EVALUATION OF PLASTICITY OF KUANTAN CLAYEY SOIL STABILIZED BY RECYCLE AND REUSE MATERIAL MIXED WITH LIME

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ABSTRACT

The main purpose of this study is to determine the utilization of reuse and recycle materials such as fly ash, bottom ash, glass and OPEFB ash in order to improve the strength of the soil. Soils that contain high plasticity index especially clayey soils, is the most common problem that occurs during the construction of pavement and highway, retaining wall, foundation and other type of construction projects. Soft subgrade soil does not have the quality engineering properties which can support the structures efficiently. In order to overcome the problem, the soils have to be stabilized so that the engineering properties of the soil will improve. There are many method of soil stabilization that can be use, such as mechanical method and chemical method. However, soil stabilization by using mechanical method is very costly. Therefore, method of stabilization by adding chemicals additives into the soil is one of the alternative methods that can improve the engineering properties of the soil and it is more economical. This study is done to evaluate the plasticity of Kuantan Clayey soil stabilized by recycle and reuse material mixed with lime, in order to determine the most optimum content of stabilizers that can be used to reduce the plasticity index hence improve the properties of the soil.

ABSTRAK

Tujuan utama kajian ini adalah untuk menentukan penggunaan bahan terguna dan kitar semula seperti abu terbang, abu dasar, kaca dan abu OPEFB untuk meningkatkan kekuatan tanah. Tanah yang mempunyai indeks keplastikan yang tinggi terutama tanah liat, adalah masalah yang paling biasa yang berlaku semasa pembinaan turapan dan lebuh raya, tembok penahan, asas dan lain-lain jenis projek-projek pembinaan. Tanah subgred lembut tidak mempunyai ciri-ciri kejuruteraan berkualiti yang boleh menyokong struktur secara cekap. Dalam usaha untuk mengatasi masalah itu, tanah perlu distabilkan supaya sifat-sifat kejuruteraan tanah akan bertambah baik. Terdapat banyak kaedah penstabilan tanah yang boleh digunakan, seperti kaedah mekanikal dan kaedah kimia. Walaubagaimanapun, penstabilan tanah dengan menggunakan kaedah mekanikal adalah sangat mahal. Oleh itu, kaedah penstabilan dengan menambah bahan kimia tambahan ke dalam tanah adalah salah satu kaedah alternatif yang boleh meningkatkan sifat-sifat kejuruteraan tanah dan ia lebih menjimatkan. Kajian ini dilakukan untuk menilai index keplastikan tanah liat di Kuantan dan distabilkan oleh bahan kitar semula dan guna semula dicampur dengan kapur, untuk menentukan kandungan yang paling optimum penstabil yang boleh digunakan untuk mengurangkan indeks keplastikan sekaligus memperbaiki sifat-sifat tanah.

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LIST OF SYMBOLS

g	Gram
kN	Kilonewton
mm	Millimetre
µm	Micrometer
%	Percentage
V	Velocity of fall of the spheres
G_s	Specific gravity of the sphere
G_f	Specific gravity of fluid (varies with temperature)
η	Absolute, or dynamic, viscosity of the fluid
D	Diameter of the sphere
cm/s	Centimetre per second

LIST OF ABBREVIATION

AASHTO	American Association of State Highway and Transportation
ASTM	American Society for testing and materials
CaO	Calcium Oxide
$Ca[OH]_2$	Calcium hydroxide
HMA	Hot Mix Asphalt
OPEFB	Oil Palm Empty Fruit Brunches
LL	Liquid limit
PL	Plastic Limit
P1	Plasticity Index
SG	Specific Gravity

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Soft subgrade soil is the most common problem that occurs during the construction of pavement and highway, retaining wall, foundation and other type of construction projects. Soft subgrade soil does not have the quality engineering properties which can support the structures efficiently. In order to overcome the problem, some methods are use, such as removing the soft soil and replacing it with stronger materials such as crushed rocks. This is the usual method that can be use to overcome the problem but very costly. Therefore, another method of soil stabilization is use as an alternative to improve the soil properties besides of using the high cost method. There are some additives such as Portland cement, lime, fly ash and bottom ash that can be used in order to improve the engineering properties of the soil. These additives can be used in variety of ways at any percentages and will cause distinctly dissimilar effects on different kind of soils. The benefits of using this method for soil stabilization is that it is more economical Moreover, these materials have been extensively tested and proved that it does not have any environmental impact.

1.2 BACKGROUND OF STUDY

The purpose of this research is to evaluate the plasticity of Kuantan Clayey Soil using recycle and reuse materials mixed with lime. The use of additives such as fly ash, bottom ash, lime and Portland cement for soil stabilization has been one of the options since many years ago. These additives when added into the soil, will reduce the plasticity of the soil. The design of pavement and highway, retaining wall and foundation is depend on the quality and type of the underlying soil and its capability to resist the shear stresses and to withstand the excessive loads from the structures to avoid deformation. Soil stabilization is the incorporation of the additives added into the subgrade in order to increase the strength of the soil and provide sufficient structural value for the structures. The reasons of stabilizing the subgrade soil is to ensure that the soil under the pavement will have lower deflections, better loads distribution and able to resist the consolidation of supporting soils. Moreover, stabilizes soils will provide a better platform for pavement or highway and other structures. Soft subgrade soils have lower stiffness compare to the soil that have been stabilized which causing it to deflect more, resulting failure on the pavement structures such as surface strains and eventual fatigue cracking of the pavement. The method of stabilization using the additives such as fly ash, bottom ash, Portland cement and lime involve physiochemical reactions between the soils and the additives. Therefore, the soils that have to be stabilized must be fine grained soil or cohesive soil.

1.3 PROBLEM STATEMENT

Soils which have soft subgrade is the common problem that have been encountered during the construction of pavement and highway. Soft subgrade is not capable to withstand the shear stress from the structure which may cause failure to the

structure. In order to overcome the problem, the soils have to be stabilized using additives so that the engineering properties of the soil will improve. This study is done to evaluate the plasticity of Kuantan Clayey soil stabilized by recycle and reuse material mixed with lime, in order to determine changes in engineering properties of the soil such as plastic index, liquid limit and shrinkage limit as the additives added into the soil.

1.4 RESEARCH OBJECTIVES

The objectives of this study are:

1. To evaluate the engineering properties such as plastic limit, liquid limit and Plasticity Index of Kuantan soil and clay stabilized by reused and recycle materials mixed with lime.
2. To determine the optimum content of stabilizers used to improve the properties of Kuantan clayey soil.

1.5 SCOPED OF STUDY

The scope of study will cover the theoretical investigation of plasticity of the stabilized soft clay mix with lime in Kuantan area. The scope can be divided into several areas:-

i. Study different type of soft clay stabilized method.
ii. Determine the particle soil analysis of the two different types of soils, which are S2 and S24 and also classifying the soils according to USCS method of classification.

iii. The soil sample and original soil mixed by using stabilizers with content (4%, 8%, 12%) by dry weight.

iv. Compare plastic limit, liquid limit and plasticity index of Kuantan clay after stabilized with recycle and reusable materials together with lime.

1.6 RATIONALE AND SIGNIFICANCE

Soil stabilization refers to the process of changing soil properties to improve strength and durability. The application of soil stabilization provides cost effective methods to improve the engineering properties of marginal or problematic soils. Soils stabilized with these materials have been extensively tested and do not have any adverse environmental impact. In fact, there is actually an added environmental benefit of reducing green house gas emissions and energy consumption by using less energy intensive materials like lime and cement.

The study will bring a significant endeavor in structural constructions as it is one of the methods that can be approach in order to stabilize the soil subgrade. By adding the additives into the soil, the engineering properties of the soil will be improve and capable to withstand higher shear stress from the structures.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter contains the discussion of the literature reviewed, during the investigation of soil stabilization with lime, fly ash, bottom ash and other reuse and recycle materials such as glass and OPFEB ash. The topics that include in this chapter are chemical modification and stabilization, reasons for stabilization, lime, Portland cement and fly ash and bottom ash.

The use of lime, Portland cement and fly ash to improve the pavement subgrade has been an option for decades. The designs of pavement structures depend on the underlying soils beneath it. The soil should have good engineering properties in order to withstand the shear stress and also to avoid excessive deformation cause by imposed loads. Soft subgrade soils usually do not have this criteria and therefore it require improvement by chemical stabilization or modification to become a sufficient load supporting material. The heterogeneity of soil properties like composition, soil structure, water interaction and overall variability require that site specific treatment and mix design development to be developed.

2.2 REASON FOR STABILIZATION

Soils under pavement have to be stabilized in order for it to have better load distribution, lower deflection and to resist consolidating of supporting soils. Soils that have been stabilized provide more stable platform for pavement structures.

The most common improvement achieve through stabilization include better soil gradation, reduction of plasticity index or swelling potential and increase in durability and strength. In wet weather, stabilization may also be used to provide a working platform for construction operations (Department of the Army, 1994).

Unstabilized soils have lower stiffness and will deflect more which causing high pavement strains and eventual fatigue cracking of the pavement. Stabilized soils will have higher stiffness, thus reducing pavement deflections which result in smaller surface strains and extended pavement life. Stabilization also prevents rutting because the subgrade soils will have less consolidation or movement.

2.3 TYPES OF ADDITIVES USED IN SOIL STABILIZATION

2.3.1 Lime

The lime in the form of quicklime (calcium oxide-CaO), hydrated lime (calcium hydroxide- $Ca[OH]_2$) or lime slurry can be used to treat soils. Hydrate lime is created

when quicklime react with water. It is hydrate lime that reacts with clay particles and permanently transform them into strong cementitious matrix ("National Lime Association", 2004). Lime generally improves the engineering performance of soils (Sujit&Monowar, 2012).

2.3.2 Fly ash

Fly ash is the finely divided residue resulting from the combustion of ground or powdered coal in electric generating plant (ASTM C 618). Fly ash has favorable properties such as light weight, high shear strength, high permeability, non plastic and has faster rate of consolidation and low compressibility. The main constituents of fly ash are oxides of silica, aluminum, iron, calcium and also magnesium. Due to its characteristics, fly ash has been widely use as road embankment and also to stabilize the subgrade soil (Kim, Prezzi, Salago, 2005).

Fly ash is most commonly used as a pozzolan in PCC applications. Pozzolans are siliceous or siliceous and aluminous materials, which in a finely divided form and in the presence of water, react with calcium hydroxide at ordinary temperatures to produce cementitious compounds.The unique spherical shape and particle size distribution of fly ash make it a good mineral filler in hot mix asphalt (HMA) applications and improves the fluidity of flowable fill and grout. The consistency and abundance of fly ash in many areas present unique opportunities for use in structural fills and other highway applications ("American coal ash association", 2008).

Table 2.1: The engineering properties of fly ash.

PARAMETERS	TEST RESULTS
Specific Gravity (G)	2.06
Sand Size (%)	14.96
Clay Size (%)	1.62
Silt Size (%)	83.42
Plasticity Index, PI (%)	Non-Plastic
Maximum Dry Density, MDD (kN/m3)	12.40
Optimum Moisture Content, OMC (%)	24.50

2.3.3 Bottom ash

Bottom ash is collected at the end of the grate in a Waste-to-Energy plant. It consists of non-combustible materials, and is the residual part from the incineration of household and similar waste. Raw bottom ash is a granular material that consists of a

mix of inert materials such as sand, stone, glass, porcelain, metals, and ash from burnt materials ("Confederation of European Waste-to-Energy Plants," 2008).

Bottom ash is a product of combustion of coal. The main producer of bottom ash is the coal fired power plants, which burn a very high volume of coal annually to generate electricity. The physical characteristic of bottom ash is grey to black in color quite angular, and has a porous surface structure. Bottom ash is widely used as filler materials for structural applications and embankments and also as aggregate in road bases, sub basses and also pavement.

2.3.4 Crushed Glass

Recycled glass is a mixture of different colored glass particles and is often comprised of a wide range of debris (mainly paper, plastic, soil, metals, and food waste). The presence of different colored glass particles and diverse types of debris are the primary obstacles in reusing recycled glass in bottle production industries. Recycled glass particles are generally angular shaped and contain some flat and elongated particles. (Disfani, Arulrahah, Bo, & Hankour, 2011)

Table 2.2: Geotechnical properties of recycled glass samples.

Test	FRG	MRG	CRG
Specific gravity	2.48	2.5	2.5
Flakiness index	N.A	85.4	94.7
Debris level (visual method) (%)	7	5	3
Debris level (weight method) (%)	1.23	2.01	2.98
Organic content (%)	1.3	0.5	0.23
pH value	9.9	10.1	9.6
Standard proctor cd, max (kN/m3)	16.7	18	N.A
Wopt (%)	12.5	9	N.A
Modified proctor cd, max (kN/m3)	17.5	19.5	N.A
Wopt (%)	10	8.8	N.A
LA abrasion value (%)	24.8	25.4	27.7

Source: (Disfani, Arulrahah, Bo, & Hankour, 2011)

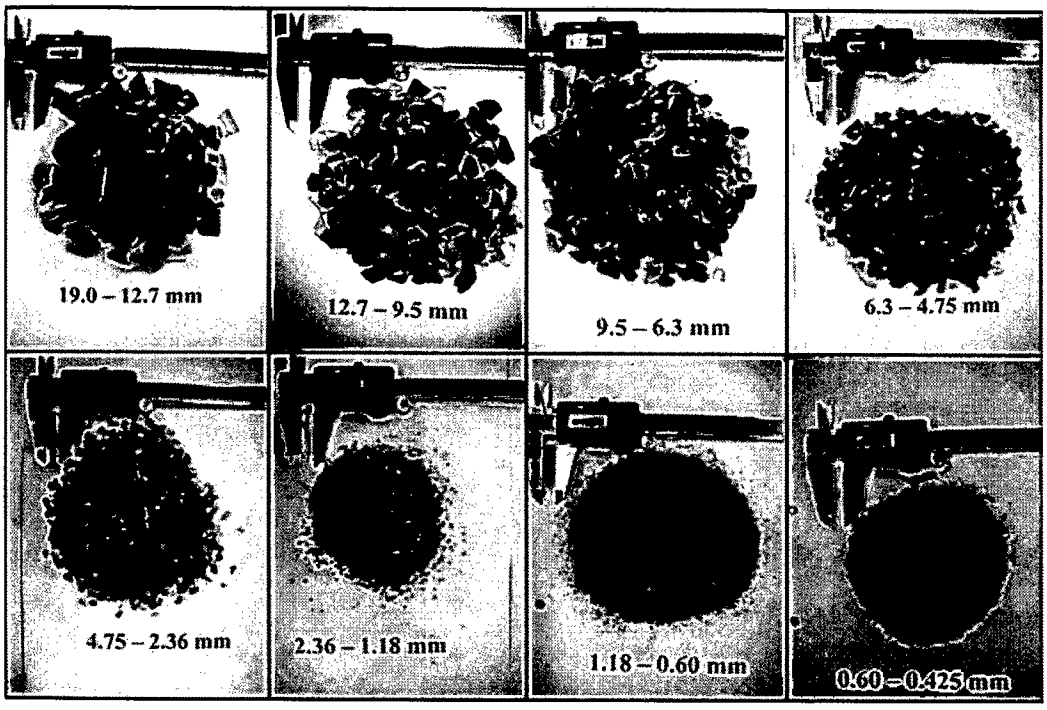

Figure 2.1: Change of glass particles shapes by size for CRG sample.

Source: (Disfani, Arulrahah, Bo, & Hankour, 2011)

2.3.5 STABILIZATION OF SOILS WITH LIME

In general all lime treated fine grained soil will exhibit decreased plasticity, improved workability and reduce volume change characteristics. However, not all soils exhibits improved strength characteristics. It should be emphasized that the properties of soil lime mixtures are dependent on many variables such as soil types, lime type,

lime percentage and curing condition which are very important ("Department of the Army", 1994).

Lime stabilization significantly changes the characteristics of a soil to produce long term permanent strength, and stability particularly with respect to the action of water and frost. Lime can permanently stabilized fine grained size soil employed as a subgrade or subbase to create a layer with structural value in the pavement system ("National lime association", 2004).