EVALUATION OF CALIFORNIA BEARING RATIO OF KUANTAN CLAYEY SOILS STABILIZED BY RECYCLE AND REUSE MATERIAL MIXED WITH PORTLAND CEMENT

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ABSTRACT

California Bearing Ratio (CBR) test is a common test that had been used especially in Highway Engineering to find the soft sub-grade strength in pavement design. But most civil engineer always faced difficulties in obtained suitable soil stabilization to make the soft sub-grade have high CBR value. The main objective of this study is to evaluate the California Bearing Ratio (CBR) of the Kuantan clayed soil and to select the most suitable additive that can be used as soil stabilization. In this study there are two phases of the laboratory testing which phase one is engineering properties of the soil. From this test we will get the plastic limit (PL), liquid Limit (LL), and plasticity index (PI) of the soil. In this phase also the sieve analysis of the soil is carried out. For the phase one, all the data will be compared and referred to the AASHTO and USCS standard as a guideline. The California Bearing Ratio (CBR) test will be carried out on phase two. In this phase, the procedure of the California Bearing Ratio (CBR) test procedure will be referred to BS 1277-4 1990 standard. From CBR test we will get the average CBR value needed to evaluate and compare with others in order to select the highest CBR value that can be recommended to be used as additive to the soil sample.

ABSTRAK

Nisbah Galas California (CBR) ujian adalah ujian yang sama yang telah digunakan terutamanya dalam Kejuruteraan Lebuh Raya untuk mencari kekuatan yang lembut sub-gred dalam reka bentuk turapan. Tetapi kebanyakan jurutera awam sentiasa menghadapi kesukaran dalam penstabilan tanah yang sesuai diperolehi untuk membuat lembut sob gred mempunyai nilai CBR yang tinggi. Objektif utama kajian ini adalah untuk menilai Nisbah Galas California (CBR) daripada tanah clayed Kuantan dan untuk memilih bahan tambahan yang paling sesuai yang boleh digunakan sebagai penstabilan tanah. Dalam kajian ini ada mempunyai dua fasa ujian makmal yang fasa satu sifat kejuruteraan tanah yang dari ujian ini kita akan mendapat had plastik (PL), Had cecair (LL) dan indeks keplastikan (PI) daripada tanah. Dalam fasa ini juga analisis penapis tanah dijalankan. Bagi fasa pertama, semua data akan dibandingkan dan dirujuk kepada AASHTO dan USCS standard sebagai panduan. Nisbah Galas California (CBR) ujian akan dijalankan pada fasa kedua. Dalam fasa ini, tatacara Nisbah Galas California (CBR) prosedur ujian akan dirujuk kepada BS 1277-4 1990 standard. Daripada ujian CBR akan mendapat purata nilai CBR perlu menilai dan perlu membandingkan dengan orang lain untuk memilih yang paling tinggi nilai CBR nilai yang boleh disyorkan untuk digunakan sebagai tambahan kepada sampel tanah.

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LIST OF SYMBOL

CBR	-	California Bearing Ratio
HDPE	-	High-density Polyethylene
LL	-	Liquid limit
PL	-	Plastic limit
PI	-	Plasticity index

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

In civil engineering works such as construction of dam, building, highway and other structures need a strong soil base layer to make the structure strong and stable for a long term. If there is a weakness and failure of the soil base layer, then it may capable cause the structure builds above of it fall and collapse. Therefore, the proper soil analysis is important in order to test the soil strength and ensure the structure remain safe and free endure settling.

In highway construction, many places in the world face a problem which is a soft grade in the construction of roadways. Because of this, many test and analysis of soil was done by all researchers. One of the test that can carry on to test the soil sub base strength is by California Bearing Ratio (CBR). California Bearing Ratio (CBR) is mostly used index test value for civil engineer particularly in those pavement constructions to assess the stiffness modulus and shear strength of subgrade. It is actually an indirect measure which represents comparison of the strength of subgrade material to the strength of standard crushed rock quoted in percentage values. The method was originally developed at California Division of Highways in 1930s to provide an assessment of the relative stability of fine crushed rock base material.

Nowadays, California Bearing Ratio is not something new to civil engineers in Malaysia especially for highway construction which involved in road pavement works. Usually, the CBR values are used by pavement engineers to design the thickness of pavement that will be laid on top of the subgrade. Subgrade that has higher CBR value will have thin pavement compared with the subgrade that has lower CBR value because high CBR value of soil have strong subgrade layer. In other words, CBR value affects much the design of pavement of the subgrade. Moreover, the different of soil types also will give different values of CBR although it is compacted at the same amount of energy and rate of penetration. So, it will need much soil sample to test compared to the CBR value.

The alternative method of highway construction has been explored by highway contractor because of the high cost of replacement on the soft sub grade. Used of chemical is one of the approaches to stabilize the soft sub grade. By using chemical product, bottom ash and fly ash are some of the residues that offer economical alternatives for a wide range application of soil stabilization.

The result of laboratory investigation on recycle and reuse material mixed with Portland cement (PC) – soil mixture was demonstrates in this paper work. There are two type of clay sub-grades from random places in Kuantan which is S2 and S24 were used in this research. The strength properties of the soil-PC, soil-PC-HDPE, soil-PC-Crushed glass, soil-PC-carpet fiber, soil-PC-fly ash mixtures and the optimum mixture contents which can achieve better preferred sub-grade was determined by The California Bearing Ratio (CBR) tests. The HDPE, crushed glass, carpet fiber, fly ash were prepared at 4%, 8%, 12% specimens and then the variation content of PC which is 2%, 4%, 6% of the total weight of the soil and the optimum water content were mixed together. Before the CBR test were performed, the sample were compacted 56 blows in each 5 layers by using standard Proctor effort in a Proctor mold (152mm in diameter and 178mm long) and then the CBR test is performed. The CBR test was based on BS 1277-4 1990 standard. The effects of High-density Polyethylene (HDPE), crushed glass, carpet fiber,

PC, fly ash then mixed with PC stabilization on strength properties are discussed in this paper to get the CBR value in each mixture.

1.2 PROBLEM STATEMENT

The difficulties to obtain the CBR value for pavement design are always encounters by civil engineer. In Malaysia, inadequate soil investigation data due to budget constraint and poor planning of soil investigation work are frequently happened. There are no established correlations of CBR value with that can help our engineer to predict the CBR value for Malaysia soil type. So, the laboratory work should be done for getting the CBR value. It will take high cost for the highway construction. In addition, the laboratory CBR test required a relatively certain clay soil sample. Therefore, if there is established correlation between CBR and suitable additive which is reuse material that added with sample with Portland cement as main additive, they will reduce the cost and number of CBR test to be performed. This study will help an engineer to choose appropriate correlation which is suitable to be used for Malaysia type of soil.

1.3 SCOPE OF THE STUDY

In order to ensure the precision of the study area, this study is done on the specific scope and it also done to achieve the objective of this study. Therefore, there are limited specific scopes which are:

a) Site Location

In this study, the location was limited in two places, which is at Kuantan, Pahang. The soil were taken near to the main road at Felda Lepar Hilir 2. Another one is taken from the Kuantan Bricks Sdn.Bhd at Felda Panching Timur.

b) Scope of Work

The sample that was taken from the site is tested in the laboratory. Then sample were prepared at the optimum water content for the sub base condition by perform the compaction test. The strength properties and the optimum mixture content of the soil-recycle and reuse material mixed with PC were determined by performed The California Bearing Ratio (CBR) test.

1.4 OBJECTIVES

The study objectives are:

I. To evaluate the Engineering Properties of Kuantan Clay

II. To evaluate the change of California Bearing Ratio (CBR) of Kuantan Clay soil and stabilized the Kuantan Clay soil.

III. To determine the optimum content of stabilizer that produced maximum California Bearing Ratio of Kuantan clay stabilizer soil.

1.5 EXPECTED OUTCOME

I. Will get the Atterberg limit of the clays

II. Will get the California Bearing Ratio (CBR) strength of the Kuantan Clay soil

III. Will get the optimum content of the stabilizer which is suitable and give the high strength of California Bearing Ratio (CBR).

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Bearing capacity is very significant in the Geotechnical Engineering. It is important to analyze the load value of the bearing capacity which is support before the construction work is proceed. So, the sample and the data provide will help to calculate the value of the bearing capacity. There are many cases that show the failure of the soft sub-based which cannot support the load that exerted to it. Therefore, it needs an efficient method to overcome these problems such as use the compaction process or consolidation process that can influence the bearing capacity of the soil. The road construction also faces the same problem. Before the construction work is proceed, the subgrade soil need to run the soil investigation to evaluate the condition of the soil before laying up the road above it. To conclude, by running up the soil investigation, the evaluation can help us to analyze whether the soil can support the load or not.

2.2 CALIFORNIA BEARING RATIO

The California Bearing Ratio (CBR) is defined as the ratio of the resistance to penetration of a material to the penetration resistance of a standard crushed stone base material. The ratio has been used as an empirical measure of the road subgrade strength. The method was developed by the California Division of Highways in 1930s as part of their study in pavement failure.

The CBR ratio was originally established to provide an assessment of the relative stability of fine crushed rock base material. Then the use of CBR test was extended to assessment of subgrade material. It is primarily intended for, but not limited to, evaluating the strength of cohesive materials having maximum particle sizes less than 19 mm (0.75 in.). Since its establishment in 1930s, it has been widely used by many countries and considerable experience has been developed ever since then. Ironically, the method was for pavement design in California for only a few years, and was superseded by the Hveen Stabilometer test (Carter and Bentley, 1991). Figure 2.1 shows the typical sample of CBR.

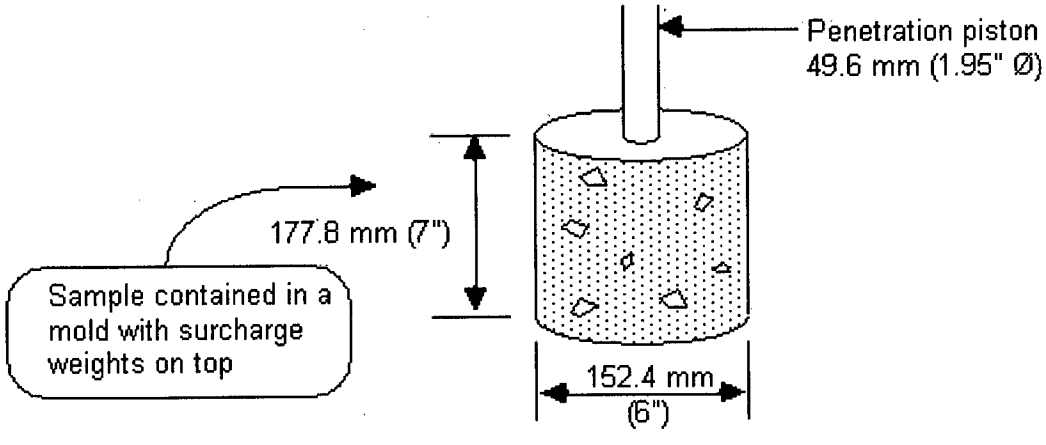

Figure 2.1: Typical CBR sample

2.3 CLASSIFYING CBR VALUE TO THE STRENGTH OF THE SUBGRADE

Table 2.2 shows the relationship of CBR value with the strength of subgrade. With the condition of strength classified, it also guides on how to face the condition of the subgrade.

Table 2.1: CBR value classification in term of strength of subgrade

CBR value, %	Subgrade strength	Needs
< 3%	Weak	Need to be covered Minimum thickness of subbase is 150mm
3% - 5%	Normal	Cover if needed follows the road categories Minimum thickness of subbase is 80mm
5% - 15%	Good	No need to cover unless the vehicle loading is high Minimum subbase is 0mm

2.4 SOIL CLASSIFICATION

In geotechnical engineering, basically soil can be separated into three board categories; cohesionless, cohesive and organics soil. These three terms always has been use widely by engineer to distinguish between the different types of soils. In the term of grain size, soil can also be separated into two categorize which is course-grained soil and fine grained soil.

In order to be able to describe, in general, a specific soil without listing value of its many soil parameter, it would be convenience to have some kind of generalized classification system. Some soil classifications systems are available at present i.e. Unified Soil Classification System (USCS), Association of State Highways and Transportation Officials (ASSHTO), and British Soil Classification System (BSCS). For highway work, the ASSHTO soil classification system is widely been used. In this research ASSHTO soil classification will be used as the guideline.

Distribution of the grain size can be determine by sieve analysis for the cohesionaless soils. Generally, it is a screening processes in which coarse fraction of soil are separated by means of series of U.S Standard Sieves Number. Table 2.2 show the soil classification of ASSHTO and USCS system based on grain size.

Table 2.2: Soil Classification based on Grain Size

	Agency	ASSHTO	USCS
Coarse-Grained	Gravel	75-2.00mm (3 in. – No. 10 sieves)	Coarse : 75-19.00mm (3 in. – ¾ in. sieves) Fine : 19-4.74mm (¾ in. - No.10 sieves)
	Coarse Sand	2.00 – 0.425mm (No. 10 – No. 40 sieves)	4.74 – 2.00mm (No. 4 – No. 10 sieves)
	Medium Sand		2.00 – 0.425mm (No. 10 – No. 40 sieves)
	Fine Sand	0.425 – 0.075mm (No. 40 – No. 200 sieves)	0.425 – 0.075mm (No. 40 – No. 200 sieves)
Fine-Grained	Silt	0.075 – 0.002mm	Fines < 0.075mm (silt or clay)
	Clay	< 0.002mm	

For the case of cohesive soil, the distribution of grain size cannot be determined by sieve analysis because the particles of soil are too small. The particles sizes may be determined by the hydrometer method, which is a process for indirectly observing the settling velocities of the particles in soil water mixture. However, this test is more complicated and difficult to conduct. Another technique for analyzing cohesive soils is by use of Atterberg Limit.

2.5 ATTERBERG LIMITS

The Atterberg limits are the basic measure of the nature of a fine-grained of the soil. The fine-grained soil may appear in four states: solid, semi-solid, plastic and liquid (as shown as Figure 2.2). In each state the consistency and behavior of a soil is different and so are its engineering properties. Thus, the boundary between each state can be defined based on a change in the soil's behavior.

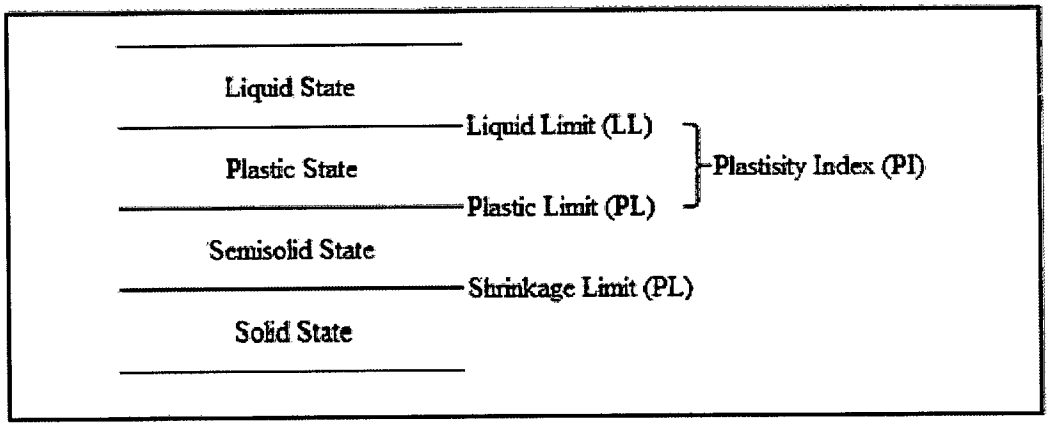

Figure 2.2: Atterberg Limits

The plastic limit (PL) signifies the percentage of moisture at which the sample changes, with decreasing wetness, from a plastic to a semisolid state (ASSHTO designation T90-70). In other word, the plastic limit (PL) is the water content where soil starts to exhibit plastic behavior. A thread of soil is at its plastic limit when it is rolled to a diameter of 3 mm or begins to crumble. To improve consistency, a 3 mm diameter rod is often used to gauge the thickness of the thread when conducting the test.

The liquid limit (LL) signifies the percentage of moisture at which the sample changes, with decrease in moisture, from a viscous or liquid state to a plastic state (ASSHTO designation T89-68). In other word, liquid limit is the water content where a soil changes from plastic to liquid behavior.

The plasticity index (PI) is the measure of the plasticity of a soil. The plasticity index is the size of the range of water contents where the soil exhibits plastic properties. It also stated as a percentage of dry weight. The PI is the difference between the liquid limit and the plastic limit (PI = LL-PL). Soils with a high PI tend to be clay, those with a lower PI tend to be silt, and those with a PI of 0 tend to have little or no silt or clay. According to Brady and Nyle (1974), the soil will become plastic when it have percentage of clay exceed 15%, which is the soil have ability to be moulded without fracturing.

The liquidity index (LI) is used for scaling the natural water content of a soil sample to the limits. It can be calculated as a ratio of difference between natural water content, plastic limit, and plasticity index as shown as Equation 2.1.

$$LI = \frac{(w-PL)}{(LL-PL)} \quad \textbf{(2.1)}$$

Where LI is the liquidity index, w is the natural water content, PL is the plastic limit and LL is the liquid limit

2.6 SOIL STABILIZATION

Stabilization of soil with a low bearing capacity is an economical way to strengthen the earth for building purposes and to diminish the amount of soil exchanges. The process of soil exchange is employed in establishing roads, pipelines, and buildings by removing low bearing soils and replacing them with, for example, gravel, crushed rock, or lightweight aggregates to increase the load bearing capacity. Relocating the mass exchange material is an increasing problem because it is difficult to maintain the stability of hills and slopes made of low-strength soils. Through stabilization it is possible to use soil material from foundation excavation and leveling of building sites as earth building material and to save gravel sources and transport costs. (Heikki Kukko, 2000).