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ABSTRACT

Clay can be categorized as a troubled land. Low soil strength and height of the pressure forces applied to be among the main factors why care must be taken into account when making plans to build something on that site. Because of this problem, a study of land on the basic characteristics of soil and soil stress to be done. This project contributes to the engineering analysis features that meet the requirements of the National Lime Association as the limits of plasticity index and the percentage of land after land sieve analysis. Many attempts have been made to study examples of suitable land as a sample. Overall, the test results against plastic index and sieving the soil are likely to correspond to the increase in soil strength. From the requirements required by the National Lime Association, land in Pekan, Pahang fit to undergo the process of improving the strength of the soil. Pekan clay more than 90% passing 0.075mm sieve and plasticity reaches more than 10%. Based on soil plasticity chart, Pekan clay identified as clay with medium plasticity level. Based on Eades-Grim test, the percentage of lime obtained from the experiments is 4 percent and a maximum pH obtained was pH 11.8. This test shows the results of obtained pH value give almost the same value from 4 percent to 12 percent mixture of lime. Tests on the stress of clay soils after treatment with lime showed clay in Pekan, Pahang is 116 kPa.

ABSTRAK

Tanah liat boleh dikategorikan sebagai tanah yang bermasalah. Kekuatan tanah yang rendah dan ketinggian daya tekanan yang dikenakan menjadi antara faktor utama mengapa ketelitian perlu diambil kira tatkala membuat perancangan untuk membina sesuatu di atas tempat tersebut. Disebabkan masalah ini, satu kajian tanah terhadap ciri-ciri asas tanah dan tekanan tanah perlu dilakukan. Projek ini menyumbang kepada analisis kejuruteraan ciri-ciri yang menepati kehendak National Lime Association seperti had keplastikan tanah dan peratus pelepasan tanah setelah membuat analisis pengayakan. Banyak percubaan telah dilakukan untuk mengkaji contoh tanah yang sesuai dia ambil sebagai sampel. Secara keseluruhannya, daripada hasil ujian terhadap had kepalastikan dan pengayakan terdapat besar kemungkinan tanah tersebut sesuai untuk proses peningkatan kekuatan tanah. Daripada kehendak yang diperlukan oleh National Lime Association, tanah di Pekan, Pahang sesuai untuk menjalani proses peningkatan kekuatan tanah. Tanah liat lebih 90% melepasi ayakan 0.075mm dan mencapai tahap keplastikan lebih dari 10%. Berdasarkan carta keplastikan tanah, tanah liat di Pekan dikenalpasti sebagai tanah liat yang mempunyai tahap keplastikan sederhana. Berdasarkan ujian Eades-Grim, peratus kapur yang diperolehi dari proses ujikaji ialah 4 peratus dan pH maksimum yang diperolehi ialah pH 11.8. Ujian ini menunjukkan hasil apabila nilai pH yang diperolehi mencatatkan nilai yang lebih kurang sama dari 4 peratus ke 12 peratus campuran kapur. Ujian terhadap tekanan tanah menunjukkan tanah liat Pekan, Pahang adalah 116 kPa.

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LIST OF ABBREVATION

UCS - Unconfined compressive strength

CBR - California Bearing Ratio

ASSHTO – American Association of State Highway and Transportation Officials

ASTM - American Society for Testing and Materials

LIST OF SYMBOLS

Ca - Calcium

$Ca(OH)_2$ – Calcium hydroxide

CaCO3 – Calcium Oxide

H - Hydrogen

kPa - Kilo pascal

O - Oxygen

^oC – degree Celsius

^oF – degree Fahrenheit

w - Water content

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CHAPTER 1

INTRODUCTION

Soil is the base of any structures as building will stand firm on it. Normally, a base must be strong, can resist failure and able to support huge load of a structure. This is why, before any constructions work can be done, analysis and study must be applied to the soil in order to know the condition of the soil. The soil will give problems and difficulties to engineers as soil can present in many types, properties and strength. The variety of the soil is the factors that cause some soil to undergo excessive settlement, collapse, and have distinct lack of strength.

Soft clay soil can be categorized as problematic soil. The low strength and high compressibility characteristics the soil had are the major reasons why a careful design analysis should be taken for any structure built on it. Due to these problems, soil investigation on the basic properties and shear strength of the soil must be carried out.

Clay is one of the three principal types of soil, the other two being sand and loam. A certain amount of clay is a desirable constituent of soil, since it binds other kinds of particles together and makes the whole retentive of water. Excessively clayey soils, however, are exceedingly difficult to cultivate. [1]

Clay stiffness presents resistance to implements, impedes the growth of the plants, and prevents free circulation of air around the roots. They are cold and sticky in wet weather, while in dry weather they bake hard and crack. Clods form very often in clayey soils. Clays can be improved by the addition of lime, chalk, or organic matter; sodium nitrate, however, intensifies the injurious effects. In spite of their disadvantages, the richness of clay soils makes them favourable to the growth of crops that have been started in other soil.

Soil improvement is usually an alternative to the provision of a structural solution to a practical problem, such as provision of retaining wall or buttresses, thickening of road pavements or increasing the extent of foundations. In the case of clay soils, chemical improvement is commonly most effective since it can be used to change the nature of the material. Chemical means can be used to strengthen the soil, but also to remove its sensitivity both to water and its subsequent stress history.

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. Quicklime is manufactured by chemically transforming calcium carbonate (limestone – $CaCO3$) into calcium oxide. [2]

Hydrated lime is created when quicklime chemically reacts with water. It is hydrated lime that reacts with clay particles and permanently transforms them into a strong cementitious matrix. Most lime used for soil treatment is "high calcium" lime, which contains no more than five percent magnesium oxide or hydroxide. On some occasions, however, "dolomitic" lime is used.

Dolomitic lime contains 35 to 46 percent magnesium oxide or hydroxide. Dolomitic lime can perform well in soil stabilization, although the magnesium fraction reacts more slowly than the calcium fraction. Sometimes the term "lime" is used to describe agricultural lime which is generally finely ground limestone, a useful soil amendment but not chemically active enough to lead to soil stabilization. [2]

1.2 PROBLEM STATEMENT

Clay is a material with low strength and markedly affected by water but it can be relatively strong in dry condition. If water is added to clay, it will behave as plastic or flow like liquid. Soft clay normally has very high percentage of clay fraction. Because of its low permeability, dissipation of excess pore pressure in soft clay is slow. This phenomenon creates a lot of problem at construction site in Malaysia, so the improvement of soil is needed.

Lime provides an economic and powerful means of chemical improvement, as demonstrate by the dramatic transformation that is evident on mixing lime with heavy clay. The traditional used of lime stabilization is in the treatment of clay subgrades to create improved road foundations without the need for large quantities of imported granular aggregates.

The problems at site are sometime unlike sand, silt and loam soils, clay soils have small, densely packed particles that are difficult to penetrate. Once the soil is penetrated with water, it holds onto it for a long period of time. In general construction problems in this deposit are insufficient bearing capacity, excessive post construction settlement and instability on excavation and embankment forming.

1.3 OBJECTIVES

Pekan clay soils need to do the improvement method. A research had been done to know the suitability and the effectiveness of the improvement method. The objectives of this study are:

a) To determine the soil strength with adding of hydrated lime to the clay soil,
b) To check the properties of the clays before and after treatment on plasticity index.
c) To determine the optimum lime content required in the soft soil at Pekan.

1.4 LIMITATION

1.4.1 Scope of work

Scope of works is plan based on the study requirement. Every testing need to provide the sample of the soft soil. The sample will be used is clay soil at Pekan, Pahang. The lime to be used in this research is hydrated lime. By identifying the engineering properties of soil that will be analysed, the matters need to be considering are the colour of the soil and particle size in order to fulfil the criteria for soil improvement.

1.4.2 Testing

The need for finding the optimum lime content, the Eades-Grim test need to be done. In the test, we only consider hydrated lime with different percentage of content to be mix with the clay soil. The constant pH level and the less of hydrated lime content will be selected as the optimum lime content for the clay soil.

By using the optimum lime content, the proctor test done to know the optimum moisture content and maximum dry density of the clay soil. The moisture content with different percentage in 5 percent, 8 percent, 10 percent, 15 percent, 20 percent and 30 percent are to be tested by mixing with the soil and optimum lime content.

The curing process are done by wrapping the specimen in plastic wrap and seal in air tight, moisture proof bag. Cure the specimens for 14days at 40°C ± 5°C. After that, place the cure specimen on the porous plate in contact with water before testing.

CHAPTER 2

LITERITURE REVIEW

2.1 Lime

Calcium hydroxide, traditionally called slaked lime, is an inorganic compound with the chemical formula $Ca(OH)_2$. It is a colourless crystal or white powder and is obtained when calcium oxide (called lime or quicklime) is mixed, or "slaked" with water. It has many names including hydrated lime, builders lime, slack lime, Cal, or pickling lime. It is of low toxicity and finds many applications, including for food. [1]

2.2 Properties

When heated to 512 °C, the partial pressure of water in equilibrium with calcium hydroxide reaches 101 kPa, which decomposes calcium hydroxide into calcium oxide and water. [1]

$$Ca(OH)_2 \rightarrow CaO + H_2O$$

A suspension of fine calcium hydroxide particles in water is called milk of lime. The solution is called lime water and is a medium strength base that reacts with acids and attacks many metals. Lime water turns milky in the presence of carbon dioxide due to formation of calcium carbonate:

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

Calcium hydroxide crystallizes in the same motif as cadmium iodide. The layers are interconnected by hydrogen bonds.

2.3 Lime Modifies Clay Soils

On many construction sites there is a need for short-term soil modification to temporarily strengthen the working area. The benefits of modified soils include:

1. Making clay soils friable and easier to handle.
2. Providing a working platform for subsequent construction.
3. Reducing plasticity to meet specifications.
4. Conditioning the soil for further treatment.
5. Spot treatment of spongy subsoil areas.

After initial mixing, the calcium ions (Ca++) from the lime migrate to the surface of the clay particles and displace water and other ions. The soil becomes friable and granular, making it easier to work and compact. At this stage the Plasticity Index of the soil decreases dramatically, as does its tendency to swell and shrink. The process, which is called "flocculation and agglomeration," generally occurs in a matter of hours. Small amounts of lime, such as 1% to 4% by mass of dry soil, can upgrade many unstable fine-grained soils. With heavy clay soils, additional lime may be necessary for these purposes. Modification improvements are generally temporary and will not produce permanent strength in clay soils. [4]

2.4 Lime fixation in clayey soils

Previous work in stabilization of clayey soils with lime has shown that small amounts of lime considerably improve workability but contribute little to strength, whereas larger amounts of lime also improve the strength and bearing capacities of these soils. This suggests the possibility that lime added to soil must first satisfy an affinity of the soil for lime, an affinity referred to as lime fixation.

In some clayey soils the addition of flyash with the lime caused an even more significant gain in strength. The research described in this paper was undertaken to determine whether lime fixation does occur, and if so, to determine the mechanisms involved and the amount of lime utilized.

Samples of six natural clayey soils were mixed with varying amounts of lime (0 to 12 percent), cured two days at 100 percent humidity and 70 Fahrenheit temperature, and subjected to Atterberg limits tests. Similar mixes were compacted at optimum moisture content to standard proctor density and tested in unconfined compression after 7 and 28 days moist curing. Curves of lime content versus Atterberg limits and lime content versus unconfined compressive strength indicate that when the plastic limit increases, with small amounts of lime, the strength remains relatively constant, whereas with larger amounts of lime the plastic limit remains constant and strength increases. Thus, the plastic limit is indicative of the amount of lime fixation in clayey soils. Further correlations show that the amount of fixation is proportional to the type and amount of 2-micron clay present and is independent of the adsorbed cation present. [5]

As a result of the unconfined compressive strengths, kaolinitic and montmorillonitic clayey soils were found to be well stabilized with lime alone, whereas illitic- chloritic clayey soils require additions of flyash to obtain significant gains in strength.

2.5 Effect of Lime, Moisture and Compaction on a Clay Soil

In an effort to use economically material otherwise unsuitable for subgrade construction, the state of Virginia is in many instances adding a small percentage of lime to improve such material. This project investigates the change in engineering characteristics of a typical clay soil when different amounts of hydrated lime were added.

The testing program consisted mainly of studying the effect of three variables-percent lime, moisture content, and compactive effort by fabricating California Bearing Ratio (CBR) specimens and obtaining values of CBR, density, and swell. In addition, Atterberg limit determinations were made on the soil containing different percentages of lime. [6]

The trends shown by this study are:

a) The plastic properties of the soil were improved appreciably by the addition of hydrate lime.
b) Addition of hydrated lime materially increased the strength of soil as measured by the California Bearing Ratio method.
c) Increases in compactive effort were more effective on lime-treated soil than on untreated soil.
d) For the natural soil, the values of California Bearing Ratio as molded were generally greater than those of California Bearing Ratio soaked for 4 days, but with the addition of lime the situation was reversed and the California Bearing Ratio - soaked values observed were greater than those of California Bearing Ratio as molded.
e) Although the increase in lime content increased the California Bearing Ratio as molded, the change was not a pronounced as for California Bearing Ratio soaked.
f) The addition of hydrated lime reduced the swell percentage of the clay soil appreciably.
g) The California Bearing Ratio test on natural soil and soil-lime mixture using varying compactive effort and moisture content indicated that strength is a function of both density and moisture content. [6]

2.6 A Quick Test to Determine Lime Requirements for Lime Stabilization

The use of hydrated lime, $CaOH^2$ for modifying, upgrading, and stabilizing soils is increasing greatly. This means highway laboratories have had their work loads increased, and in many instances, more than doubled for a particular job. Before the advent of the use of lime, the laboratory was finished with testing when a soil was classified as unsuitable. Now the same soil is tested and retested to find the percentage of lime required to bring the soil within specifications. [7]

In most cases the percentage is determined by compressive tests, Atterberg limits tests, or both. The reaction of lime and soil can be described as a series of chemical reactions. The results of these reactions are expressed as a change in the plasticity, swell, shrinkage or compressive strength of the soil.

Therefore, a quick or simple test is needed to show the amount of lime required to react chemically with a soil to bring about these physical changes to an optimum degree. Laboratory tests, involving mineralogical, physical and chemical characteristics of untreated and lime treated soils have proven that pH tests can be used to determine the optimum lime requirements of a soil.

The soil-lime pH test is performed as a test to indicate the soil-lime proportion needed to maintain the elevated pH necessary for sustaining the reactions required to stabilize a soil. The test derives from Eades and Grim. Performance tests are normally conducted in a laboratory to verify the results of this test method.

Eades-Grim test is a method to know the pH level of soil reacts with lime. This method describes the determination of the actual lime content of a lime-treated soil using the pH method. Determinations are based on comparing the pH of a lime-treated soil to the pH of a similar untreated soil at various known percent lime content.

This test method will not provide reliable information relative to the potential reactivity of a particular soil, nor will it provide information on the magnitude of increased strength to be realized upon treatment of this soil with the indicated percentage of lime. This test method can be used to estimate the percentage of lime as hydrated lime or quicklime needed to stabilize soil.

2.7 Lime Permanently Stabilizes Clay Soils

In contrast to lime modification, lime creates long-lasting changes in soil characteristics that provide structural benefits. Lime is used in stabilizing and strengthening subgrades (or sub-bases) and bases below pavements. Non-pavement applications for lime treatment include building foundations and embankment stabilization.

Lime stabilization chemically changes most clay soils:

1. Markedly reduces shrinkage and swell characteristics of clay soils.
2. Increases unconfined compressive strength by as much as 40 times.
3. Substantially increases load-bearing values as measured by such tests as CBR, R-value, Resilient Modulus, and the Texas Triaxial tests.
4. Develops beam strength in the stabilized layer and greatly increases the tensile or flexural strength.