APPLICATION OF POLYSTYRENE AND CEMENTITIOUS MATERIAL AS LIGHTWEIGHT FILL FOR ROAD EMBANKMENT

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ABSTRACT

Embankment can be explained by the increasement in height of the newly built roads from the original level. Embankment fill is known as the selected fill materials that are placed and compacted to reduce the load on the foundation which is subgrade soils. However, due to the poor geotechnical of soil properties causing settlement and shear failure. So, surveying site location is important to understand the soil type at the site location. In addition, soil failure affected the road condition and leading flooding during heavy rain and height decreasing by the surcharge load applied on it. Thus, the application of polystyrene and cementitious materials is one of the technique to improve the stability of road embankments. There are four aim as a target to complete this project which two of them is to determine the soil type that is used in the project by doing some experiments is sieve analysis and Atterberg limits and determine the optimum content of polystyrene and cementitious material in soil mixed sample. The significant study of this project is reducing the soil density, improving the slope stability of embankment and preventing landslides to happen. On top of that, the scope of work of this project is to explained the objective that is made. The experiment conducted on Faculty of Engineering University Malaysia Sabah and the listed test is sieve analysis, Atterberg limit, compaction test, unconfined compressive test, and California bearing test. Next, the literature review are discussing the soil classification using USCS also the effectiveness of using geobeads and Portland cement to the soil mixture presented by the previous study. As for the methodology, the flow chart is shown in this chapter. Then, the percentage of geobeads used is 0%,5% and 15% and Portland cement is 8% and 15%. The procedure for conducting the listed experiment is also included in this chapter. In the conclusion, chapter four listed the expected outcomes and work progress are mentioned. As for the standard proctor test for the addition of the polystyrene and cementitious materials have reduce the overburden stress which is up to 35.14%. As this compressive strength it decrease with the increases of the polystyrene beads into the soil mixture. CBR value obtained from the data are passing the requirement and higher value, the lightweight fill which is polystrene beads and Portland cement can be used as alternative materials. Response Surface Methodology (RSM) it can be concluded that the experiment made before testing out using this software found out not very effective since the addition of the proposed polsytrene beads are not considerable. However, the optimum value for this experiment are obtained by using this software hence it can helps the future research to use this data for silimar problem in this project.

Keywords: *Soft soil, road embankment, geobeads, Portland cement, shear strength, compressive strength*

ABSTRAK

PENGUNAAN BAHAN POLISTREN DAN BAHAN SIMEN SEBAGAI PENGISIAN RINGAN UNTUK BENTENG JALAN.

Tambak boleh dijelaskan dengan pertambahan ketinggian jalan yang baru dibina daripada aras asal. Isi benteng dikenali sebagai bahan isian terpilih yang diletakkan dan dipadatkan untuk mengurangkan bebanan pada asas iaitu tanah subgred. Walau bagaimanapun, disebabkan oleh sifat-sifat tanah yang lemah geoteknikal menyebabkan pemendapan dan kegagalan ricih. Jadi, menyiasat lokasi tapak adalah penting untuk memahami jenis tanah di lokasi tapak. Di samping itu, kegagalan tanah menjejaskan keadaan jalan dan menyebabkan banjir semasa hujan lebat dan ketinggian berkurangan oleh beban surcaj yang dikenakan ke atasnya. Justeru, penggunaan bahan polistiren dan simen merupakan salah satu teknik untuk meningkatkan kestabilan tambak jalan. Terdapat empat objektif sebagai sasaran untuk menyiapkan projek ini yang mana dua daripadanya adalah untuk menentukan jenis tanah yang digunakan dalam projek dengan melakukan beberapa eksperimen iaitu Sieve Analysis dan Atterberg limit serta menentukan kandungan optimum polisterin dan bahan bersimen dalam tanah bercampur sampel. Kajian yang paling penting dalam projek ini ialah mengurangkan ketumpatan tanah, menambah baik kestabilan cerun tambak dan mengelakkan tanah runtuh berlaku. Selain itu, skop kerja projek ini adalah untuk menerangkan objektif yang dilakukan. Eksperimen yang dijalankan di Fakulti Kejuruteraan Universiti Malaysia Sabah dan ujian yang disenaraikan ialah sieve analysis, Atterberg limit, compaction test, unconfined compressive test, dan California bearing test. Seterusnya, kajian literatur membincangkan klasifikasi tanah menggunakan USCS serta keberkesanan penggunaan geobeads dan simen Portland kepada campuran tanah yang dibentangkan oleh kajian lepas. Bagi metodologi, carta alir ditunjukkan dalam bab ini. Kemudian, peratusan geobead yang digunakan ialah 0%,5% dan 15% dan simen Portland ialah 8% dan 15%. Prosedur untuk menjalankan eksperimen yang disenaraikan juga disertakan dalam bab ini. Kesimpulannya, bab empat menyenaraikan hasil yang dijangkakan dan kemajuan kerja dinyatakan. Bagi ujian proktor piawai bagi penambahan polistirena dan bahan bersimen telah mengurangkan tegasan beban lebihan iaitu sehingga 35.14%. Oleh kerana kekuatan mampatan ini ia berkurangan dengan pertambahan manik polistirena ke dalam campuran tanah. Nilai CBR yang diperoleh daripada data adalah melepasi keperluan dan nilai yang lebih tinggi, isian ringan iaitu manik polistrena dan simen Portland boleh digunakan sebagai bahan alternatif. Response Surface Methodology (RSM) dapat disimpulkan bahawa eksperimen yang dibuat sebelum menguji menggunakan perisian ini didapati tidak begitu berkesan memandangkan penambahan manik polsytrene yang dicadangkan tidak begitu ketara. Walau bagaimanapun, nilai optimum untuk eksperimen ini diperolehi dengan menggunakan perisian ini dapat membantu kajian masa depan untuk menggunakan data ini untuk masalah sama dalam projek ini.

Kata kunci: *Tanah lembut, tambak jalan, geobeads, simen Portland, kekuatan ricih, kekuatan mampatan*

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LIST OF ABBREVIATION

CBR	California Bearing Ratio
EGS	Effective grain sizes
EPS	Expanded Polystrene
MDD	Maximum Dry Density
OMC	Optimum Moisture Content
RSM	Response Surface Methodology
UCT	Unconfined Compression Strength Test
USCS	Unified Soil Categorization System

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CHAPTER 1

INTRODUCTION

1.1 Overview

The content of this topic is about the background study of this project where it discusses the definition of road embankment and fill with this road construction. The road embankment can be simplified as the soil height for the road foundation is higher than the original soil level at the site location. However, poor soil properties can deal with the instability of this structure. Hence, it is important to determine the type of soil found at the selected location for this project also some testing is made where the experiment is listed and discussed in topic methodology chapter 3. Next, the problem statement and objective of this project are included in this chapter so we know what are need to be included in this project. For example, the problem statement helps us identify the cause of the road embankment failure and how we can apply this application to this structure. Other than that, this subsection can help what testing and action are needed to be done. Significant of study are discussing the main benefit of these applications to the road embankment structure. Lastly, the scope of the study is listed out the action taken based on the described objectives.

1.2 Background of Study

Foundation soil that has poor geotechnical properties, such as soft soil, is usually found in Malaysia during construction and it requires the application of improvement techniques for soil stabilization. In structural and geotechnical construction on soft soils, instability issues such as lateral deformations and excessive settlement are common. Soft soil with the properties of fine particles has high moisture content where it is usually located at the groundwater level (Mamat, R. C et al, 2019). However, there are many types of soil other than soft soil found during the site investigation is made such as clay, sandy, silty, loam, peat, and organic soil. Hence, to determine what types of soil are at a selected location for this project therefore some testing must be done to identify the sort of soil.

Embankments in road construction can be defined as increasing in height of newly built roads in comparison to the surrounding surface region's height (Mamat, R. C et al, 2019). There are two essential components involved in these constructions which are fill and foundation. Embankment fill can be defined as selected fill materials to be placed and compacted with proper specifications where the engineering performance can display (Mamat, R. C et al, 2019). Nevertheless, the instability of road embankments can occur on unstable soft soil. Therefore, to prevent soil failure the techniques that are being proposed are reducing the weight of soil embankment for ground improvement. The materials chosen to act as the lightweight fill are based on compressibility, good performance in compaction properties and more importantly preventing the saturation in soil mixture (Mamat, R. C et al, 2019). Materials are considered as light such as expanded polystyrene can be added to reduce the mixture weight to reduce the self-weight of soil mixture in highway embankment. Other than that, adding the agent and modified materials such as cement can be played as stabilizing the waste soil (Lu, Waihee, 2020).

Expanded polystyrene (EPS) has long been used for construction road embankments. The reason for this material was selected is due to its durability and lightweight. Expanded polystyrene (EPS) has long been pressure from road pavement

and live loads, and after validating durability, these blocks were initially utilized for roadways usually found in Malaysia during construction, requiring application of improved techniques soft clay subsoils, which minimized overall settlement. Several further experiments have been undertaken to evaluate the effectiveness of utilizing EPS beneath highways. Since then, EPS has been used in a variety of highway and bridge abutment projects all over the world (Anwar, M. et al., 2019).

The addition of cementitious materials to soil can stabilize the whole soil structure. This process can help to improve soil stabilization the engineering properties also enhance the construction materials. Generally, soil stabilization is a method of increasing soil properties by mixing addition other materials. This improvement brings big changes by increasing the unit weight sample, bearing capabilities, volume differences, the performance of soil encountered during construction in Malaysia (Ali Akbar Firoozi et al, 2019). It requires the application of improved techniques which are mixing the soil with cement and improving the application of EPS to the soil. Hence, the chosen materials are Portland cement as the binder in a soil sample.

In engineering sciences, computer-aided and statistical-based methodologies are particularly popular and commonly used methods. Response surface methodology is one of these ways (RSM). RSM is a statistical and mathematical technique for analyzing and developing one or more models of independent factors that influence the linkages between a problem's process and its responses. The primary goal of RSM is to achieve maximum results with the least amount of time, resources, and money. It is crucial in the design of processes and the determination of performance levels using alternatives to standard approaches. Although few studies on the use of RSM techniques in geotechnics have been identified in the literature, the quantity of these studies is quite restricted (Bağrıaçık, B et al, 2020). Therefore, by using this software the optimum percentage of addition can be identified to check whether the experiment is done correct.

1.3 Problem Statement

Laterite soil had been used as a fill for embankment construction materials in development project in Malaysia (Razip Selamat et al, 2019). Lateritic soils are highly worn natural materials with a high concentration of hydrated oxides of iron or aluminium as a result of residual accumulation or absolute enrichment induced by aluminium, iron, and manganese solution, transport, and chemical precipitation (Oluyemi-Ayibiowu, B. ,2019). This type of soil are considered as problematic soil since it affected by weathering since the presence of the meteorized materials which enriched by minerals with poor solubility. This soil does not fulfil the specifications set by road authorities for heavy traffic road pavement and, in certain cases, medium to light traffic as well. This can be attributed to their particle-size characteristics, the kind and strength of gravel particles, the degree of compaction, the volume of traffic, the construction site's climatic and hydrological regime, and the topography of the area (Biswal, D.R et al, 2018).

Laterite soil is always difficult for engineering project since it have swelling nature. This soil when dried it compresses and when it wet it expanded. To fulfil the standards for subbase and base course materials, several procedures are utilised to enhance the geotechnical properties of laterites. Any method that improves and makes a soil material more stable, resulting in greater bearing capacity and plasticity, higher mechanical strength or stiffness, changed grain size distribution, and durability under extreme moisture and stress conditions, is referred to as soil stabilisation. Mechanical or chemical soil stabilisation is possible which is known as soil replacement method. Mechanical stabilization it the addition materials that the purpose of it to increase the strength and stability using mechanical energy. As for chemical stabilization is involves additon of additives such as lime, cement, fly ash and bitumen (Jitsangiam, P et al, 2015). Hence, the application of polystyrene and cementitious materials as a lightweight fill is known one of the soil replacement method which is discuss in this project are suitable for this project since the swelling nature of the soil making the weight of embankment became heavier and failed. Thus, by reducing the weight where the lighweight fill are used this can solved the problem that mentioned.

1.4 Objective of Study

The aim of this study is made based on the works included for the overall studies. Therefore all the aims are listed as below:

a) To determine the soil type that is used in the project.
b) To study the shear strength parameter of mixed soil under selected experiment.
c) To determine the optimum value of polystyrene and cementitious material in soil mixed sample.

1.5 Significant of study

i. Reducing the soil density

For construction in soft soil, the instability of road embankment is caused by poor mechanical properties. This type of soil posses of poor performances in geotechnical properties such as high natural moisture content, excessive compressibility, and shallow shear strength. This matter has affected the edge stability and long-term settlement. Alternatively, this method of applying the materials to the soil can increase the bearing capacity, lowering settlement differential, avert slope stability, and most importantly, reduce the soil density. The addition of the EPS with a Portland cement stabilizer reduces the soil mixture's maximum dry density (MDD). In addition, the soil mixture's optimum moisturizer content (OMC) also slightly decreased. These results give the advantage to improve the embankment soil structure.

ii. Improving the slope stability of the embankment

The instability problem where it related to changes of displacement in ground movement affected the soil embankment structure. The problem of this failure is caused by additional loads applied which are the same as deep foundation. Thus, the heavy loads placed on top of the soil structure affected the slope stability of the embankment. Hence, the application of these polystyrene and cementitious materials can be concluded as an effective solution for the infrastructural problem where the main reason this material selected is based on lightness. Next, easier installation and adaptability of EPS and the addition of Portland cement as a binder decrease the factor of safety value for embankment stability.

iii. Preventing landslides occurred

Landslides are the result of external and internal causes. For the internal part, these landslides are caused by the inclined shear resistance of materials

inside the embankment structure within the slope. The main causes of decreasing happen are the increase of pore water pressure and continuous diminished value of the cohesion materials within the slope. Hence, adding an effective weight as fill embankment can prevent landslides from happening. Most importantly, evaluating the problem approaches which can help to create a better solution on how to deal with embankment soil.

1.6 Scope of Work

This study is to implement this technique on the road embankment by identifying which polystyrene and cementitious materials good as lightweight fill for this country. To understand more about this method, an experiment will be conducted at the Laboratory in Faculty of Engineering University Malaysia Sabah. The first objective is conducted after obtaining the soil sample at the selected location which is at Papar, Sabah. Next, the testing is made using a common geotechnical test in this study which is sieve analysis, atterberg limit and specific gravity. The after obtaining the data of soil sample, USCS soil classification system is used to determine the engineering properties.

For the second objective, the list of tests conducted is compaction test to determine the maximum dry density (MDD) and optimum moisture content (OMC) value of each soil specimen, unconfined compressive test to measure the soil mixture of sufficient cohesion to permit the unconfined material's test and California bearing ratio (CBR) to identify the load-bearing capacity of soil specimen. All of the tests above will help to determine the suitable amount of polystyrene and cementitious materials that are needed for this project.

Therefore, the materials chosen for the experiment above is as a lightweight fill are Expanded Polystyrene (EPS) in form of geo beads with the size of a diameter of around 2 to 4 mm. The amount of EPS used for this research is 0%, 5%, 10%, and and 15% from the weight of the dry soil sample. For polystyrene, materials can be