SOIL CBR IMPROVEMENT BY FLY ASH WITH RELATION TO PAVEMENT THICKNESS, CASE STUDY IN LEPAR HILIR, KUANTAN

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ABSTRACT

Increasing rate of traffic load will influence the highway construction technology revolution. It is because of continuation rapid growing in economic activities and technology. Therefore it is necessary to produce high durability and serviceability of road structure as the main of an objective. Subgrade layer is the most important component which influences the stability of the road structure. The good subgrade can influence the thickness of road structure, strength and the cost in construction stage. California Bearing Ratio (CBR) is a commonly used indirect method to assess the stiffness modulus and shear strength of subgrade in pavement design work. Basically, subgrade must be stable in performance to carried load in any weather. Method that used in strengthening the subgrade structure is soil stabilization. The method used in this study is adding with fly ash as admixture to improve CBR value. Hence, the thickness of pavement structure can be decrease when CBR value is increase. As a result, the cost of construction a road pavement will decrease and more economically.

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LIST OF SYMBOLS AND ABBREVIATIONS

AASHTO	-	American Association of State Highway and Transportation Officials
ADT	-	Average daily traffic
ASTM	-	American Society for Testing and Materials
CBR	-	California Bearing Ratio
CD	-	Consolidated drained
CU	-	Consolidated undrained
CU'	-	Consolidated undrained with pore water pressure measurements
ef	-	equivalence factor
ESAL	-	Total Equivalent Standard Axle Load
JKR	-	Jabatan Kerja Raya
LL	-	Liquid limit
n	-	Design period (years)
□$_{op}$	-	Optimum moisture content
Pc	-	Percentage of commercial vehicles
PI	-	Plastic index
PL	-	Plastic limit
r	-	Estimate the rate of annual traffic growth
SSA	-	specific surface area
T_A	-	Equivalent thickness
UU	-	Unconsolidated undrained
V_c	-	The total number of commercial vehicles
V_o	-	The initial yearly commercial vehicle traffic
$\gamma_{d.max}$	-	Maximum dry density

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Soil stabilization is the alteration of soil properties to improve the engineering performance of soils. The properties most often altered are density, water content, plasticity and strength. Modification of soil properties is the temporary enhancement of subgrade stability to expedite construction. Soils must be compacted to their maximum practical density to provide a firm base for overlying structures. For soils to be compacted the moisture content must be controlled because of the relationship between soil density and moisture content. If the soil to be compacted is either to wet or too dry, the moisture content must be adjusted to near optimum to achieve maximum density. If a soil is too dry, moisture is simply added. If a soil is too wet, the moisture content of the soil must be lowered.

A highway is a main road for travel by the public between important destinations, such as cities, large towns, and states. Highway designs vary widely and can range from a two-lane road without margins to a multi-lane, grade-separated expressway, freeway, or motorway. Daily human activity is depending on the highways. Highways are the most important part of the automobile industry. If there were no roads or highways there would be any need for automobiles. Highways can be large or small in the number of lanes available in each direction. Highways can consist of tunnels, bridges and even ferries.

Geotechnical engineering has been critically to highway construction since engineers realized that successful civil works depended on the strength and integrity of the foundation material. Road design and construction over soft ground especially over very soft and marine deposits are interesting engineering challenges to engineers especially at the approaches to bridges and culverts. Many geotechnical options are available for engineers' consideration. The soils are very soft and soft deposits of river alluvium and marine deposits common in Southeast Asia. The river alluvium and marine deposits normally consists of clay, silt clay and occasionally with intermittent of sand lenses especially near a major river mouth and delta. The marine deposits in Malaysia are encountered along the coast of the Peninsular, where they up to 20km in width. Cross-section of a typical flexible pavement is illustrated in Figure 1.1.

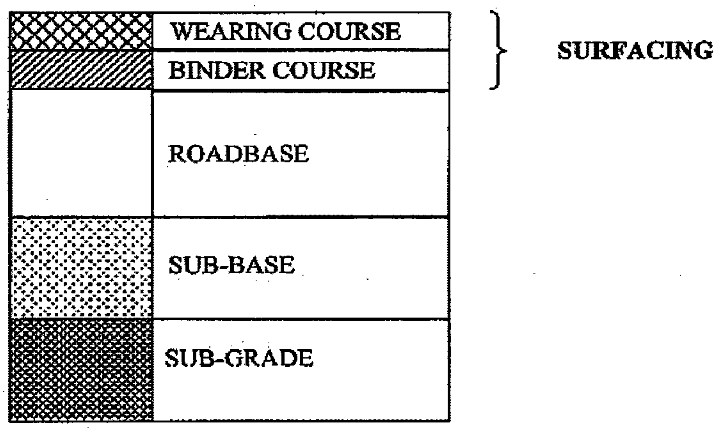

Figure 1.1: Typical section of flexible pavement (Rahim, 2007)

Pavement evaluation technique plays very important rules in determining the flexible pavement condition. The choice of equipment, information quality requirement, accuracy, method of analysis and techniques uses will contribute to the accuracy of the findings, thus will also influence the decision in determining the rehabilitation methods. Initial assessment of the physical pavement condition can be carried out through visual assessment on the flexible surface condition and drainage assessment. Detailed assessment including sampling and fields test can be scheduled as and when required depending on the nature of the failures.

Embankment design of roads needs to satisfy two important requirements among others; the stability and settlement. The short term stability for embankment over soft clay is always more critically than long term simply because the subsoil consolidates with time under loading and the strength increases. In design, it is very important to check for the stability of the embankment with consideration for different potential failure surfaces namely circular and noncircular. It is also necessary to evaluate both the magnitude and rate of settlement of the subsoil supporting the embankment when designing the embankment so that the settlement in long term will not influence the serviceability and safety of the embankment.

In many sub-tropical and tropical arid regions of the world, marl soils (marls) and lime or cement stabilization of marl soils are used as a convenient and expedient means of developing foundation base courses and inexpensive wearing courses for transport purposes. The failure of many of these natural and stabilized marls to perform their function has been reported. Mechanical factors commonly used to explain the causes of the foundation failures are unsatisfactory and have not been accepted. This study uses physicochemical (reaction) factors to explain the general basic causes of the deterioration of support capability for these types of soils.

The presence of palygorskite and sepiolite in marl soil provides it with some very unique features in its natural state, particularly when it is stabilized with lime or cement. The formation of an expansive mineral, ettringite, as a transformation product of palygorskite increases the swelling potential of the stabilized soil. A set of physic chemical and mechanical experiments, which include slake durability, specific surface area measurement (SSA), California bearing ratio (CBR), Atterberg limits testing were performed.

1.2 Problem statement

Nowadays in Malaysia, there are so many constructions of highways. Since highways also involve foundation, these means geotechnical aspects are also important in the highway construction. Shear strength parameters are always associated with the bearing capacity of the soil. However for highways engineers, they always prefer to use CBR test to determine the suitable strength for designing road pavement. In order to make the construction of highway is economical the engineer must design the best thickness from lower layer of subgrade to surface course.

The cost of materials is decrease from top to bottom which is from surface coarse to subgrade. This means the engineer must design the less thickness for surface coarse layer and more depth for subgrade layer. So that this study was carried out as to find the improvement of CBR value in soil by using fly ash with relation to reduce pavement thickness.

These are the real culprits of surface deterioration; the ultra-violet rays of the hot sun cause oxidation and the aggregate material to protrude from the surface, making the pavement rough. The surface becomes brittle, cracks develop and the pavement deteriorates. Gasoline, oils, and fuels dissolve asphalt causing it to soften or even worse fail. Water in the underlying soil may make it unable to resist even ordinary loads. As the soil yields way, the pavement begins to crack and deteriorate. As time goes by, freeze-thaw cycles widen the cracks, letting in even more water and the problem continues to worsen at an accelerated pace.

1.3 Objectives of the study

The study is carried for the following objectives;

i. To determine the engineering soil properties in Lepar Hilir;
ii. To determine the optimum content of fly ash in soil that improve CBR value;
iii. To determine the suitable thickness of pavement after added by fly ash, based on JKR standard and cost of pavement.

1.4 Scope of study

The sample used in this research only involved soils from Lepar's areas. The samples for this research are based on compaction sample. This study is done based on the specified scope in order to ensure the precision of the study area. It is also done in order to achieve the objective of the study. Therefore, its limit has been specific scopes which are:

a) Location of site
The location of this study is limited in areas of Lepar which are soils taken from Felda Lepar Hilir that near to main road and from Felda Lepar Hilir 2.

b) Scope of work
In this study, the aim is to measure the value of CBR and its effect to pavement thickness. After adding fly ash as an admixtures in the soil samples, test the sample to get its properties such Atterberg limit and maximum dry density.

1.5 Significant of study

From this study, this research will narrow the gap of understanding on soil strength for the geotechnical and highway engineer. Since these two different disciplines in civil engineering have their own understanding on the use of the soil parameters in design, it is appropriate some basis for interpretation of CBR in terms of shear strength parameters and vice versa.

CHAPTER 2

LITERATURE REVIEW

2.1 Pavement components and materials

A flexible pavement is a layers consisting of the following components;

a) Pavement surfacing
b) Road base
c) Sub-base
d) Sub grade

2.1.1 Pavement surfacing

The surfacing is the upper layer of the pavement, which provides the following functions;

a) To provide an even, non-skidding and good riding quality surface
b) To resist wear and shearing stress imposed by traffic
c) To prevent water from penetrating into the underlying pavement layers

d) To be capable of surfacing a large number of repeating loading without distress
e) To withstand adverse environment condition

Bituminous surfacing consists of crushed mixed aggregate, bitumen and filler and the most common type of plant mixed surfacing are asphaltic concrete or bituminous macadam. Thick bituminous surfacing can provide additional strength to the existing pavement structure but the thin resurfacing, which is less than 50mm thickness does not give direct additional strength. It merely protects the pavement from water infiltrate and improve skid resistant.

2.1.2 Road-base

The road-base is the main structural layer of the pavement, which spread the load from heavy vehicles thus protecting the underlying layer. The function of this layer is to reduce the compressive stress in the sub-grade and sub-base to an acceptable level to avoid cracking on surfacing layer. The road-base is commonly constructed using unbound crushed aggregate as this material is readily available in most area in Malaysia.

2.1.3 Sub-base

The sub-base is the secondary load-spreading layer underlying the road-base. The materials used for this layer is normally consists of lower grade granular materials as compared to the road-base materials. This layer also serves as a separating layer preventing contamination of the road-base by the sub-grade materials as well as a drainage layer. Sand and laterites are commonly used as the sub-base and are easily available.

2.1.4 Sub-grade

Sub-grade is referred to the soil under the pavement within a depth of approximately 1.0 mater below the sub-grade. It can be either be natural undisturbed soil or compacted soil obtained from elsewhere and placed as filled materials. The strength of this layer is important in determining the thickness of the upper layers.

2.2 Particles size analysis

Particles size analysis is commonly known as sieving test or mechanical test. This test can determine the range of size of particles in the soil sample and the percentage of particles in each of the sizes between the maximum and minimum. In this test, a series of standard test sieves by having different-size- opening are stacked with the larger with the larger sized over the smaller. The soil sample in the sieving aperture is vibrated mechanically with the minimum period of 10 minutes. In each sieving apertures, the mass of retaining soil is determined and the percentage of mass passing of each sieve id computed. A grading curved is plotted on a semi logarithmic coordinates, where sieving aperture sizes is on horizontal logarithmic scale and the percentage of soil mass passing is on vertical arithmetic scale. Normally, the grading curves are obtained from dry and wet sieving methods.

The grading curves will render the characteristic of the soil samples, which range the size particles from coarse-grained to fine grained sizes. The flatter the distribution curve indicated the larger range the particles in the soils; the steeper curve implies the smaller the size range.

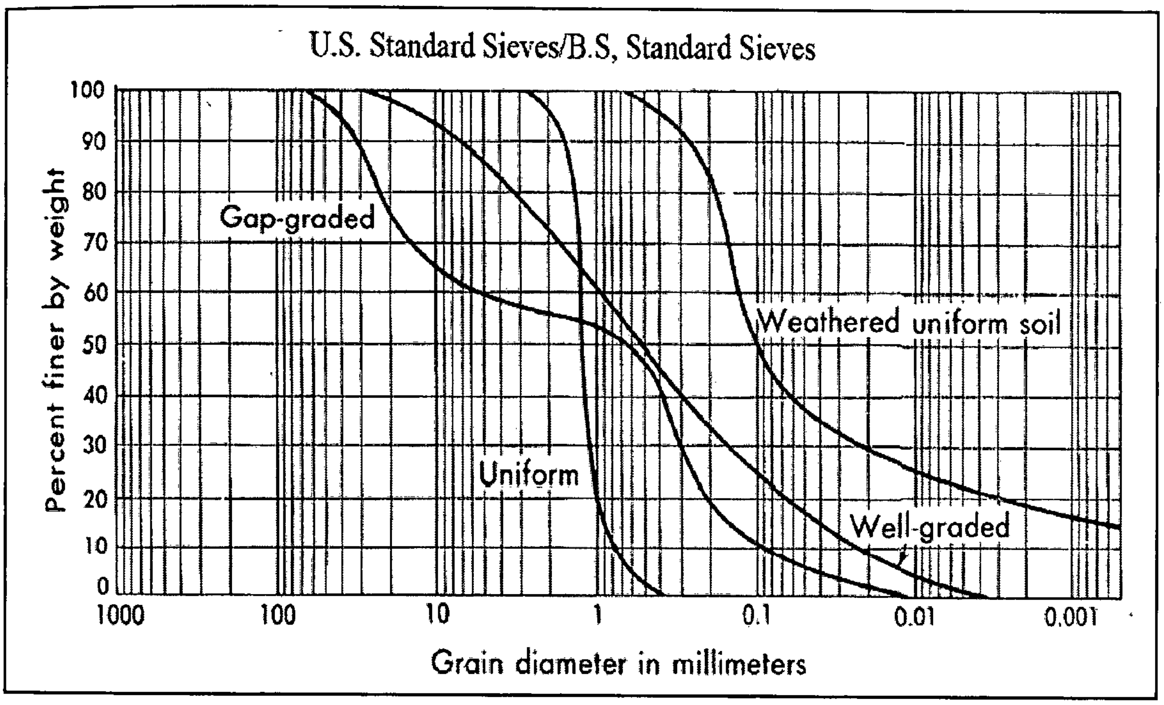

Figure 2.1: Typical particle size distribution curves (Jeremy, 2006)

Well-graded soil is a distribution of over relatively large range of sizes, which no excess or deficiency of particles in any size range and no lacking of intermediate size. *Poorly graded* is cited to the soil if a high proportion of the particles have narrow limit (a uniform soil) or if of both large and small sizes are present but with a relatively low proportion of particles of intermediate size (a gap-graded soil).

2.3 Atterberg Limits

Soil will display the properties of plasticity and cohesiveness if the containing fines (silt and clay). This property depends on amount and mineralogy of the fines and amount of water present, or moisture content. In remoulded state, the consistency of clay varies in proportion to the water content, at high water content, the soil will be in liquid state; at moderate water content, the volume of soil will be decrease and still show the properties of a plastic; at still lesser water content, the soil becomes on semi-solid state and finally as a solid.

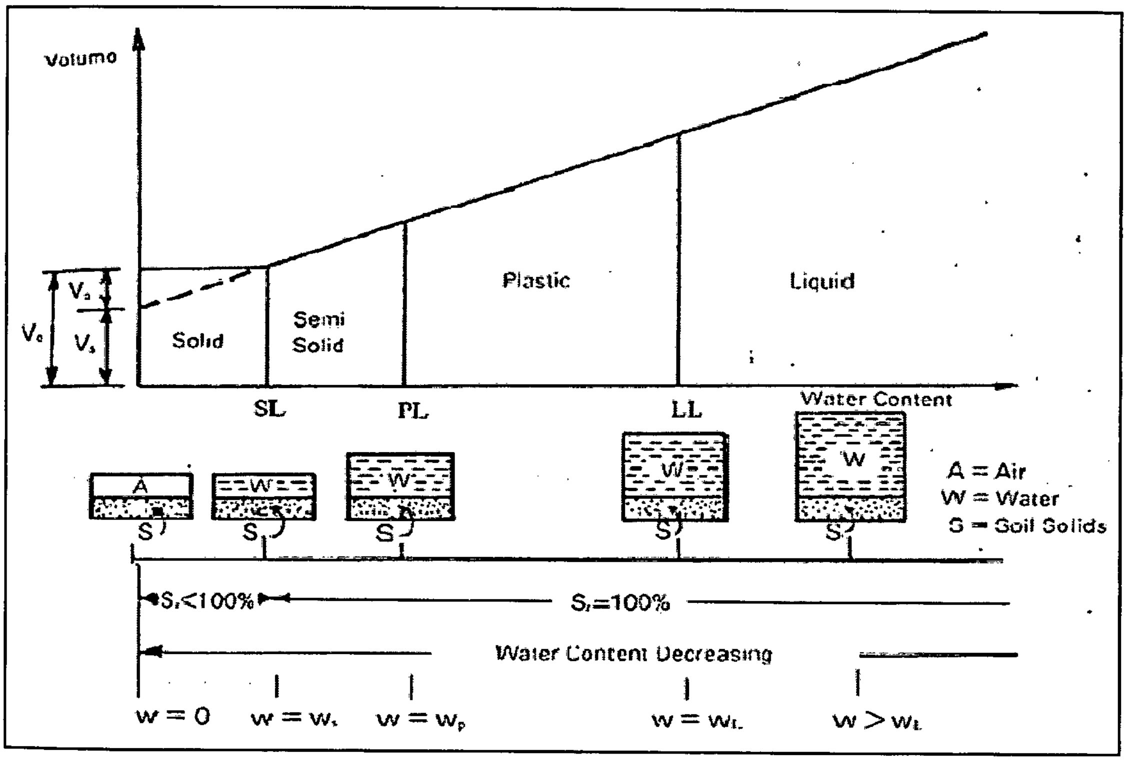

Figure 2.2: Consistency relationship (Jeremy, 2006)

There are three arbitraries limits which corresponding to changing moisture content:

Liquid Limit (LL) = Water content at which the stops to be liquid and becomes plastics

Plastics Limit (PL) = Water content at which the stops to be plastics and becomes a semi-solid

Shrinkage Limit (SL) = Water content at which drying-shrinkage at constant stress

Plastics Index (I_p) is defined as the soil is in plastic form in the range of water content between PL and LL.

$$I_p = LL - PL$$

The greater the plastic index, the higher will be the interaction and attraction between the soil particles and also greater the plasticity of the soil.

Since the plasticity of fines (silt and slay) gives significant impact in soil engineering properties, such as shear strength and compressibility, the transition from one state to the next physical state of soil characteristics at given moisture content, must be identified carefully in order to produce accurate and reliable results.

Column chart as Table 2.1 was developed in United Kingdom and both liquid and plastic could be determined from graph. Plastic index (I_p) can serves as an additional means to soil identification, citing Sandy loam, Sandy-clay loam, Silt, Silt clay and clay as examples.

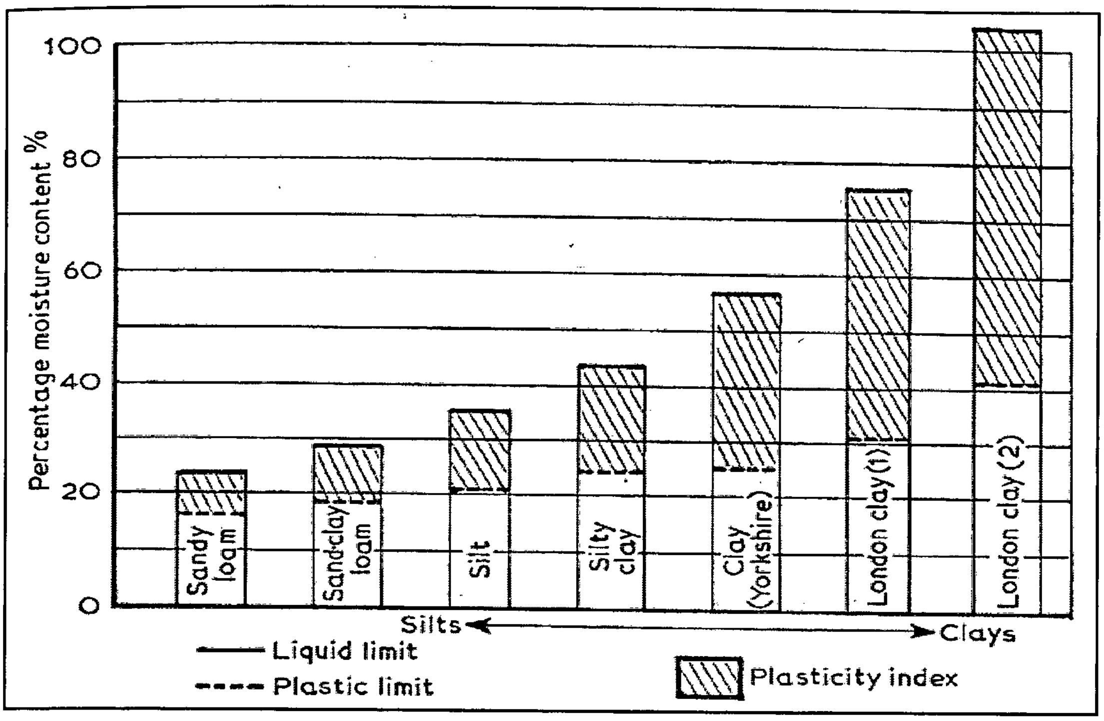

Figure 2.3: Liquid and plastic for various soils (Jeremy, 2006)

2.4 Cohesive Soil

Cohesive soil is type of soil that small soil particles forms and has higher water content. Cohesive soils consist of silts, clay and organic materials. Clay is low strength and high compressibility and many are sensitive. The clay is consisting of several minerals. Silica Tetrahedron and Alumina Octahedrons are the basic units to compose the clay minerals. The size of clay is very small, which is less than 2μm and electrochemically very active. Clay minerals are produces mainly from the chemical weathering and decomposition of feldspars, such as Orthoclase and Plagioclase and some Mica.

2.5 Shear Strength of Cohesive Soil

Soil can be classified as being either non plastic or plastic. Shear strength of non plastic soils known as cohesion less soils or granular soils. Shear strength of plastic soils, known as cohesive soils. Cohesive soils have fines, which are silt and clay size particles that give the soil a plasticity or ability to be moulded and rolled. Typical types of cohesive soils are silts and clays. The shear strength of cohesive soil is much more complicated than the shear strength of cohesion less soils. Also, in general the shear strength of cohesive soil tends to be lower than the shear strength of cohesion less soils. As s result, more shear induced failures occurs in cohesive soils, such as clays, than in cohesion less soils.

The strength of cohesive soil can generally be divided into four broad groups:

1. Undrained shear strength

   This is also known as the shear strength based on a total stress analysis. The purpose of these laboratory tests is to obtain either the undrained shear strength analysis. The purpose of these laboratory tests is to obtain either the undrained shear strength of the soil or the failure envelope in terms of total stresses. These types of shear strength tests are often referred to undrained shear strength tests because there is no change in water content of the soil during shear portion of the test.

2. Drained shear strength

   This is also known as the shear strength of soil based on an effective stress analysis. The purpose of these laboratory tests is to obtain the effective shear strength of the based on the failure envelope in terms of effective stress. These