semenanjung Malaysia terutamanya berhampiran kawasan pantai. Pelbagai masalah sering dihadapi semasa pembinaan jalan raya dijalankan di atas tanah lembut. Tanah lembut adalah kurang stabil dan mengalami enapan primer dan enapan jangka masa panjang yang besar apabila dikenakan dengan pertambahan beban. Sebelum turapan dibuat di atas tanah lembut, kebiasaannya tanah tersebut akan diperkuatkan dahulu dengan menggunakan geotekstil. Ujikaji ini dijalankan untuk mendapatkan hubungkait di antara kekerapan beban dinamik menggunakan lori 5 tan dengan enapan bagi jalan yang dibina di atas tanah lembut.

Dalam kajian ini, dua (2) jenis geotekstil telah digunakan. Ianya adalah *Rawell Geosynthetic Clay Liner(RGCL)* dan *Woven Geotextile(WG)*. Ujian dan pemerhatian yang berterusan dijalankan ke atas 3 model jalan skala penuh yang dibina di atas tanah lembut di Pusat Kajian Tanah Lembut(RECESS), KUiTTHO. Beban dengan menggunakan lori 5 tan dikenakan ke atas setiap bahagian jalan semasa proses pembebanan dinamik dan statik dijalankan. Daripada analisa yang dijalankan terhadap keputusan kajian, didapati bahawa semasa beban dinamik 50 pusingan sehari dikenakan ke atas jalan,nilai enapan bagi RGCL ialah 0.030 m dan 0.063 m, dan bagi WG pula ialah 0.168 m dan 0.082 m masing-masing bagi bahagian yang dikorek 0m dan 0.5 m.Semasa beban dinamik sebanyak 100 pusingan sehari pula, nilai enapan bagi RGCL ialah 0.026 m dan 0.068 m, dan bagi WG pula ialah 0.168 m dan 0.088 m masing-masing bagi bahagian yang dikorek 0 m dan 0.5 m. Daripada data di atas, kita dapat melihat bahawa keberkesanan penggunaan RGCL adalah lebih baik jika dibandingkan dengan WG. Malah, dengan penambahan beban dinamik, nilai enapan juga turut bertambah.

ABSTRACT

Construction of roads on soft soil is common in Southern part of Peninsular Malaysia especially on its coastal area. Many problems were faced during road constructions when done on soft soils. They are subjected to instability and massive primary and long term consolidation settlements when subjected to even moderate load increases. Most pavements constructed in such a difficult grounds are improved with the use of geotextiles. This research is carried out to get a correlation between the frequency of standard truck loading with the settlement for road embankment constructed on soft soil using different reinforcements.

Two (2) types of geotextiles are used. They are Rawell Geosynthetic Clay Liner(RGCL) and Woven Geotextiles(WG). Continuous monitoring and evaluation are conducted on three (3) different full-scale road embankment models at Research Centre for Soft Soil (RECESS). All sections are loaded using 5 ton truck during Static and Dynamic loading. The performance of road in every sections are monitored and evaluated. From findings, it shows that for frequency of 50 passes per day the settlements for GCL are 0.030 m and 0.063 m, and for WG are 0.168 m and 0.082 m for both 0 m and 0.5 m excavated sections respectively. For frequency of 100 passes per day the settlements for GCL are 0.026 m and 0.068 m, and for WG are 0.168 m and 0.088 m for both 0 m and 0.5 m excavated sections respectively. From the data, we can see that the performance of GCL is better compared to WG for the 0 m and 0.5 m excavated sections. The values of settlement in every sections are also increased when the frequency of dynamic load is increased.

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LIST OF SYMBOLS

GCL	Geosynthetic Clay Liner
RGCL	Rawell Geosynthetic Clay Liner
WG	Woven Geotextile
1 A	0 m Excavated Section Reinforced with RGCL
2 A	0 m Excavated Section Reinforced with WG
3 A	0 m Excavated Control Section
1 B	0.5 m Excavated Section Reinforced with RGCL
2 B	0.5 m Excavated Section Reinforced with WG
3 B	0.5 m Excavated Control Section
kPa	Kilo Pascal

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CHAPTER I

INTRODUCTION

1.1 Research Background

Malaysia is a developing country. As a result of the rapid development of the country coupled with a strong economic performance over the past years, there has been a considerable amount of development in all major city areas. As a result, there is an increasing scarcity of suitable land for developments.

Character of Malaysian soil differs from the north to the south and from the east to the west of Malaysia. Some parts are of granites and some of clays. But, most of the southern Malaysian soil consists of soft clayey soils, peaty soils and some sandy-clay soils. The latter types of soils are not conducive to road construction thus, if the techniques of road design and construction is not in accordance with the soil conditions, then failure will prevail before its design life. The south of Malaysia region has a high water table that will directly affect the performance and design life of the road pavement. (Masirin, 2002)

Most pavements constructed in such difficult grounds are improved with the use of geotextiles. The most popular geotextiles used in Malaysia are the HDP and Polyfelt, which act as an agent to hold the pavement together and function as a slab. Meanwhile it is also used to ensure zero subsurface water seepage into the road pavement, which will affect the performance and design life of the pavement. Thus, in this project, a new type of geosynthetic is introduced as an agent to enhance performance and design life of the road pavement especially when constructed on difficult ground conditions. The new geosynthetic is known as pre-hydrated geosynthetic clay liner (RAWMAT), which is produced by Rawell Environmental Ltd, United Kingdom.

1.2 Problem Statement

Soft soils can create over-drainage and will in turn cause a chain of problems such as increase in rate of subsidence, occurrence of flooding, increase in the occurrence of acid-sulphate soils, forest fire, pest infestation and termite attack, nutrient imbalance to crop and greenhouse effect. Most of the settlements on soft soils are due to subsoil consolidation when excessive pore pressure induced by embankments dissipates with time and creeping effect. The south of Malaysia region has a high water table that will directly affect the performance and design life of the road pavement.

1.3 Research Objective

This research topic is aimed to achieve the followings:

1. To determine and analyze the vertical settlement characteristics of trial road embankments constructed on soft soil conditions.
2. To observe and monitor the performance of a rural road embankment constructed at Research Centre for Soft Soil (RECESS) Malaysia as a case study and obtain a correlation between frequency of standard truck loading passes with vertical settlement under a road embankment constructed on soft soil with different reinforcements.

1.4 Scope of Study

The necessity to study the behaviour of road embankments especially pertaining to its vertical settlement characteristics may lead to the ability to monitor and reduce severe road pavement failures. With the availability of quantitative data correlating frequency of truck loading passes with earth pressures and settlements, engineers will be able to determine the actual functional life of the road pavement.

In order to achieve correlation between frequency truck loading passes with earth pressure and vertical settlement under a road embankment constructed on soft soil project headed by Associate Professor Mohd Idrus Mohd Masirin and Mr. Adnan Zainorabidin at RECESS Malaysia in KolejUniversiti Teknologi Tun

Hussein Onn and collected the relevant data via the state of the art computer-based equipment monitoring system. These data are obtained from actual field experiments and with permission from RECESS Malaysia.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

Malaysia is categorized as a tropical country and is situated near the equator between latitudes 1°20'N to 6°40'N and longitudes 99°35'E to 104°20'E has an area of 131,794 square kilometers. Its climate is warm and humid all year round and enjoys an equatorial climate with temperatures ranging from 22°–32°C in the lowlands. Highland areas experience cooler weather. It has a high annual rainfall intensity averaging 200 cm –250 cm. With a diverse difference of temperature and heavy rainfall intensity, infrastructure construction may experience a lot of challenges in especially construction of roads on difficult ground condition. Malaysia consists of 15 states, which include a Federal Territory, were spread-out and built among plains, hills, and mountains. An environmental impact assessment is conducted during the planning of a road. Project planning and construction must also consider the rainy season and its location. Malaysian soil is geologically diverse; from gravelly granite rocks to peaty soft soil. The soils of Peninsular Malaysia is termed as 'Tropical Soils', as, they are produced principally by the process of tropical weathering (Hussein, AN; 1995).

Geographically, most Malaysian low lands were covered with swampy, limestone, peat or soft soils. This is due to the existence of rivers and heavy rain in

Malaysia. These conditions created a challenge to Malaysian road builders as road construction on difficult ground conditions has always experience failure and disastrous results (Liang CY, 2001). Some stretches of Malaysian roads has either failed to sustain its design life or performed unsatisfactorily during its service to the public. Thus, this will create a dangerous environment to road users who will be involved with road accidents and sometimes could lead to fatality. Almost 90% of coastal areas in Malaysia are sited on soft soils and these areas are mostly places where economic activities are situated. As an example, the city of Johor Bahru and Kota Bharu are located on alluvium soft soil. This also includes big towns such as Kangar, Alor Setar, Seberang Prai, Muar, Batu Pahat and Pontian. With the research, RECESS may be able to introduce achievable and worthy or practical solutions to problems encountered when constructing on soft soil conditions. The efforts may take sometime before it can be implemented but it is better than not even making an effort to come up with an effective and efficient solution for the future.

2.2 Research Area

This research will be carried out at Research Center for Soft Soil (RECESS). Test site is situated on soft soil, located about 20 km from Batu Pahat and 15 km from Air Hitam. The topography of the test area is relatively flat with the original ground is about 1.35 m to 1.5 m above the mean sea level. The center is situated on an area which has water table of 0.5 m to 0.65 m from the ground surface. Bore holes were dig in RECESS to survey the type of soil in the area. The top soil of this area is organic soil from the decay of the oil palm trees elements (trunks, leaves, branches and the seeds) since the site was previously planted with oil palm trees. Underneath the top soil is clayey-silt soil which has high percentage of moisture content. The clayey-silt soil contains some rotten roots and other organic materials. The range is from 1 m to 30 m (as the depth of boreholes). There is no sign of bedrock at the depth of 30m.

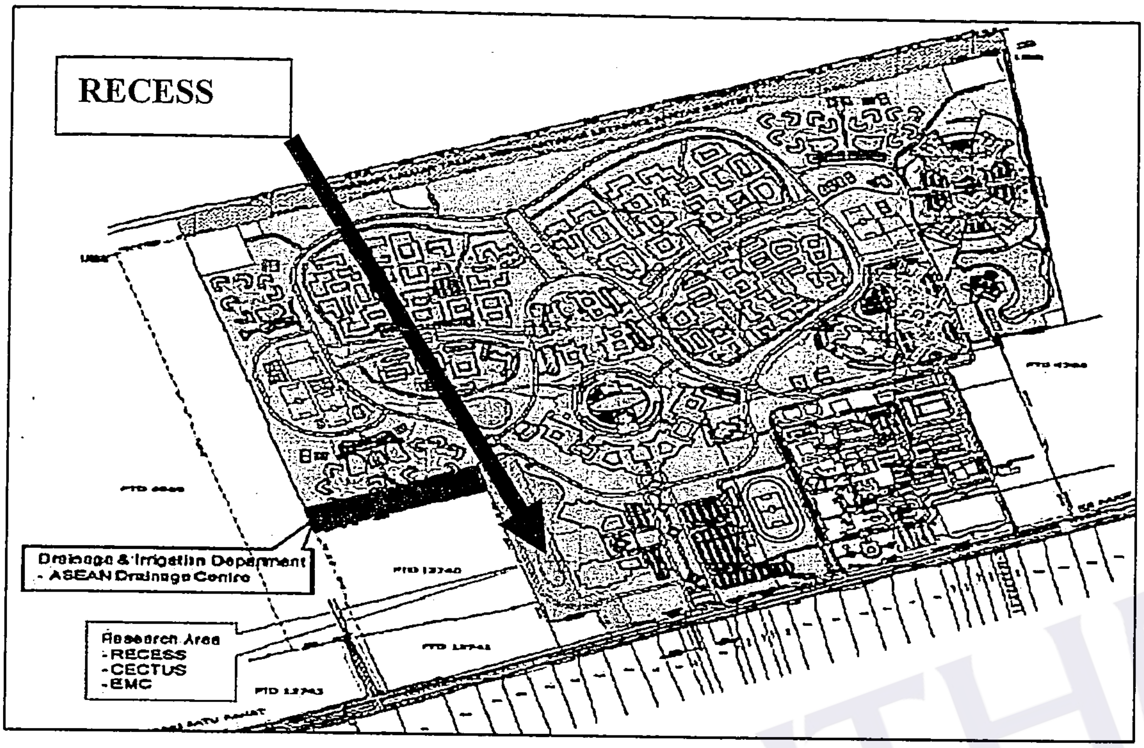

Figure 2.1: Plan of RECESS

Figure 2.2: Research Area (RECESS)

2.3 Soft Clay Deposit

Soft clay deposits are widespread and they present very special problems of engineering design and construction, many of which are not common to other earth materials. By definition, soft clays are of low strength and high compressibility and many are sensitive , in that their strength is reduced by disturbance. Soft clay is an interesting and rewarding material with which to work. It poses abundant engineering challenges whereby the designer must often use very low safety factors and about which the decisions he takes can have large economic consequences for a project

The construction of buildings, roads, bridges, canals, harbours and railways in soft clays has always been associated with stability problems and settlements. Soft clay is defined as a clay with a shear strength less than 25 kPa. The main regions with soft clay are the Nordic countries(except Denmark), Canada and northern United States(Chicago and Boston), where deposits of soft glacial and postglacial clays are often more than 100 m thick. Other areas where deep deposits of soft clay occur are Mexico City, Rotterdam in Netherlands, Elbe around Hamburg in Germany, Leningrad in USSR, Euphrates and Tigris Rivers in Iraq and the Yangtze River around Shanghai in China. The well-known Bangkok Clay and Boston Blue Clay should also not be forgotten. .(Brand & Brenner,1981)

2.3.1 Clayey Silt

Clayey silt is the combination of clay and silt and is classified as soft soil. Clayey silt exhibits generally undesirable engineering properties. They tend to have lower shear strength and to lose shear strength further upon wetting or other physical disturbances. Clay soil is plastic over a range of moisture content; that is, the soil can be remoulded or deformed without causing cracking, breaking or change in volume and will retain the remoulded shape. (McCarthy, 2002)

Silty soil falls in two categories; nonplastic and plastic silt. In general, nonplastic silt can be considered as sand regarding on the bearing capacity in footing design. Meanwhile, plastic silt is considered as clay in footing design. Silty soils generally have low permeability but not as low as clayey soils. The silt particles do not absorb water as clay particles do. (McCarthy, 2002)

Clay and silts are considered as fine-grained soil. The classification of clay and silt is based on the plasticity and nonplasticity of the material. The reasons for the differences in behavior are due to the difference in mineralogy composition and particle shape. Silt soils are very small particles of disintegrated rock, as are the sands and gravels and posses the same general shape and mineralogy composition as sands and gravels which are nonplastic. The clay minerals represent chemical changes that have resulted from decomposition and alteration of the original rock minerals. The effect is that their size and shape are significantly different from other types of soil particles. (McCarthy, 2002)

2.3.2 Compressibility, Shrinkage and Expansion

When the particles of clay are forced closer together, the soil is said to consolidate. Consolidation is directly related to the decrease in thickness of the diffuse double layer between the particles as the water content and perhaps air is reduced. The change in the cay particle size is relatively insignificant. The cause for such volume reduction are commonly attributed to external loads. But sometimes, the evaporation or the changes in the diffuse double layer due to ion transformation or base exchange may be additional causes. The cause of consolidation could also be attributed to drying as well as changes in the groundwater table.(Cernica, 1995)

Not all clay masses deform equally under comparable external influences, since wide variations exist in particle properties and structural arrangements for various clay types. Among the factors influencing compressibility of clay are the amount water absorbed and retained by different minerals, the ion change capacity of different clay minerals, the structural arrangement and the clay particle orientation, and the type and duration of the external influences.(Cernica, 1995)

Swelling is the rebound of a clay soil and thus, in a sense, it is the opposite of consolidation. Like consolidation, however, it is related to a number of clay properties. They are the affinity of clay minerals for water, the expansion of entrapped air within the mass and the mineral type. Both phenomena are indeed complex.

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