CALIFORNIA BE[illegible]MENT OF KUANTAN CLAY SUBGRADE USING GLASS WASTE AS STABILIZER

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ABSTRACT

Cement and lime are commonly used for soil stabilization. These materials are expensive and it directly increase the construction cost, the usage of recycle material is an ideal choice to overcome this problem. The objective of this project is to study the applicability and effectiveness of Glass waste in order to stabilize soil that is obtains from the subgrade. These studies involve two major studies, the engineering properties of soil before mixing with additives and strength of the soil after mixing with Glass waste. California Bearing Ratio test were conducted to obtain the CBR value of the stabilize soil. The CBR value increased mainly depends on Glass waste content. The variation content of Glass waste is 0%, 4%, 8%, 12%.

Key Word: (Soil Stabilization, Glass Waste, CBR, Clay)

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LIST OF ABBREVIATIONS

AASHTO	-	American Association of State Highway and Transportation Officials
ASTM	-	American Society for Testing and Materials
BSCS	-	British Soil Classification System
CBR	-	California Bearing Ratio
LL	-	Liquid Limit
MDD	-	Maximum Dry
PI	-	Plastic Index
PL	-	Plastic Limit
USCS	-	Unified Soil Classification System

LIST OF SYMBOLS

oC	-	Degree Celsius
ρs	-	Particle Density
%	-	Percent
mm	-	millimeter
µm	-	micrometer
cm^2	-	centimeters square
g	-	Gram
kg	-	Kilogram
Gs	-	Specific gravity
ρ_{dmax}	-	Maximum Dry Density
kN/m^3	-	Kilo Newton Per meter cube

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CHAPTER 1

INTRODUCTION

1.1 OVERVIEW`

Soft sub-grade on road construction is not suitable without any soil improvement due to their poor shear strength. The common method problem is removal and replacement of the unsuitable subgrade. The removal and replacement of subgrade is expensive and will increase the construction cost. Soil stabilization can apply to the subgrade instead of removal and replacement of soil. Cement and lime are commonly used for soil stabilization. These materials are expensive and it directly increase the construction cost. The usage of local material such as recycled material is an ideal choice to overcome the problem. The objective of this project is to study the applicability and effectiveness of Glass waste in order to stabilize soil of subgrade. The study involves two major parts. The engineering properties of soil before mixing with the additives and the shear strength of soil after mixing with glass waste.

1.1 BACKGROUND

Weak soil or soft Soil always found at the subgrade of road way construction in Malaysia. The common method to solve the problem is removal and replacement of the unsuitable soil. The removal and replacement of subgrade is expensive and it will increase the construction cost. Soil stabilization can apply to the subgrade instead of removal and replacement of the unsuitable soil. Cement and lime are commonly used for soil stabilization but these materials are expensive. The usage of local recycled material as stabilizer such as Glass waste is an ideal choice to overcome the problem.

1.2 PROBLEM STATEMENT

Soft cohesive soils are normally found both in East and West of Malaysia, especially along the west coast of West Malaysia in Johore, Malacca, Port Klang, Penang and Pahang. Most difficult problem faced by geotechnical engineers at construction site is the properties of soil which are unable to fulfill the specification requirement for construction activity.

Kuantan clay was high plasticity. These soils cannot be used as embankment material or have to avoid. If the used of soils cannot reasonably avoided, such material shall be used only on bottom portion of embankment. The engineering properties of these soils could be improved by stabilizer: glass waste

Normally, clay has low strength, high compressibility, low workability, and gives large settlement during or after completion of a construction. The construction site dealing with cohesive soil may experience bearing capacity failure caused by inadequate shear strength of the soil and is unsuitable for any construction activity. Therefore the clay soil has to be improved or modified before starting any engineering work.

Alternative ways to deal with soft clayey soil included attempts to dry and compact the soft clay, adding chemical stabilizer such as lime, cement, polymer or designing a very expensive foundation. Chemical stabilizer such as lime or cement treatment can be very effective in soil treatment, but these material are expensive. This Proposal highlights the efficiency and performance of Glass waste to treat the clayey soil by conducting laboratory tests on selected clayey soil.

1.3 OBJECTIVE

a) To determine the engineering properties of Kuantan clay.
b) To demonstrate the stabilized of Kuantan clay by using Glass waste
c) To analyse the effect of Glass waste as soil stabilizer

1.4 SCOPE

The main purpose of this research is to determine the effectiveness between glass waste as stabilizer to develop CBR value of clayey soil. The scope of this research includes:

i. The cohesive soil selected is clay from kuantan mean while the stabilizers are Glass waste.
ii. Physical properties and classification tests of clayey soil to identify physical properties of soil such as, Atterberg limits, particle density of clayey soil, standard proctor test
iii. Obtaining CBR value and soil shear strength of clay stabilized with Glass Waste
iv. The 0%, 4%, 8%, 12% of the sample weight is added to the sample in order to stabilize the clay.

CHAPTER 2

LITERATURE REVIEW

2.1 Soft Soil

The construction industry is constantly facing with challenges dealing with soft soil construction since the old days because of its special characteristics. These characteristics include high compressibility, low shear strength and low permeability. All these characteristics will eventually lead to bearing capacity and excessive settlement problem. Soft soils are sensitive too. It is because of their strength can be reduced by a slight disturbances. Besides, soft clay deposits are widespread and cover many coastal regions of the world such as in Japan, Eastern Canada, Norway, Sweden, India and South East Asian countries (Nagaraj and Miura, 2001).

According to Kempfert and Gebreselassie (2006), 'soft soils' can be defined as clay or silty clay soil which is geologically young and is under a stable condition due its own weight yet has not undergone significant secondary consolidation since its formation. Moreover, the soils are just capable of carrying its own overburden weight and any imposed additional load will result in relatively large deformation. Soils which have not completed the consolidation under their own weight are also can be included in this group.

According to Brand and Brenner (1981), soft soil deposits have unconfined compression strength between 25 kPa to 50 kPa. Generally, soft soils deposits is a natural material that have fine grain and will result in certain plasticity characteristic when some water is added in it (Saiful Azhar, 2004). This plasticity characteristic imply for deform damp material trait when some pressure is applied, yet when the pressure is released, the deform shape is permanent.

As mention earlier, the soft clay deposits exist extensively in South East Asian countries including in Malaysia. The occurrence of thick deposits of soft clay covers almost the entire west coast and some parts of the east coast of Peninsular Malaysia. It is due to the result of quaternary deposition. Geologically, coastal deposits in Peninsular Malaysia have been classified as quaternary deposits from the Cenozoic era (Jamal, 1997). This deposit generally consists of thick layer of unconsolidated soil strata predominantly soft clays, silts, peat and other soft organic deposits. Figure 2.1 shows the unconsolidated quaternary sediments in Peninsular Malaysia.

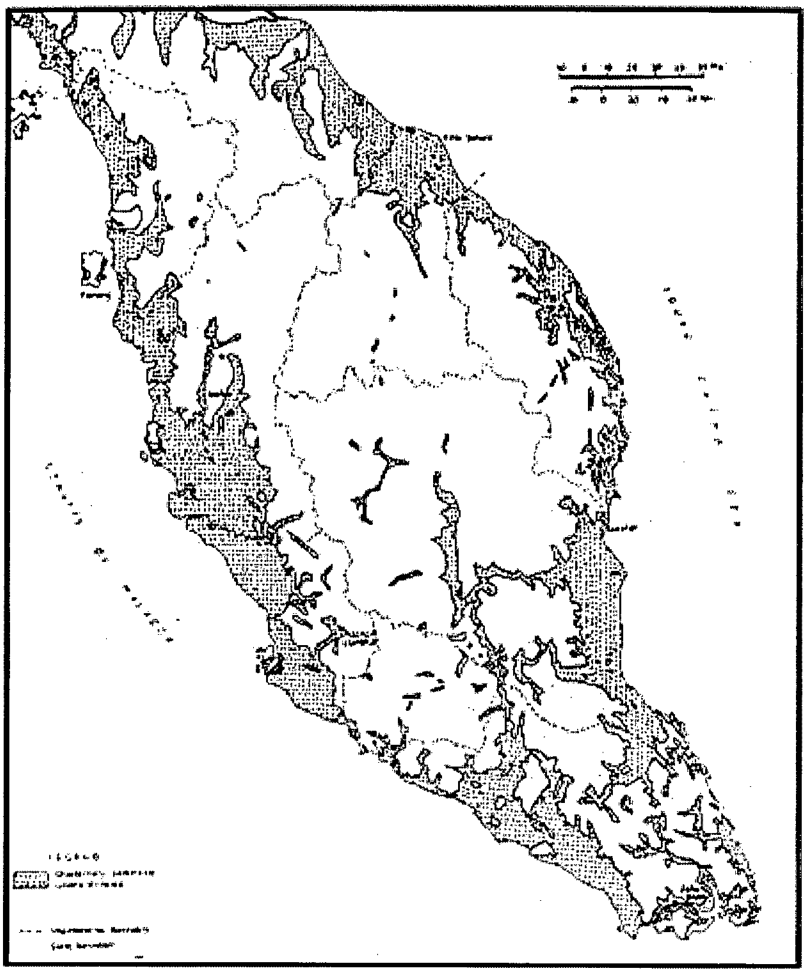

Figure 2.1: Quaternary Sediments in Peninsular Malaysia (Gue and Tan, 2000)

Kuantan clays were high plasticity. These soils cannot be used as embankment material or have to avoid. If the used of soils cannot reasonably avoided, such material shall be used only on bottom portion of embankment. (Achmad, Nazmiand Juniansyah, 2011). There are two common stabilizers which can be used in cohesive soil stabilization, namely cement or lime. By using cement or lime as stabilizer, the compressive strength of the cohesive soil can be increased (Goh, 2011) . Lime and cement is suitable as soil stabilizer.

2.2 Soil Improvement

The soil at a construction site may not always suitable for supporting structure such as building, bridge and highway. Depending on the structural load, unusually large consolidation settlement may occurs In such case, the soil needs to be stabilized to increase its shear strength.

Sometimes the top layers of soil are undesirable and must be removed and replaced with better soil or crushed stone which can form a subgrade for structure can be constructed. There are also alternative methods which some cases proved to be more economical than remove and replacement of the soil. These alternative methods are soil improvement or frequently described as soil stabilization which changes of the soil properties and improve its engineering performance to suit the construction requirement. The characteristics of soil improved are as below:

i. Increases shear strength
ii. Reduces the settlement of structure
iii. Increase the shrinkage limits

Hence, soil improvement is an important element in studying the geotechnical engineering. Without site investigation, failures may happen and will cause losses of money and life. Therefore, site investigation should be carried out to determine the type of soil improvement to be adopted before any construction is started. The soil improvement can be done either by:

i. Mechanical stabilization
ii. Admixture Stabilization

2.3 Mechanical stabilization

Mechanical stabilization is accomplished by mixing or blending soils of two or more gradations to obtain a material meeting the required specification. The soil blending may take place at the construction site, a central plant, or a borrow area. The blended material is then spread and compacted to required densities by conventional means. Among the techniques being used in mechanical stabilization are replacement of soil and mixing with fine soil particles, compaction, and vibration or vibroflotation dewatering by vertical drains and others.

2.3.1 Vibroflotation

Vibroflotation involves the use of a vibrating probe that can penetrate granular soil to depths of over 100 feet (Stapelfeldt, 2006). The vibrations of the probe cause the grain structure to collapse thereby densifying the soil surrounding the probe and Figure 2.1 is shown the vibroflotation. To treat an area of potentially liquefiable soil, the vibroflotation is raised and lowered in a grid pattern. Vibro Replacement is a combination of vibroflotation with a gravel backfill resulting in stone columns, which not only increases the amount of densification, but provides a degree of reinforcement and a potentially effective means of drainage. The vibroflotation process consists of a flotation of the soil particles as a result of vibration, which then allows for a rearrangement of the particles into a denser state.

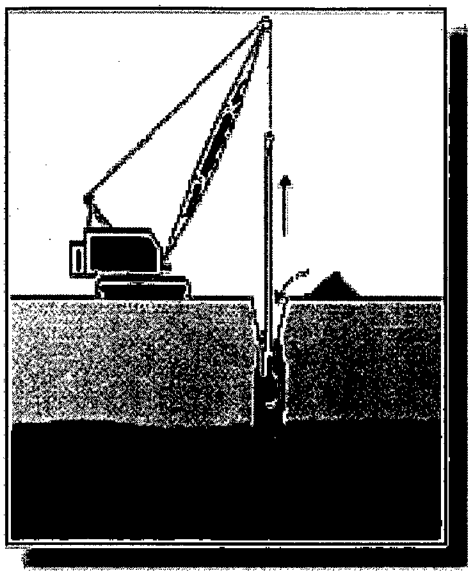

Figure 2.2: Vibroflotation

2.3.2 Vertical drains

The purpose of vertical drains is to increase the shear strength of the soil, to reduce the soil compressibility and to reduce the permeability of the soil prior to construction and placement of the final construction load and prevent large and/or differential settlements and potential damages to the structures. Because of its low permeability, the consolidation settlement of soft clays takes a long time to complete. To shorten the consolidation time, vertical drains are installed together with preloading either by an embankment or by means of vacuum pressure. Vertical drains are artificially-created drainage paths which are inserted into the soft clay subsoil. The Figure 2.3 is shown the preloading with vertical drains.

The vertical drain installation reduces the length of the drainage path and, consequently, accelerates the consolidation process and allows the clay to gain rapid strength increase to carry the new load by its own.

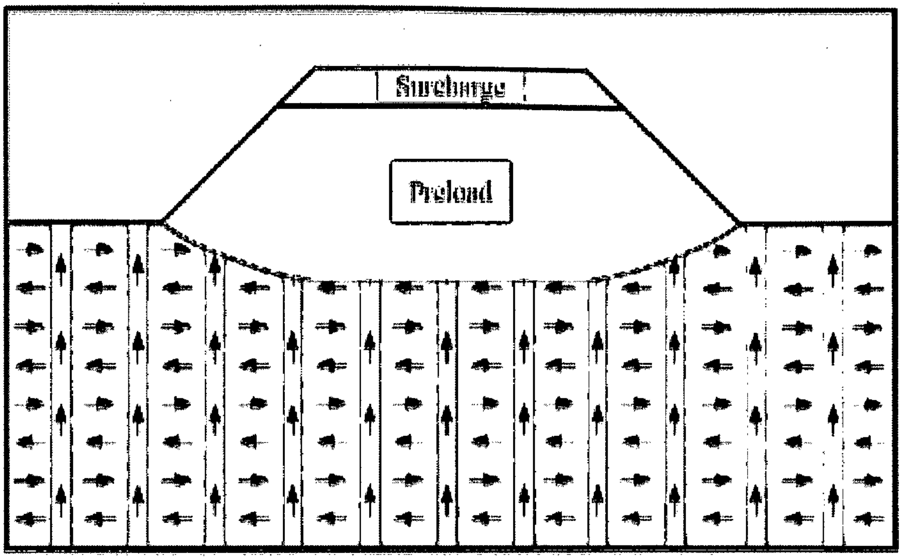

Figure 2.3: Preloading with vertical drains (Stapelfeldt, 2006)

2.4 Soil Stabilization by Using Admixture

The important engineering properties of soils can be economically improved by using admixture or stabilizer. The admixtures or stabilizers used include lime, Portland cement, asphalt, fly ash, polymers, salt (Sodium Chloride) and others. The procedure of soil stabilization involves the mixing of admixture with the soil with appropriate quantity which changes its soil properties and then applying adequate degree of compaction to the stabilized soil. This soil stabilization method is applicable for soils in the base courses of roads, airfield pavements, shallow foundation, etc. Larger quantities o additive are used when it is to improve the strength and durability significantly. After the additive has been mixed with the soil, spreading and compaction are achieved by conventional means (McCarthy, 2005)

2.4.1 Cement Stabilization

Soil stabilization by using cement as stabilizer was began with trial on Salisbury Plain in 1917. This technique has been accepted as the alternative to improve engineering properties of soil. Cement stabilization is still uncommon in Malaysia due to high cost comparing to the production cost of concrete mix and bituminous. The cement stabilization method most applied in the east Malaysia such as the Sabah's North and Labuk Roads where the mine gravel placed with the soil cement mixtures. The usage of cement in stabilized soil done in the Sandakan and Labuan road project is to reduce depending to crushed aggregate.

The cement particles will act as binding agent within the soil matrix. To increases the effective of cement stabilization, the mechanical compaction need to be done at the optimum moisture content. The moisture content required for the cement hydration is normally lower than the moisture content required to archive the maximum dry density. Numbers of experimental analysis have been done on the cement stabilized soil. Most of the experimental analyses investigated the shrinkage and cracking behaviors, strength characteristics and application in road works. Various studies have been done with different procedure and induced difficulties in making the comparison. However, compressive strength and durability were the two major concerns in the geotechnical engineering.

2.4.1.1 Type of Cement

Cement available at market or used in construction can be categorized into hydraulic and non-hydraulic cement. Hydraulic cement such as Portland cement due to the hydration process occurs independently with the water content. The hydraulic cement can harden when it is continuously exposed to wet weather. When the anhydrous cement powder is mixed with water, the chemical reaction will occur and produce hydrates which are non-soluble in water. Non-hydraulic cement such as lime and gypsum plaster must be kept dry in order to maintain its strength. Normally Portland cement is used in stabilized soil due to the availability in market and lower cost comparing to other types of cement. Portland cement is produced by heating limestone (calcium carbonate), with the other materials such clay at temperature about 1450 ^{o}C in kiln. In calcinations reaction, gas carbon dioxide is liberated from the calcium to form calcium oxide. Then, calcium oxide is blended with other materials to that have been included in mix to form Portland cement.

Cement as stabilizer in soil had been found effectively in stabilizing variety type of soil including granular materials, silts and clay. The cement stabilization method normally used in stabilizing pavement base, sub-base and subgrade construction. Soil-cement is a mixture that contains soil material and/or aggregates with certain amount of Portland cement and water that is compacted to high density. Sufficient amount of cement is added to produce a hardened material with the durability and strength required for construction activity. Cement stabilization improves the geotechnical properties of soil as below:

2.4.2 Lime Stabilization

Laboratory testing shows that lime reacts with fine-grained, moderately and medium soil to produce increased strength, increased workability and decreased plasticity (Little, 1995). The chemical reaction between the soil particles and lime will increase the strength of soil. These reactions happen in two phase which are immediate reaction and long term reaction. The initial reaction or modification phase of the chemical reaction is the immediate changes in soil properties and soil texture due to cations exchange. The lime which contains free ion calcium will discharge cations of clay mineral. This reaction will result in reduction of the diffused water layer surrounding the clay particles hence the clay particles will have a closer contact with another. The clay will transform into a more silt-like or sand-like material through the process of flocculation or agglomeration of the clay particles. Therefore the lime stabilization will produce a soil which is more compactable, workable, readily mixable and ultimately. In practically, all fine-grained soils will undergo flocculation reaction and cations exchange when soil treated with lime in the presence of water (Eades and Grim, 1960).

The lime stabilization method has a lot of advantages. First, by using lime stabilization method, the construction cost can be minimized. Lime stabilization is applied in-situ thus the cost for the transportation of the unsuitable soil from site and other materials to site is avoided. On the other hand, it also can reduce the construction traffic where minimize vehicle movement. Beside there, it also can minimize the waste generated by cutting and aggregate fill demand in construction site. Thus, the activity construction can be more environmental friendly.

2.4.2.1 Type of Lime

Various forms of lime have been successfully used as soil stabilizing agents for many years. However, the most commonly used products are hydrated high-calcium lime, monohydrated dolomitic lime, calcite quicklime, and dolomitic quicklime. Hydrated lime is used most often because it is much less caustic than quicklime; however, the use of quicklime for soil stabilization has increased in recent years mainly with slurry type applications. The design lime contents determined from the criteria presented herein are for hydrated lime. If quicklime is used the design lime contents determined herein for hydrated lime should be reduced by 25 percent (McCarthy, 2005).

2.5 Glass waste

Presently, the amount of solid wastes was produced in Kuantan is about 500 tons daily. These solid wastes will then being dumped at Jerangau Jabor Landfill, Kuantan (Zahari,Faizal and Armi, 2010). 3.7% of municipal waste of Malaysia is Glass (Ariyuki, 2006). Hence, 18.5 tons of glass waste will produced in Kuantan daily

Glass constitutes a significant part of solid waste produced in the society. Glass is primarily used for bottles or other containers for storing consumables and for drinking glass or windows. Compared to many other types of waste, glass is unique because it can be 100% recycle .Glass recycling in Malaysia is still in its infancy, less than 30% of glass recycled. (Carl and Chen, 2010). That means, more than 12.95 tons of glass haven recycled in kuantan daily. Soil stabilization by using glass waste will increase the percentages of glass recycled.

CHAPTER 3

METHODOLOGY

3.1 Overview

This research is qualitative research and does by experiment in laboratory. The method of research are:

1. Desk study : Gather information, collect secondary data, gather jpurnal with relation to this research and review those information and data.
2. Writing Research proposal : Write proposal as require by UMP Authority
3. Soil and material sampling : Collect soil sample and stabilizer material
4. Soil and material properties testing : Engineering properties test for soil sample and material such as, particle size analysis, specific gravity test, atterberg limit test, standard protor test.
5. Soil stabilization design and Soil Preparation
6. Soil strength test: CBR Test
7. Coding and Analyzing : Test result data coding and analyze follow the AASTHO,BS,ASTM and or Malaysia specification and support by computer and soft ware.
8. Discusion: Discuss the result validity.
9. Report writing : Report writing follow the UMP format.