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CHAPTER 3

Soil Stabilization Using Lime And Fly Ash

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3.1 INTRODUCTION

In Malaysia, road is an important form of communication that connects to a destination to other destination. In this study case referred at Sabak Bernam road because the road condition was very bad and not satisfactory and many accidents occur at that road. The problems such as holes and damaged on the roads and cracking pavement. Poor maintenance of road such as potholes, water ponding debris on the road edges, drains are not properly maintained, poor construction, wrong design and poor road surface. The consolidation of the soil also not good and have settlement at certain soil, that's all factors can cause drivers lose control with their vehicle and in-crease the risk of accident. The poor condition of road could probably cause by the unstable strength characteristic of sub grade, the engineering properties of sub grade need to be taken into consideration as it influence the ability of sub grade to resist force from the upper layer. The bad condition of road was the result from poor construction of the road. In site investigation of road, the most important thing is in determination of the engineering properties of soil. In this case study, the contractor need to confirm the soil classification in order to use the parameter for design. Poor classification could be the problem of the bad condition of road. Commonly, the type of soil is soft soil. If the soil under the surface layer is not good, then the upper layer will be broken down. In any road in Malaysia, especially at Sabak Bernam the sub grade layer is the critical part we must obtain their strength so that there are not have any problems to the users. This research aims to identify the effect of lime and fly ash on the geotechnical characteristic of clay soil and to determine the maximum dry unit weight of compaction using lime and fly ash.

3.2 LITERATURE REVIEW

Soil stabilization is a way of improving the weight bearing capabilities and performance of in-situ sub-soils, sands, and other waste materials in order to strengthen road surfaces. The prime objective of soil stabilization is to improve the California Bearing Ratio of in-situ soils by 4 to 6 times. The other prime objective of soil stabili-zation is to improve on-site materials to create a solid and strong sub-base and base courses. In certain regions of

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the world, typically developing countries and now more frequently in developed countries, soil stabilization is being used to construct the en-tire road. Traditionally and widely accepted types of soil stabilization techniques use products such as bitumen emulsions which can be used as a binding agents for producing a road base. However, bitumen is not environmentally friendly and be-comes brittle when it dries out. Portland cement has been used as an alternative to soil stabilization. However, this can often be expensive and is not a very good "green" alternative. Cement Fly Ash, Lime Fly Ash (separately, or with Cement or Lime), Asphalt, Bitumen, Tar, Cement Kiln Dust (CKD), Tree resin and Ionic stabilizers are all commonly used stabilizing agents.

3.2.1 Lime Stabilization

Lime is one of the additives, which is widely used in stabilization of fine-grained soils. Various forms of lime such as hydrated high-calcium lime (2 Ca(OH)), monohydrated dolomitic lime (Ca(OH) 2−MgO), and dolomitic quicklime (CaO − MgO) have been successfully used as stabilizing agent for many years. Quick lime (calcium oxide) is delivered in the form of coarse-grained powder. It reacts quickly with water producing hydrated or slaked lime, generating heat and volume change (Equation 3): $CaO + H_2O = Ca(OH_2) + 65.3$ kJ/mol. Quick lime must be handled with care; it can burn the skin in the presence of moisture it also can cause corrosion of equipment. The main contribution of lime to the strength of soil is from its ability to create cementation be-tween soil particles. The higher the surface area of the soil, the more effective this process of lime cementation is. Reflectivity and reflectance generally refer to the fraction of incident electromagnetic power that is reflected at an interface, while the term "reflection coefficient" is used for the fraction of electric field reflected (Klein, 2001).

3.2.2 Chemical Reactions In Lime Treated Soils

Several reactions occur when lime is added to clay in the presence of water. The reactions are cation exchange, flocculation-agglomeration, carbonation, and pozzolanic reaction (Mallela et al., 2004). Cation exchange and flocculation agglomera-tion reaction occur immediately after mixing and these reactions cause immediate changes in strength, plasticity index, and workability of the soils Carbonation is reaction of carbon dioxide in the open air or voids in the ground with lime, which forms a relatively weak cementing agent. Cementation caused by carbonation on the clay surface results a rapid initial increase in strength (Hausmann, 1990). Pozzolanic reaction occurs between lime and silica and alumina of the clay mineral and produces cementing material including calcium silicate-hydrates and calcium alumina hydrates. The long term result of pozzolanic reactions (Equation 4 and 5) is solidification of the soil (Hausmann, 1990). Rate of the pozzolanic reactions depends on time and tem-perature.

3.2.3 Stress Strength Behavior

Lime treatment leads to significant increase in strength. The immediate increase in strength results from flocculation-agglomeration reaction and leads to better workability, whereas long-term strength gain is due to pozzolanic reactions.

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3.2.4 Optimum Lime Content

The required amount of lime to be added to the soil depends on the application. For modification purposes 2% to 3% lime by dry weight of soil is sufficient (Maher et al. 2005). For stabilization purposes, normally 5% to 10% lime by dry weight of the soil is suitable. To determine the optimum lime content for soil stabilization several methods have been suggested.

3.2.5 Fly Ash Stabilization

Fly ash is a by-product of coal combustion in power plants. Fly ash contains silica, alumina, and different oxides and alkalis in its composition. Its general appearance is light to dark gray powder and the size is the same as silt. The specific gravity of fly ash ranges from 1.9 to 2.5. There are two types of fly ash: type “C” and type “F”. Type “C” fly ash has significant amount of free lime. This type of fly ash causes pozzolanic and cementitious reactions. Addition of fly ash to lime and cement can improve the engi-neering properties of soil like lime or cement. However, fly ash properties are highly variable and depend on chemical composition of coal and combustion technology (Klein, 2001).

3.2.6 Soil Modification With Fly Ash And Lime

Addition of mixtures of lime (L) and fly ash (F) to aggregates (A) results in LFA. For cohesion less soils with low plasticity fly ash treatment with cement will be more effective than lime, and for plastic soils fly ash treatment either with cement or lime is more effective (Hausmann, 1990). Less permeable layer is created by stabilization of a sandy road base with fly ash-cement mixture rather than cement alone. It is also convenient that cement fly ash-sand or cement-fly ash-gravel mixtures shrink less than soil-cement mixtures. Lime and fly ash reduce the maximum dry density of clay; the corresponding optimum water content tends to increase (Hausmann, 1990). Re-sults of the research by While and Genendran (2005) indicate that one hour delay between mix fly ash treated soils. Construction of runway 9-27 at Houston Interna-tional Airport is an example of the applications of Lime-Fly ash stabilization (Little et al, 2000).

3.3 WORK METHODOLOGY

The focus of the problem statement in this project is the problem of soil in is weak which cannot resist the oncoming loads. In this study, fly ash and lime were mixed with clay soil to investigate the relative strength gain in terms of unconfined com-pression, bearing capacity and compaction. The effect of fly ash and lime on the geotechnical characteristics of clay-fly ash and clay-lime mixtures was investigated by conducting Standard Proctor compaction test.

The materials used in this experiment are ordinary clayey soil and additives. Soil is brought from Sabak Bernam. Soil over there is highly plastic clay. Therefore the strength of pavement sub-grade needs to be as curtained to withstand the compres-sive load under traffic. The additives used for stabilization and modification include lime and fly ash (charcoal). The soils were mixed with each of these additives for which there were reasonable expectations of improved engineering properties. The amount of additive used was determined based on testing the strength for addition of varying percentages and selecting the one with greatest strength. The lime percent-age was fixed at 14% and fly ash 10%.

The steps that are planned for this experiment were as follow:

3.3.1 Soil preparation

The soil was collected from site in large sacks. It is brought to the lab and is dried in oven for 24 hours in large pans. This soil due to loss of water formed big lumps which is broken to smaller pieces or even fine powder and is sieved according to the needs of different experiments.

3.3.2 Standard Proctor test

Compaction is the densification of soil by reduction of air voids. The purpose of a la-boratory compaction test is to determine, the quantity of water to be added for field compaction of soil and resultant density expected. When water is added to dry fine grained soil, the soil absorbs water. Addition of more water helps in sliding of particles over each other. This assists the process of compaction. Up to a certain point, addi-tional water helps in reduction of air voids, but after a relatively high degree of satu-ration is reached, the water occupies the space, which could be filled with soil parti-cles, and the amount of entrapped air remains essentially constant. Therefore, there is an optimum amount of water for a given soil and compaction process, which gives rise to maximum dry density. Compaction of clay, clay-lime and clay-fly ash, clay lime and fly ash mixtures were carried out using standard proctor test with three layers on each 25 blows. Samples for conducting compaction tests were prepared using molds of dimensions 10 cm diameter and 15 cm height. In this study, lime is added for about 14% and cured for a day. Also, fly ash is added for about 10% and is cured for a day. The values of optimum moisture content and maximum dry density are ob-tained in a plot of dry density versus moisture content.

3.3.3 Produce the sample

Table 1 shows about procedure of the sample. The first sample is clay that used 4 kg clay. The second sample is clay + fly ash using clay as much as 4 kg and fly ash 0.40 kg. Sample for clay + lime was used 4 kg clay and lime 0.56 kg. The last sample is a sample of clay + lime + fly ash. This sample uses 4 kg of clay, lime of 0.56 kg and 0.40 kg of fly ash.

Table 1 Mixture Proportions used for each sample

Replacement (%)	Ash (kg)	Lime (kg)	Clay Soil (kg)
0	0	0	4
10	0.4	0	4
14	0	0.56	4
10 & 14	0.4	0.56	4

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4.0 ANALYSIS DATA

Compaction is the densification of soil by reduction of air voids. The purpose of a laboratory compaction test is to determine, the quantity of water to be added for field compaction of soil and resultant density expected.

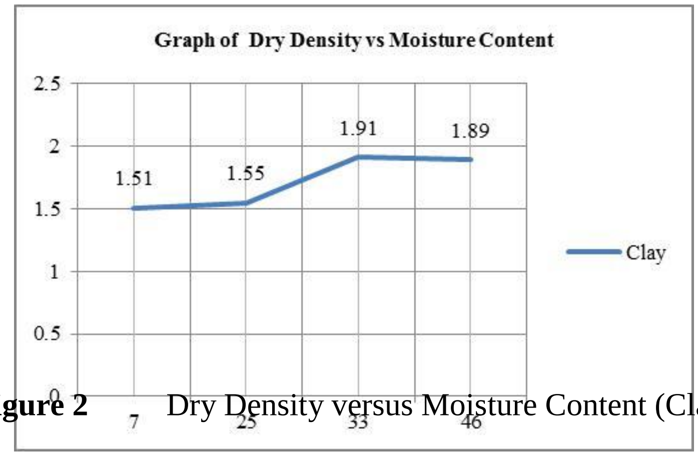

Figure 2 Dry Density versus Moisture Content (Clay)

Figure 2 shows the maximum dry density and optimum moisture content for the native clay soil are 1.91g/m^3 and 33%.

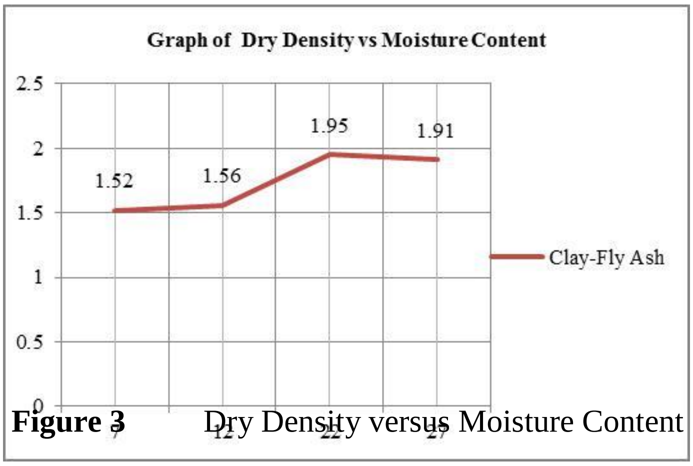

Figure 3 Dry Density versus Moisture Content

Figure 3 shows the maximum dry density and optimum moisture content for the clay soil mixed with fly ash are 1.95g/$m^3$and 22%.

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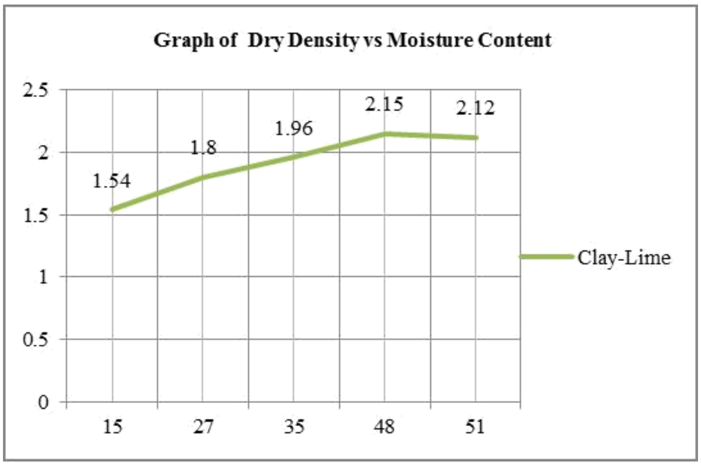

Figure 4 Dry Density versus Moisture Content

Figure 4 shows the maximum dry density and optimum moisture content for the clay soil mixed with lime are 2.15g $/m^3$ and 48%.

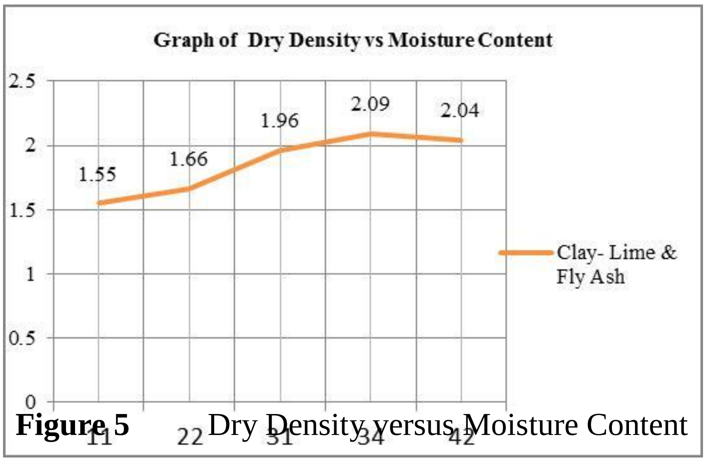

Figure 5 Dry Density versus Moisture Content

Figure 5 shows the maximum dry density and optimum moisture content for the clay mixed with lime and fly ash are 2.09g$/m^3$ and 34%.

From the Standard Proctor Test, it can be observed that the maximum dry density and optimum moisture content for the native clay soil were 1.91g/m^3 and 33%. The first objective of the project was to evaluate the effect of lime and fly ash on the geotechnical characteristic of clay soil and base on the result there were effects of lime and fly ash found. When clay soil was mixed with fly ash the optimum moisture content decreased and the maximum dry density were increased. The maximum density was 1.95g/m^3 at an optimum moisture content of 22 %. Whereby, when clay soil was mixed with lime, both the optimum moisture content and maximum dry density were increased. The maximum dry density was 2.15g/m^3 at an optimum mois-ture content of 48%. Finally when clay soil was mixed with both fly ash and lime both the optimum moisture content and maximum dry density decreased. The maximum dry density was 2.09g/m^3 at an optimum moisture content 34%. The second objective is to determine the maximum dry unit weight of compaction of soils using lime and fly ash, which can be used for specification of field compaction and according to the data collected from the samples the highest maximum dry unit weight that was obtained is 2.15g/m^3 from the mixing of clay soil with lime. Therefore we assume that 2.15g/m^3 can be used for specification of field compaction.

5.0 CONCLUSIONS

The suitability of using fly ash and lime as an additives for soil stabilization has been explored. The maximum dry density of compaction and optimum moisture content of clay soil by mixing fly ash and lime was measured by the standard proctor test. Based on the results obtained, the sample which clay mixed with 14% of lime has obtained the maximum dry density and optimum moisture content that is satisfying compare to all the other samples. The maximum dry density value obtained was 2.15mg/ and optimum moisture content 48%. The expected sample that were supposed to obtain the satisfying maximum dry density and optimum moisture content is clay mixed with fly ash and lime. The obtained result was not satisfying may be by the cause of tec h-nical errors during the test was carried out.

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