SOME INDEX PROPERTIES ON RENGIT PEAT SOIL STABILIZE WITH CEMENT-LIME

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PROSIDING KEBANGSAAN AWAM '07,
LANGKAWI, KEDAH (AWAM 2007)
29 – 31 MEI 2007

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Abstract

Peat soil commonly occurs as extremely soft, wet, unconsolidated deposits commonly found at surface that are integral parts of the wetland systems. This problematic soil is known for their high compressibility and low shear strength. The study of index properties includes determination of natural moisture content, particle size distribution, Atterberg limits and loss of ignition. Chemical test also included in this study which is pH test. Cement is the most widely used additive for soil stabilization due to its high strength and the addition of lime for these soils had give potential in increasing strength of this soils. Hence, a study on the improve soil properties is seems very important to gain on insight of the efficiency of stabilization process. Soil samples utilized in this property was taken from Rengit, Batu Pahat, Johor. The aims of this research are to obtain the index properties of peaty soil that stabilized with cement and lime and the optimum percentage of additives materials needed in this soil. The constant value of 11% lime was used while cement percentages were 5%, 10%, 15% and 20% from dry weight of soil. Testing was made before and after the soil was cured for 1, 3 and 7 days. Comparisons results achieve between before and after stabilization were discussed in this paper summary. The results show that liquid limit and shrinkage limit percentages decreased while pH and specific gravity value increased when additives percentages increasing. From the study, it shows that the optimum percentage of cement that need for the stabilization in this peaty soil is 20% after 7 days curing.

Keywords: Peat Soil, Chemical Stabilization, Cement, Lime, Index Property Tests

1.0 Introduction

Two third of 30 million hectares of peat soil areas can be found in South East Asia. About 8 % of this amount is in Malaysia. In Johor, peat area can easily found in Batu Pahat, Pontian, Muar, Kota Tinggi and Mersing. In Batu Pahat district this type on soil can be originate in area of Rengit, Parit Botak, Parit Raja and Semerah. The depth of the soil is various according to location. As one of type under categorization of soft soil it has to be improved to ensure construction works can be carry out in this area. Low bearing capacity and very high compressibility are the two main factors that gives a challenge for an engineer when they dealing with this type of soil. This have been affirmed by Bujang K.H, 2004, the general challenges faced for construction on peat soil include the limited accessibility and difficult traffic ability, expectations of very large settlements over an extended time period and also possibility of stability problems.

Molekamp and Heshmati (1997) stated that peat is very deformable low strength type of soil with a high organic content. It is composed of dead hygrophytes, which have been deposited over a long period of time without fully decomposing. In former days peat was removed from geotechnical designs whenever possible. However in regions with very thick peat layers removal remained economically unattractive and practically impossible. Respect to this matter the usage of chemical additives material is one of alternatives can be take into consideration. Based on Bergado D.T, *et al.* (1996), chemical admixture stabilization has been extensively used in both shallow and deep stabilization in order to improve inherent properties of the soil such as strength and deformation behavior. Lime or cement has commonly been used as chemical admixtures for soil stabilization and mixing method to improve the properties of soils since olden times.

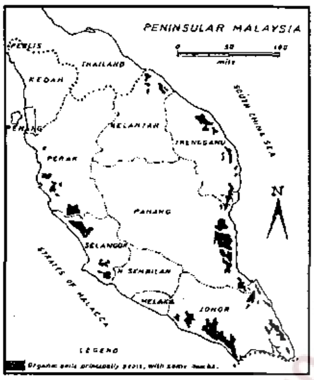

Figure 1: Distribution Of Peat Soil In West Malaysia (Joseph *et al.*, 1974)

An example of problem related to peaty soil was happen during the construction of the foundation for bridge on the perimeter road to span across a river known as Sungai Labu. KLIA or Kuala Lumpur International Airport covers an area located mainly on flat, swampy lowlands. A perimeter road that services the airport and its facilities is more than half constructed on peat (Hassandi, 1998). Bell F.G (1983) also stated that, differential and excessive settlement is the principal problem confronting the engineer working on a peaty soil. When a load is applied to peat, settlement occurs because of the low lateral resistance offered by the adjacent unloaded peat. Serious shearing stresses are induced even by moderate loads. For the reason that of, peaty soils have to be stabilizing to make sure that the strength, bearing capacity and the settlement have to be overcome or increased and it could support any structure built on it without any massive problem occurs.

The main objective of this study is to determine index properties of peaty soil that stabilized with cement and lime. To determine the optimum percentage of cement that need for the stabilization in this peaty soil.

2.0 Literature Review

According to Eriktius, *et al.* (2001), chemical stabilization is a general method in which one or more chemical compounds are mixed into the soil to improve its engineering properties. The main purposes of soil stabilization are to modify the soil, expedite construction and improve the strength and durability of the soil (Das, 1999).

2.1 Cement

According to Bell F.G (1993), any type of soil, with the exception of highly organic soils or some plastic clays, may be stabilized with cement and also any type of cement may be used for soil stabilization but ordinary Portland cement is most widely used. The addition of small amount of cement, that is, up to 2%, modifies the properties of a soil, while large quantities cause radical changes in these properties.

Cement is increasingly used as a stabilizing material for soil, particularly for the construction of highways and earth dams. It is due to the fact that cement helps increase strength of soil given the curing time (Das, 1999).

Type of cement that will be used in this research is Portland cement. Portland cement is hydraulic cement produced by pulverizing clinker consisting essentially of hydraulic calcium silicates, usually containing one or more of the forms of calcium sulfate as an inter ground addition (ASTM, 1992).

Bergado D.T, *et al.* (1996), stated that when the pore water of the soil encounters with the cement, hydration of the cement occurs rapidly and these cement particles bind the adjacent cement grains together during hardening and form a hardened skeleton matrix, which encloses unaltered soil particles. In addition, the hydration of cement leads to a rise pH value.

According to Eriktius, *et al.* (2001), laboratory studies have shown that addition of cement can improve the engineering properties of soft soils. For cement content 10% to 28%, the rate of strength improvement was the highest. The effectiveness of cement stabilization depends on several factors. Two of the important factors are the amount of cement added and soil type.

Some researches have been done for stabilizing peaty soils with cement and the results are as shown in Figure 2 and Figure3.

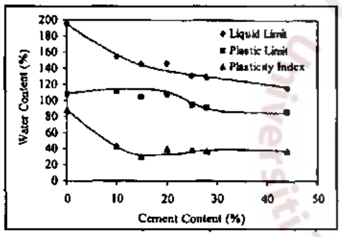

Figure 2: Relationship between Atterberg Limits and Cements Content for Peaty Soil **(Eriktius, 2001)**

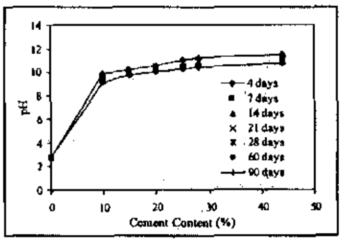

Figure 3: Relationship between pH and Cement Content on Different Curing Time for Peaty Soil **(Eriktius, 2001)**

2.2 Lime

Lime stabilization refers to the stabilization of soil by the addition of burned limestone products, either calcium oxide (quicklime) or calcium hydroxide. On the whole, quicklime appears a more effective stabilizer of soil than hydrated lime. Moreover, when quicklime is added in slurry form it produces a higher strength that when it is added in powder form (Bell F.G, 1993).

Type of lime that will be used in this research is quicklime. Quicklime is a calcined limestone, the major part of which is calcium oxide or calcium oxide in association with magnesium oxide and capable of slaking with water (ASTM,1992).

Bergado D.T, *et al.* (1996), stated that the major strength gain of lime treated clay is mainly derived from three reactions which are dehydration of soil, ion exchange and pozzolanic reaction. The use of lime as a stabilizing additive is mainly due to its well-known effects when mixed with soils.

The effectiveness of lime treatment is generally evaluated in terms of the improvement attained to the engineering properties of the soil-lime mixtures. According to Consoli and Thome (1998), 11% is as the minimum amount of lime required to cause long term strength changes for organic clay. The results also revealed that, in terms of strength parameters, the occurrence of pozzolonic reactions changes just the cohesion intercept and does not interfere with the friction angle of organic clay.

Some researches have been done for stabilizing peaty soils with cement and the result is as shown in Figure 4.

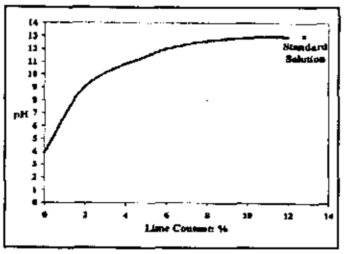

Figure 4: Effect of the Percentage of Lime on pH for Organic Soft Soil
(Consoli, *et al.*, 1998)

2.3 Peat Soil

The term peat according to Bujang, 2004 refers to highly organic soils derived primarily from plant remains. It normally has dark brown to black color, a spongy consistency and on organic odor. Plant fibers are sometimes can be see but in advanced stages of decomposition, they may not be evident.

Peat and organic soil have low bearing capacity and high compressibility is considered to be among the worst foundation materials. It exhibits a high degree of spatial variability, generally much higher than exhibited by inorganic soils, and its properties can change drastically in response to stress application (Edil, 1997). According to Bell F.G (1983), peat is accumulation of partially decomposed and disintegrated plant remains which have been fossilized under conditions of incomplete aeration and high water content. Physico-chemical and biochemical processes cause this organic material to remain in a state of preservation over a long period of time.

The definition of peat over time and to different people has differed, although essentially all are agreed that it is primarily an organic soil (Salmah and Mohd. Adnan, 1989). Improving soil are used to reduce the settlement of structures, improve the shear strength of soil and thus increase the bearing capacity of shallow foundation and reduce the shrinkage and swelling of soils (Das, 1999).

3.0 Methodology

The research was done in a peaty soil area at Rengit, Batu Pahat, Johor. This location was suitable because it meet s the requirements for problem soil to do the construction works. This area is private property, so permission from the owner was getting before soil samples were taken. The soil samples taken are around 1 meter depth below the surface. All the soil samples from site area than brought to the geotechnical laboratory for testing works.

For samples without additive material, the study of index properties includes determination of moisture content , particle size distribution, Atterberg limit, specific gravity meanwhile the chemical properties were pH test, and loss on ignition. In the meantime, for the samples with additive material the laboratory index properties tests that involved were Atterberg limit and specific gravity, and the chemical testing was pH test. All the testing was conducted according to BS 1377:Part 2:1990. Samples with additive material are mix with 11% of lime and 5% until 20% cement from dry weight of soil with 5% interval and cured which is wrapping up the mix soil with moist material (cloth) and then put in the plastic bag with a tight tie. The samples were tested before curing and for 1, 3 and 7 days curing.

4.0 Result and Analysis

4.1 Index Properties

4.1.1 Sieve Analysis

A sieve analysis determines the sizes of the studies soil. In this research, wet sieving had been done. Soil is wet sieved to remove the clay and silt-sized particles (<0.06mm). In this research, soil classification is based on the USCS (Unified Soil Classification System). Figure 4 show the particle size distribution and the result of this wet sieve analysis showed that 87.8% sand and 12.2% silt and clay. The effective size, D_{10} is 0.13, uniformity coefficient, Cu is 3.846 and the coefficient of gradation, Cc is 1.47.

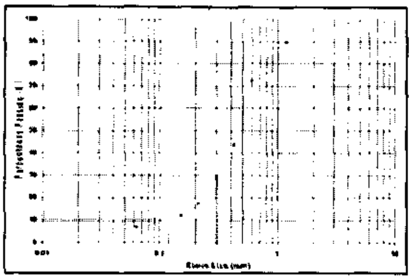

Figure 5: Particle Size Distribution

4.1.2 Loss Of Ignition

According to Bujang K.H (2004), organic content is an important parameter for peat and organic soils, which set them apart from the mineral soils. The organic content is usually determined from the loss of ignition test as a percentage of oven dried mass. This test conducted according to BS 1377: Part 3: 1990:4 and the organic content of this soil is 72.5348%.

According to Jarret (1995), soil which is organic content of 25-75% is classified as organic soil (O) while Bujang K.H (2004) stated that West Malaysia peat has organic content of 65-97%. It show that this soil is classified as organic soil(O) and has organic content value in range of West Malaysia peat.

4.1.3 Moisture Content

According to Head K.H (1992), moisture content is the mass of water which can be removed from the soil by heating at 105°C and expressed as a percentage of the dry mass. For peats and soils containing organic matter, a drying temperature of 60°C is preferred, to prevent oxidation of the organic content. It's also referred as water content. This test conducted according to BS 1377:Part 2:1990:3.2 and ASTM D2216. The moisture content of this soil was 364.6% and it was in range of moisture content in West Malaysia which is 200-700% according to Bujang K.H (2004).

4.1.4 Atterberg Limit

According to Bujang, K.H., *et al.* (1991), there are five tests for Atterberg limit which is liquid limit, plastic limit, shrinkage limit, plasticity index and liquid index. For this research, only liquid limit and shrinkage limit have done. Plastic limit, plasticity index and liquid index not be done. According to Adnan Zainorabidin (2001), plastic limit test hard to be definite because peaty soil is easy to separate when it formed.

Liquid limit (LL) is the moisture content at which soil passes from the plastic to the liquid state, as determined by the liquid limit test. Cone penetrometer method was used in this test. This test is according to BS1377:Part 2:1990:4.3. The liquid limit of this soil was 242% that is in range of the value for liquid limit at West Malaysia peat which is 190-360% according to Bujang K.H, (2004).

Figure 5 shown a typical plot to determine the Liquid Limit (LL) from cone penetration (mm) versus moisture content (%) while Figure 6 shown the percentages of liquid limit decreasing when the percentages of cement wass adding and the smallest percentages of LL was obtained when 20% of cement mix with 11% of lime for 7 days curing which is 112%.

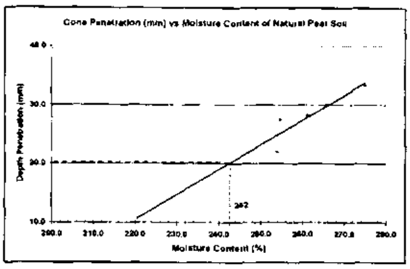

Figure 5: Determination of Liquid Limit

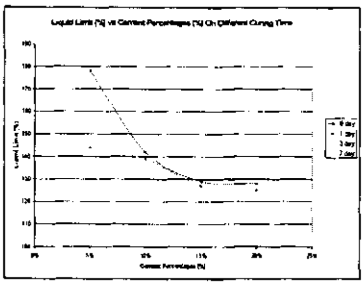

Figure 6: Relationship between Liquid Limit and Cement Percentages on Different Curing Time

For shrinkage limit test, it used linear shrinkage method. This test gives the percentage linear shrinkage of a soil. The linear shrinkage of the soil is reported to the nearest whole number. This test conducted according to BS 1377:Part 2:1990:6.5. The shrinkage limit obtained from this test was 35.24%. When 11% of lime and 5% of cement had been mixture to the soil, the shrinkage limit was decreased and gives the value of 32.32%.

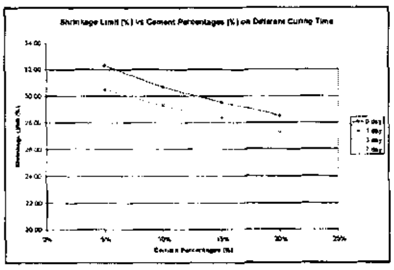

Figure 7: Relationship between Shrinkage Limit and Cement Percentages on Different Curing Time

4.15 Specific Gravity

Specific grvity of solids (G_s) is the ratio of unit weight of solids (weight of solids divided by volume of solids) to unit weight of water or of unit mass of solids to unit mass of water. Because of peat soil is light and not easy to absorb water, small pyknometer method not suitable to be done. Method that suitable is by referring to the research by Blake, 1965. The specific gravity for the studied soil was 1.39 and in range of specific gravity for West Malaysia peat which is 1.38-1.70 based on Bujang K.H, (2004).

Figure 8 shows that the highest value of specific gravity was 1.8693 which is after soil was mixing with 11% lime and 20% of cement at 7 days curing.

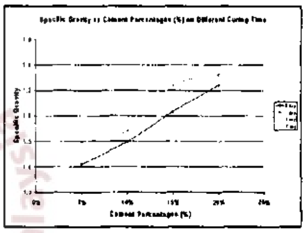

Figure 8: Relationship between Specific Gravity and Cement Percentages on Different Curing Time

4.2 Chemical Property

4.2.1 pH Test

This test is according to BS1377: Part 3:1990:9 using electrometric method which is determination of the pH value of a soil suspension in water. It can be the most accurate method and gives a direct reading to 0.05 pH unit or with some instruments to 0.02 pH unit. The pH value of natural soil was 2.65 which was classified as acidity soil. Head K.H stated that pH value less than 7 is acid and greater than 7 are alkaline.

Figure 9 show that this acidity soil have changed to be alkaline soil which have pH value of 7.7 when only 11% lime and 5% cement mixture with the soil before curing. This value than increasing until 9.38 when the cement adding to 20% for 7 days curing.

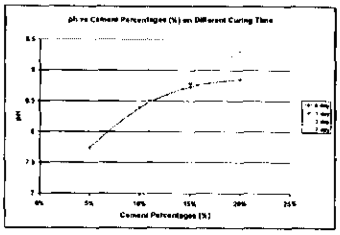

Figure 9: Relationship between pH and Cement Percentages on Different Curing Time

5.0 Discussion

From the result of tests for samples without additives materials and samples with additive material, it can be seen a huge different between it. For moisture content, liquid limit and shrinkage limit test, it shows that the increasing percentages of cement that used in mixtures with soil had gave the decreasing percentages value for that test. While the value for pH and specific gravity test were increased when additives percentages were increasing.

Figure 10 show a graph of vane shear strength versus moisture content. According to Al-Raziqi *et al.* (2003), the behavior of peat shear strength is decrease with increasing moisture content. It means that if the moisture content can be decrease, the strength of the soil can be increased. It showed that this stabilization method can improve the strength of the soil with decreasing the moisture content which is one of the index properties.

The optimum percentage of cement that need for stabilization in this peaty soil also have been determine which is 20% at 7 days curing. This is because all the maximum increasing and decreasing value after mixing with additive is at 20% cement for 7 days curing.

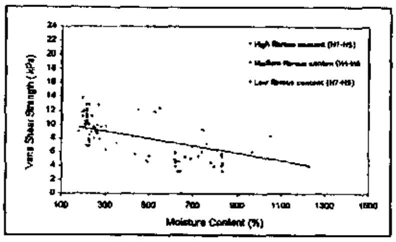

Figure 10: Vane Shear Strength – Moisture Content for Peat Soil (Al-Raziqi *et al.*, 2003)

6.0 Conclusion

The conclusion of the research can be drawn as follows:

- The determination for optimum percentage of cement that needed on the stabilization in this peaty soil have been achieved which is 20% at 7 days curing.
- In this study the values Rengit peat soil properties is in the range of peat soil obtainable in West Malaysia.
- The usage of cement and lime shows that the increasing amount of additives used, the shrinkage value will decrease.
- Better result can be achieved thru longer curing period.

Acknowledgement

The work was funded by a short-term research grant from the Universiti Tun Hussein Onn Malaysia (Grant No 0196 lead by Mr Adnan Zainorabidin). The assistance from the Geotechnical laboratory staff and Faculty of Civil and Environmental Engineering, UTHM, in carrying out this research is gratefully acknowledged. The author acknowledges the Geotechnical laboratory, FKAAS UTHM for providing equipment and laboratory facilities in carrying out this research.

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