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Pekan Soft Clay Treated With Hydrated Lime As A Method Of Soil Stabilizer

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Abstract

The main objective of this paper is to determine the optimum lime content (OLC) required for Pekan soft soil treatment program and its strength. The OLC will be determined using Eades-Grim pH test. Another testing that involved in this study are Atterberg Limit, Unconfined Compressive Strength and Standard Proctor Test. From the study, the optimum amount to stabilize the clay soil in this particular area and minimum amount of lime to raise soil pH level to 12 is 4%. The soil strength is reach 116kN/m^2 while the maximum dry density and optimum moisture content for treated soil are 16kN/m^3 and 13% respectively. All the samples tested reach a significant strength level when enough lime is provided. It can be concluded that, lime stabilization method can be used as a soil treatment program for Pekan Clay especially for road construction.

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Keywords: Soft Soil, Hydrated Lime, Lime stabilization, Soil improvement.

1. Introduction

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 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 demonstrated by the dramatic transformation that is evident in the mixing of lime with heavy clay.

Four types of reaction can take place during stabilization which are cation exchange, flocculation and particles aggregation, lime carbonation and pozzolonic reaction between lime, silica and alumina. [1] When adequate quantities of lime and water are added, the pH of the soil quickly increases to above 10.5, which enables the clay particles to break down. Silica and alumina are released and react with calcium from the lime to form calcium-silicate-hydrates (CSH) and calcium-aluminate-hydrates (CAH). These compounds form the matrix that contributes to the strength of lime-stabilized soil layers. As this matrix forms, the soil is transformed from its highly expansive, undesirable natural state to a more granular, relatively impermeable material that can be compacted into a layer with significant load bearing capacity. [2] The controlled pozzolanic reaction creates a new material that is permanent, durable, resistant to cracking, and significantly impermeable. The structural layer formed is also strong and flexible. Lime addition of 3% to 6% by mass of the dry soil is the customary range for lime stabilization in road foundations.

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The traditional use 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. In United State and Europe, lime stabilization is commonly used for improving traffic ability, loading capacity of foundations of road and embankment and for erosion control. 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.[2] Lime stabilization chemically changes most clay soils, which results in;

i) Marked reduction in shrinkage and swell characteristics of clay soils.

ii) Increment of unconfined compressive strength by as much as 40 times.

iii) Substantial increment of load-bearing values as measured by such tests as CBR, R-value, Resilient Modulus, and the Texas Triaxial tests.

iv) Development of beam strength in the stabilized layer and great increment of the tensile or flexural strength.

v) Formation of water-resistant barrier. Impedes migration of surface water from above and capillary moisture from below; thus helping to maintain foundation strength.patchouli oil extraction yield.

vi) The lowering of plasticity in most cases and initially strengthening the improved soil, the strengthening effect increases over time.

Figure 1 shows the value of Unconfined Compressive Strength versus percentage of hydrated lime for various site from previous study.

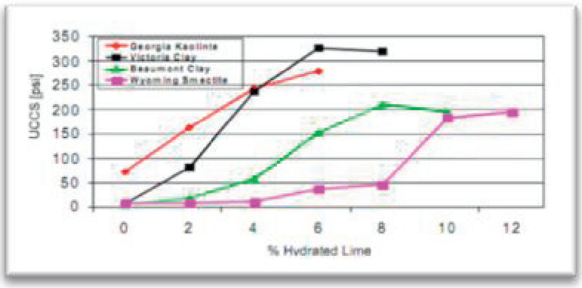

Fig. 1. Graph of UCCS versus % Hydrated Lime for Various Site [2]

2. Soil Characteristics

Generally, soil with at least 25% passing the No 200 sieve (74mm) and having a plasticity index (PI) greater than 10 can be stabilized using this method. [4] From sieve analysis, the soil was passing No 200 sieve was 35% and the PI recorded as 22.4 which is greater than 10. From the plasticity chart, the soil was classified as inorganic clays of medium plasticity. This concludes that Pekan clay soil can be stabilized by adding hydrated lime. Figure 2 shows the particle size distribution for case study site.

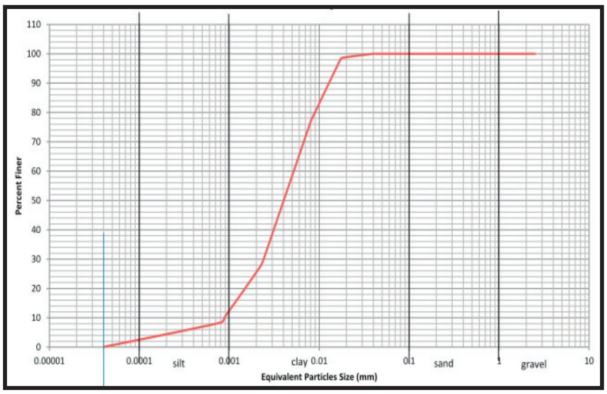

Fig. 2. Particle size distribution for Pekan Clay

3. Methodology

The soil-lime pH test is performed to indicate the soil-lime proportion needed in maintaining the elevated pH necessary, hence the reactions required to stabilize a soil can be sustained. This test method can be used to estimate the optimum hydrated lime or quicklime content (OLC) needed to stabilize soil. The test is derived from Eades and Grim that was established in 1960. [3] Performance tests are normally conducted in a laboratory to verify the result s of this test method. The graph of pH value versus percentage of lime content by volume will be plotted to determine the OLC which is shown by the constant pH level. By using the optimum lime content, the proctor test was conducted to get the optimum moisture content and maximum dry density of the treated clay soil. The moisture content with different percentages (5 %, 8%, 10%, 15%, 20% and 30%) is to be tested by mixing the water with the soil sample and OLC. The Atrerberg Limit was then conducted to determine the plasticity index of the treated sample.

The unconfined compressive test (USC) was done to check the strength value of specimens with different percentages of lime. The strength value was then compared with other clay sample from various locations. The curing processes were done by wrapping the specimen in plastic wrap and seal in air tight, moisture proof bag. The sample was cured for 14 days at 40oC ± 5oC then placed on the porous plate in contact with water before testing.

4. Analysis and Result

A. Optimum Lime Content (OLC)

The OLC can be determined through Eades & Grim Test (ASTM D 6276). The lowest percentage of lime in soil that produces a laboratory pH of 11 to 12 (the flat section of pH versus lime percentage curve produced by the test) is the minimum lime content for stabilizing the soil. Results in Figure 3 show that 4% lime is the optimum amount necessary to stabilize the clay soil in this particular area and minimum amount of lime to raise soil pH level up to 12.

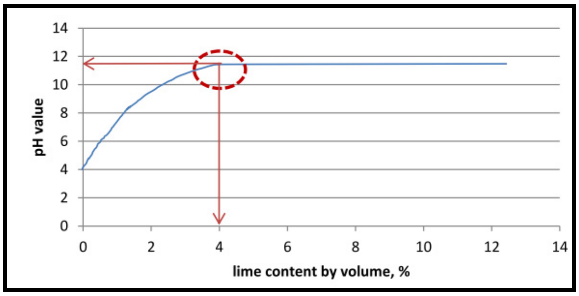

Fig. 3. Graph of pH value versus lime content

B. Compaction Test Standard Proctor Test

The Standard Proctor Test (ASTM D 698) was conducted to determine the optimum moisture content (OMC) and the maximum dry density (MDD) of soil sample with OLC mix. Figure 4 show that MDD of the sample is 16 kN/m^3 and the OMC obtained from the test is 13%. The compaction should target the modified OMC moisture and density, not the OMC and density value of the untreated soil. From the Atterberg Limit Test (ASTM D 4318), the PI after treatment was found at 18.9% which was lower than untreated value.

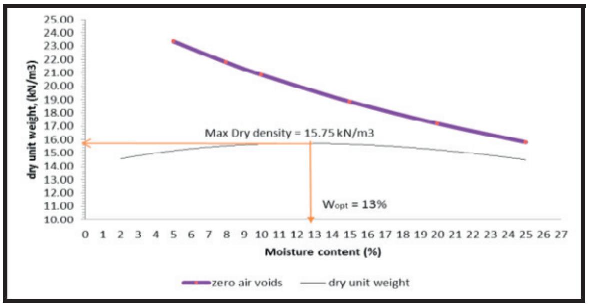

Fig. 4. MDD & OMC for Pekan Clay Treated Soil

C. Unconfined Compressive Strength

Samples for Unconfined Compressive Strength (UCS) test were prepared at the OMC and MDD of the Pekan Clay lime mixtures. The UCS mode of failure for the soil testing was splitting failure. When the loading was applied, the soil sample tended to hold the stress on it until the maximum loading that can be hold. The soil immediately failed after the maximum load had been reached. The reading for the load increment was then stopped due to the soil failure. In Figure 5, the result of the highest axial stress obtained is 116 kN/m^2 at 15% of water content. This means that Pekan clay can hold the stress more than 100 kN/m^2.

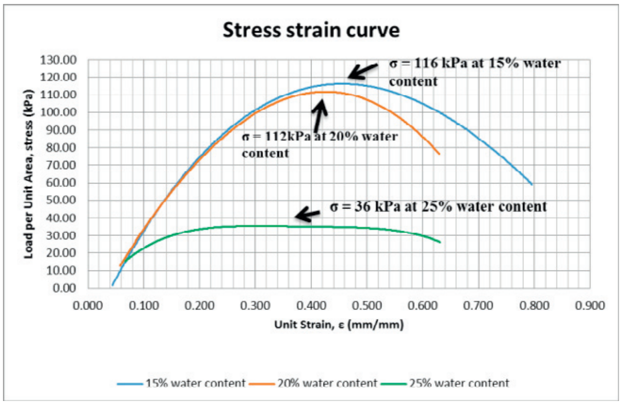

Fig. 5. Stress strain curve

As a comparison, Pekan clay can be placed among the Victoria Clay in Texas and Beaumont Clay in California as shown in Figure 6.

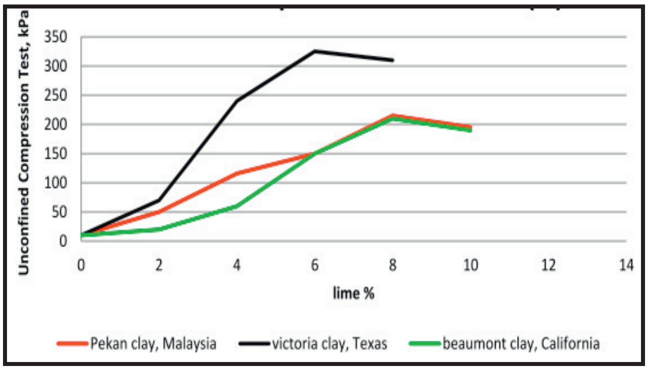

Fig. 6. Comparison chart

5. Conclusion

As one can observe, hydrated lime addition to a soil causes reactions that are difficult to understand or predict immediately, since many parameters have to be interpreted in the analysis. The main conclusions that come from this study as follows;

i) From the Eades-grim test, the optimum lime content obtained for this Pekan Clay is 4%. It is the lowest percentages of lime for stabilizing the particular soil that produces a laboratory pH of 12.

ii) The MDD of the Pekan Clay treated soil is 16 kN/m^3 and the OMC obtained is 13%.

iii) All the samples tested reach a significant strength level when enough lime is provided.

iv) High water content soils can be successfully stabilized with lime.

v) The lime stabilization method can be used as a treatment program for Pekan Clay especially for road construction.

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