Comparison between Effect of Lime and Rice Husk Ash on California Bearing Ratio on Soil in Changkat Chermin

by

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Dissertation submitted in partial fulfillment of

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Civil Engineering Programme
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Approved by,

(Niraku Rosmawati Binti Ahmad)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

January 2008

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

YUSRA MAZLIZA BINTI MD YUNUS

ABSTRACT

Subgrade that contained substantial amount of clay minerals has low strength and cannot be guaranteed under load, especially in presence of water. Normally the soil would be removed and replaced by granular material or adding stabilizer to increase the CBR value. Instead of replacing the soil with granular material, soil stabilization can be adapted. The process of soil stabilization can be done by mixing soil and an additive with the existence of water. Cement and lime were common additives being used. However, this study was conducted to compare the effect of Rice Husk Ash (RHA) and Lime on California Bearing Ratio (CBR) of soil in Changkat Cermin. Rice Husk Ash is a good pozzolanic material from by product of paddy. 12% to 42% of RHA and 2% to 6% of lime had been used in order to achieve the objective of this research. Compaction test was carried out in order to determine the value maximum dry density (MDD) and optimum moisture content (OMC) which be used for conducting CBR test. CBR test had been conducted for unsoaked, soaked and 24 hour curing. For soaked condition, swell pressure value were recorded to compare the effect of RHA and lime on swell improvement. There was an improvement in CBR value with increase in RHA with peak values between 18-42% RHA contents. Meanwhile for lime, the CBR increase with maximum value between 2.5 to 4% of lime. The minimum swelling reading was at 35% of RHA and 2.5% of Lime. Soil Stabilization by using RHA is not cost effective since RHA more costly than lime. However, RHA can be used as alternative additive for soil stabilization since it can increase the CBR value of the soil.

Keywords : Rice Husk Ash (RHA) stabilization , Lime stabilization, Optimum Moisture Content, Maximum Dry Density, California Bearing Ratio

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RHA (Rice Husk Ash)

CBR (California Bearing Ratio)

UTP (Universiti Teknologi Petronas)

USCS (Unified Soil Classification System)

MDD (Maximum Dry Density)

OMC (Optimum Moisture Content)

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Soil that contained clay particle had been identified as soil that can give problem when dealing with construction because of its natural properties that cannot sustain excessive load in the present of water. Therefore, this kind of soil needs to be replaced or stabilized prior to utilizing it as a supporting layer. Soil stabilization that used additives to mix with soil is called chemical stabilization. Chemical admixture stabilization like using lime and cement had extensively used to improve soil strength and deformation behavior. In highway construction, (D.T Bergado, 1994) stated that lime and cement treatment had extensively used for road construction to increase bearing capacity of soft subgrade, and enabling a reduction in the thickness of base course. However, 'The over dependent on the utilization of industrial manufactured soil improving additives like cement and lime , have kept the cost of construction of stabilized road financially high', (Musa AlHassan et.al,2007). Thus, the usage of abundance agriculture waste that had pozzolana material like rice husk ash had gained considerable attention from geotechnical engineer to use this material in order to reduce the construction cost and improved the strength of soil. Deepa G. Nair et.al (2006) defined the pozzolanas as siliceous or aluminous materials that contain little or no cementing properties, but will in a finely dispersed form in the presence of water chemically react with calcium hydroxide to form compound possessing cementations properties. Rice Husk Ash is an agriculture waste from paddy milling that contained pozzolanic properties that could be potentially used, considering it is sufficiently produced and is widespread ,(Agus Setyo Muntohar and Gendut Hantoro, (2000)). Many researchers like Lazaro and Moh (1970), Rahman (1987), F.Haji Ali et al (1991), Balasubramaniam et al (1999), Muntohar and Hantoro (2000) and Basha e al (2003) had done research on using RHA as an alternative additive and they claimed that Rice Husk Ash as superior material to enhance geotechnical properties of lime or cement stabilized soils.

1.2 Problem Statement

Over the times, cement and lime which are the two main additives used in soil stabilization, rapidly increased in price due to sharp increase in the cost of energy since 1970s (Musa Al Hassan et.al 2007). Therefore, the use of various waste products in Civil Engineering construction had gained considerable attention in view of shortage and high cost of suitable conventional aggregates, increasing costs of waste disposal and environmental constraints. One of the waste products that is abundance for agriculture waste was rice husk. Rice Husk Ash is produced as a waste by product of milling process. In Malaysia, about 350,000 tones of rice husk are produced annually.

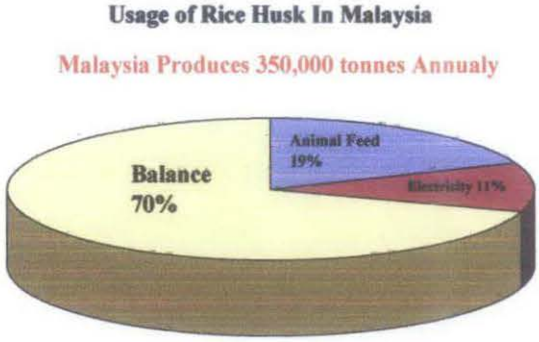

Figure 1. 1: Divison of Usage of RHA in Malaysia, (Annual Report Padi Beras Nasional Berhad, 2000)

Figure 1.1 above shows that about 70% of the total amount of Rice Husk had not been utilized. It showed that there is still abundance of Rice Husk left in Malaysia. Previously, this waste material is burn in the field or trucked dump out and dumped traditionally. Cumulative ash produced when burning RHA required a lot of spaces. The ashes that light in weight are easily carried by water and air that can lead to environmental pollution. With the growing awareness of an improved environmental management, these practices are rapidly becoming unacceptable. Practical alternatives that lead to tangible benefits are being sought and developed. Recent research, based on pozzolanic activity, found that rice husk ash was a potential material to be utilized for soil improvement, (Agus Muntohar and Gendut Hantoro, 2000).

1.3 Objectives and Scope of Study

The objectives of this covered as follows:

- ❖ to determine the effect of Rice Husk Ash on California Bearing Ratio on soil
- ❖ to determine the effect of Lime on California Bearing Ratio on soil
- ❖ to compare the effect of Rice Husk Ash and Lime on California Bearing Ratio on soil

The scopes of study for this project included of:

- Conducted research to find literature review and information related to the project.
- Experimental based to determine the basic properties of soil and RHA
- Conduct California Bearing Ratio test by using RHA or Lime to determine the shear value of the soil.
- Experimental based to determine the basic properties of soil mixture with Lime and RHA
- Comparison of CBR value between stabilization by using Lime or RHA

CHAPTER 2

LITERATURE REVIEW

2.1 California Bearing Ratio

The CBR test is an empirical test for estimating the bearing value of highway sub-base and subgrade, (K.H Head, 1992). The California Bearing Ratio Value for subgrade would determine the thickness design of the pavement. Subgrade is the uppermost part of soil, natural or imported and supporting the load transmitted from the overlying layers. However, subgrade that contained clay amount had tendency to swell when their moisture content was allowed to increased, (Agus Muntohar, 2000). This is due to characteristic of clay that greatly influence the amount of attracted water held in soil. , (F.G Bell, 1993). Moreover, (Musa Alhassan, 2007) added that there are instances where subgrade may contain substantial amount of clay minerals that its strength cannot be guaranteed under load, especially in presence of water. Therefore, the soil which contained clay need to be stabilized to increased the strength of the soil. According to manual pavement design by Department of Work, Malaysia, the CBR value of natural soil which less than 20% can undergo soil stabilization because 20% of CBR value is the minimum value for pavement design. A lot of research had been done by previous researcher like (Agus Muntohar et al, 2000), (Musa Alhassan et al, 2007), and (M.A Rahman 1987) in utilizing RHA as secondary additive to stabilize soil. They claimed that:

- There was increase of CBR with increase in RHA at specified cement contents with peak value between 4-6% RHA contents. (Musa Alhassan, 2007).
- CBR value increased nonlinearly as amount of RHA increased, (M.A Rahman 1987).
- CBR and shear strength improved at 6% lime content and 6-12.5% maximum of RHA, (Agus Muntohar et al, 2000).

Meanwhile, (Joel Mannaseh and Agbede I.Olufemi, 2008) had proved that lime can increase CBR value of natural soil as the amount of lime increased. He stated that CBR exhibit peak value of 37% at 8% lime content

2.1.1 Relationship of CBR to Density and Moisture Content

(K.H Head (1992)) stated that CBR value of soil depended on the soil dry density and moisture content. CBR value reduced with increasing in moisture content and the CBR value becomes rapidly decrease above the optimum value. The relationship between CBR and moisture content is shown in Figure 2.1 below.

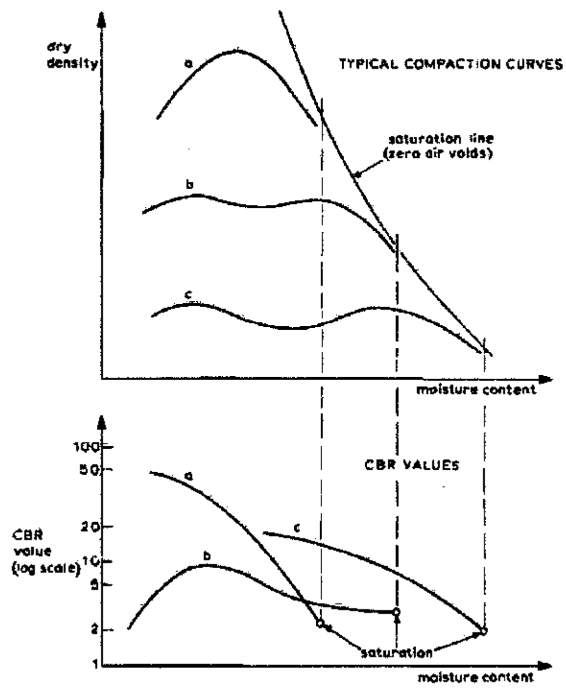

Figure 2. 1: CBR value related to moisture content and compaction curves for typical soils: well graded silty sand with clay, b) uniform fine sand, c) heavy clay, (K.H Head, 1990)

From Figure 2.1, K.H Head claimed that uniformly graded fine sand normally would give pattern of double peak like in curve B. Moreover, the two peaks for curve C normally occurred when clay is compacted with dry optimum, especially, for low compaction.

2.2 Rice Husk Ash

Rice Husk Ash is a major by-product obtained from food crop of paddy. The ash from rice husk contain high amount of silica. Silica from rice husk produced from controlled burn is amorphous silica which is highly reactive and burning above required temperature will produce crystalline silica which is far less reactive. Active silica that being produced from RHA is benefit for process of soil stabilization. Previous research state that chemical analysis of the ash showed high silica (SiO_2) content (more than 50%) is a requirement for a good pozzolanic material.,(B. Waswa-Sabuni et al, 2002).Moreover, "High percentage of silicious material indicates that RHA can be an excellence material for soil stabilization, as previous research on fly ash shows that the stabilized strengths depends on the percentage of silicon and aluminum oxides in the fly ash ,(Goeker and handy, 1963:Vincent et al.,1961: Mateos and Davidson, 1962,), (F.Haji Ali et.al, 1991). For every four tons of rice produced, one ton is rice husk, (F.Haji Ali et.al, 1991). Rice Husk Ash had been used in many countries as low cost admixture because of its role as filler and pozzolanic reaction, (S. Charoenvai et. al, 2005). When RHA being added to toil, the most important effects are changes in pore structure and voids by the reduction in the grain size caused by pozzolanic reaction and the obstruction of pores and voids by the action of the finer grains (physical or filler effect), (G.C. Isaia et.al, 2001). Moreover, (D.D Bui et.al, 2003) claimed that the small particles of RHA improved the particle packing density of mixture, leading to a reduced volume of larger pores and more homogeneous microstructure of paste, particularly in the interfacial zone. He also added higher packing densities near the aggregate grain interface was leading to improved behavior of the mixes. Meanwhile, pozzolanic effect occurred when cation exchange takes place between the ions on the surface of clay particles and the calcium ions of the RHA. Therefore, bonds between the soil particles become stronger. However, the pozzolanic effect for RHA solely in soil stabilization is little because of fewer amounts of calcium hydrates. Because of that, physical effect of the RHA as filler is more significant in soil stabilization. Soil stabilization by using RHA had been done by previous researchers like (Agus Muntohar, 2000), (Musa AlHassan and Alhaji M. Mustapha, (2007) and (M.A Rahman 1987) to increase the properties of soil. Those researchers focused on pozzolana properties of RHA to enhance the pozzolanic reaction since they also added other additive like cement or lime to the mixture of soil and RHA. The amounts of RHA used by previous researchers had been summarized in Table 2.1.

Table 2. 1: Amount of RHA used by Previous Researcher

Researchers	**Year**	**Amount of RHA**	**Amount of other Additives**
M.A Rahman	1987	6 % , 12%, 18 % of RHA	3%,6%, 9% Cement
F Haji Ali et.al	1991	6%, 12%, 18% of RHA	3%, 6%, 9% Lime
Agus Setyo Muntohar and Gendut Hantoro	2000	7.5%, 10% and 12.5 % RHA	6%, 8%, 10%, 12%
Musa AlHassan and Alhaji Mohammed Mustapha	2007	2%, 4%, 6%, 8% RHA	2%, 4%, 6%, 8% Cement

2.3 Lime

F.G Bell, (2000) stated that lime is produced from natural limestone, and particular type of lime formed depends upon the parent material and production process. There are five basic types of lime. Two of them were Calcium hydroxide (slaked lime) and Calcium oxide (quick lime). Calcium hydroxide is most widely used for stabilization. Nevertheless, Calcium oxide (quick lime) may be more effective in some cases. However, the quick lime would corrosively attacked equipment and may cause severe skin burns to personnel, (Agus Muntohar et al, 2000). (G Bell, 1993) stated that there are limitations that need to be considered when dealing with lime stabilization.

Those limitations are:

- Lime react with soil contain plasticity index range from 10-50%.If plasticity index < 10%, add other pozzolans like fly ash
- Not effective in organic soil since organic matter retards hydration.
- Lime is an alkaline material that is reactive in the presence of moisture.

Moreover, lime had low effect in soil that contain low amount of clay because the shear strength increased is highly dependent on pozzolanic reaction which is the reaction between lime with silicates and aluminates in soil,(D.T Bergado et al 1994). He also claimed that for lime treatment to be successful, the amount of

Clay should not less than 20% and amount of sum of silt and clay should preferably exceed 35%. The amount of lime added to the soil must be related to the amount of clay in the soil. (Ingles 1972), (Agus Muntohar et al, 2000) recommended the criteria of lime mixture as shown in Table 2.2.

Table 2. 2: Recommend criteria of lime mixture, (Agus Muntohar et al, 2000)

Soil type	**Content for modification**	**Content for Stabilization**
Sands	Not recommended	Not recommended
Sandy clay	Not recommended	~ 5 percent
Silty clay	1 – 3 percent	2 – 4 percent
Heavy clay	1 – 3 percent	3 – 8 percent
Organic soils	Not recommended	Not recommended

The primary main reaction of lime stabilization included of cation exchange, flocculation, lime carbonation and pozzolanic reaction. (John D. Nelson et.al, 1992).

2.4 Pozzolanic Reaction

Pozzolanic reaction occurred when Calcium hydroxide in the additives reacts with silicates and aluminates in soil with presence of water to form cementing materials or binders, consisting of calcium silicates or aluminates hydrates (Diamond and Kinter,1965),(D.T Bergado et.al,1994). The reaction of silicates and aluminates with Calcium hydroxides studied by (D.T Bergado et.al, 1994) is shown below:

$$Ca^{++} + 2(OH)^{-} + (SiO_2) \longrightarrow CSH \ldots\ldots \text{(Eqn 2.1)}$$

$$Ca^{++} + 2(OH)^{-} + (Al_2O_3) \longrightarrow CAH \ldots\ldots \text{(Eqn 2.2)}$$

The gel of calcium silicates (and/or aluminates hydrates) cements the soil particles in a manner similar to the effect produced by the hydration of Portland cement, but the lime cementing process was much slower reaction and need longer time than the hydration of cement. The main part of the reaction does not start until a couple of days after the mixing of lime (Assarson et al.1974).

2.5 Effect of RHA on Properties of Soil

2.5.1 Effect on Atterberg Limit

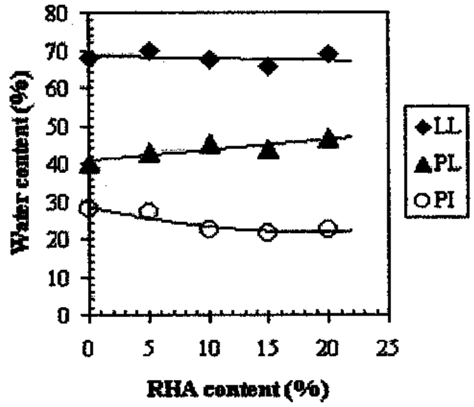

Figure 2. 2: Variation of liquid limit, plastic limit and plasticity index with RHA content, (E.A.Basha et al, 2003).

Figure 2.2 showed that, when the value of RHA increased, the value of liquid limit and plasticity index reduced while the value of plasticity index increased. (E.A.Basha et al, 2003) stated that when plasticity index reduced, it showed that there was an improvement in the soil properties.

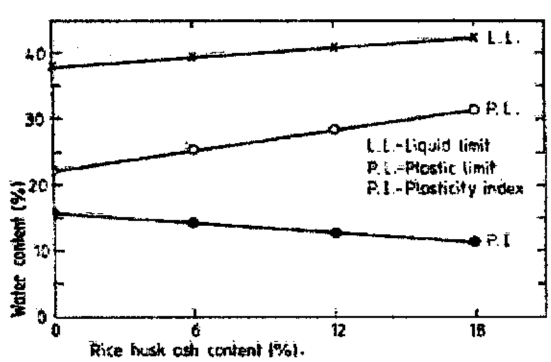

Figure 2. 3: Variation of liquid limit, plastic limit and plasticity index with RHA content, (M.A Rahman, 1987)

From Figure 2.3, (M.A Rahman, 1987) claimed that both liquid limit and plastic limit increased when amount of RHA increased while plasticity index reduced.

2.5.2 Effect of RHA on Dry Density and Optimum Moisture Content

Figure 2.4 below showed the result of maximum dry density and optimum moisture content of soil with RHA content by (E.A. Basha et al, 2003).

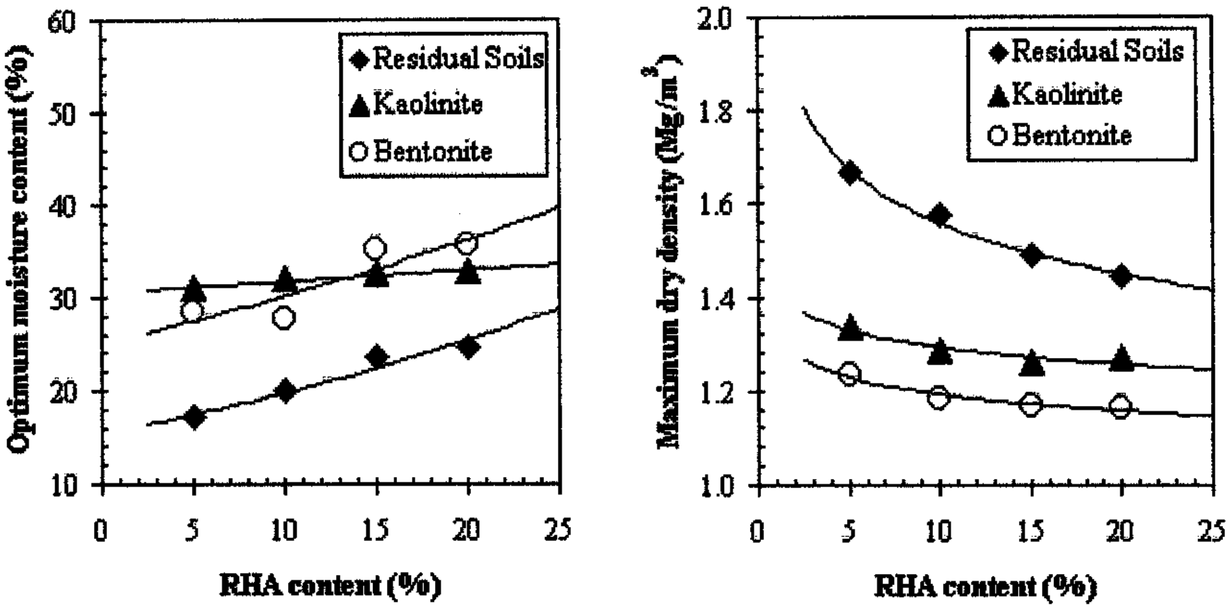

Figure 2. 4: Characteristic of Maximum Dry Density and Optimum Moisture Content with RHA content, (E.A. Basha et al, 2003).

Figure 2.4 showed that the optimum moisture content increased as the percentage of RHA increased in three types of soil. E.A Basha et al, (2003) stated that the optimum moisture content increased due to the porous properties of RHA which absorbed more water. While, maximum dry density was decreased as the percentage of RHA increased. He also claimed that this is because replacement of soil by RHA which have relatively lower specific gravity compared to the soil reduced the particle density and specific gravity of the mixture.

Figure 2.5 and 2.6 below showed results on maximum dry density and optimum moisture content for adding RHA with soil done by (Musa AlHassan and Alhaji M. Mustapha, 2007). Based on the result, MDD decreased and OMC increased as the amount of RHA increased. Maximum Dry Density decreased due to coating of the soil cement by the RHA produced large particles with larger void which resulted in less density. Meanwhile, OMC increased because when RHA being added, quantity of free silt and clay fraction decreased, hence coarser materials with larger surface areas were formed (these processes need water to take place).

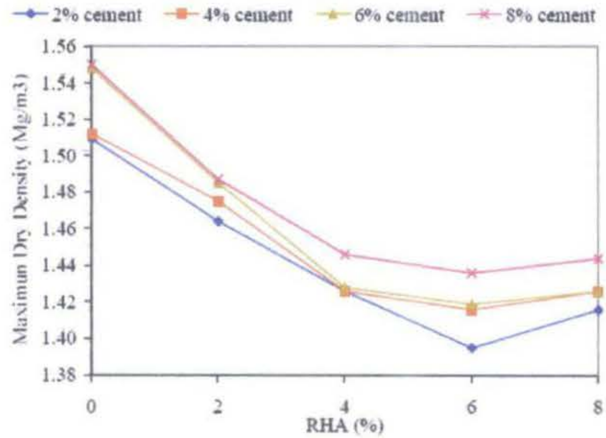

Figure 2. 5: Characteristic of Maximum Dry Density with RHA content, (Musa AlHassan and Alhaji M. Mustapha, 2007).

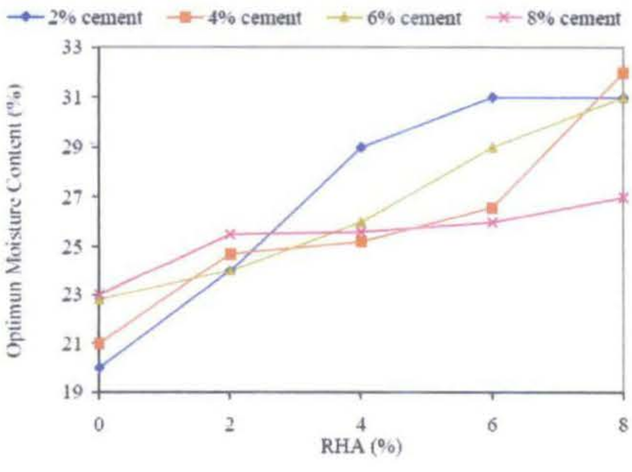

Figure 2. 6: Characteristic of Optimum Moisture Content with RHA content, (Musa AlHassan and Alhaji M. Mustapha, 2007).

2.5.3 Effect of RHA on California Bearing Ratio Value

Figure 2.7 shows on the result of California Bearing Ratio of soil with added in RHA by (M.A Rahman, 1987)

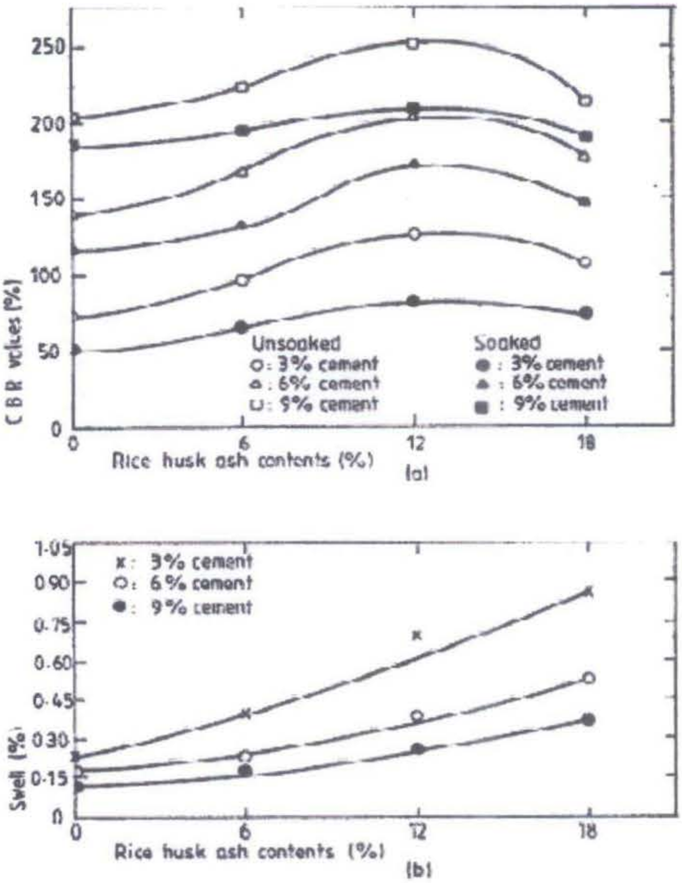

Figure 2. 7: Variation of both unsoaked and soaked California Bearing Ratio with cement-rice husk ash content, (M.A Rahman, 1987)

From Figure 2.7 M.A Rahman, (1987) explained that value of California bearing ratio increased as the percentage of rice husk increased. However, in the case of soaked CBR, he claimed that the value of swelling increased as percentage of RHA increased.

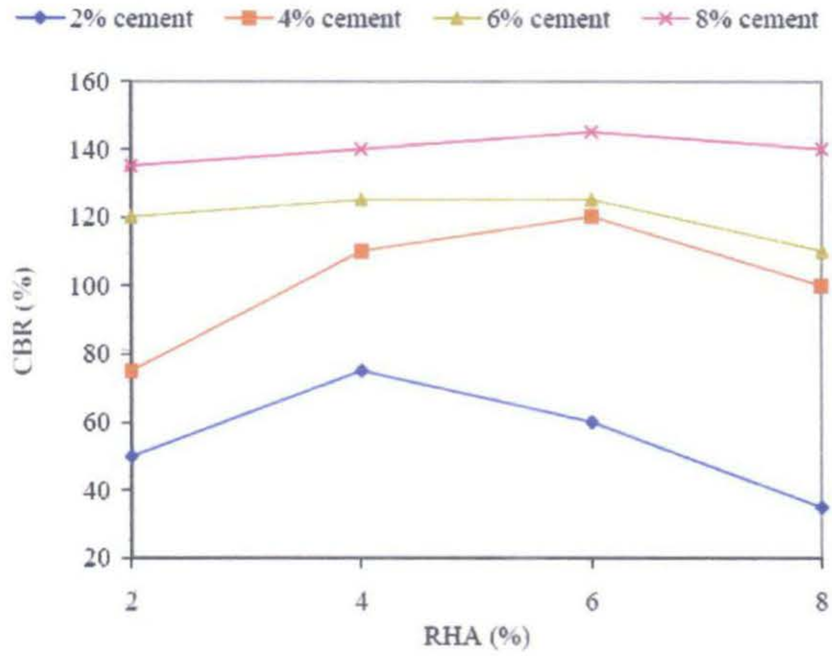

Figure 2. 8: Variation of CBR Value added with RHA and Cement Content, (Musa Al Hassan and Alhaji M.Mustapha, 2007)

(Musa AlHassan and Alhaji M. Mustapha, 2007) showed in Figure 2.8 that there were improvement in CBR value when adding RHA to soil. He claimed that the improvements resulted from the cementations materials were from:

- The pozzolanic reaction between the lime librated from the hydration reaction of cement and the RHA
- Interparticle bonding between RHA and soil cement mixture. (RHA gave filler effect).

2.6 Effect of Lime on Properties of Soil

Research to determine the effect of Lime on some geotechnical properties had been carried out by Joel Mannaseh and Agbede I.Olufemi, (2008). The results on Atterberg limit, compaction and California Bearing Ratio are discussed below.

2.6.1 Effect on Atterberg Limit

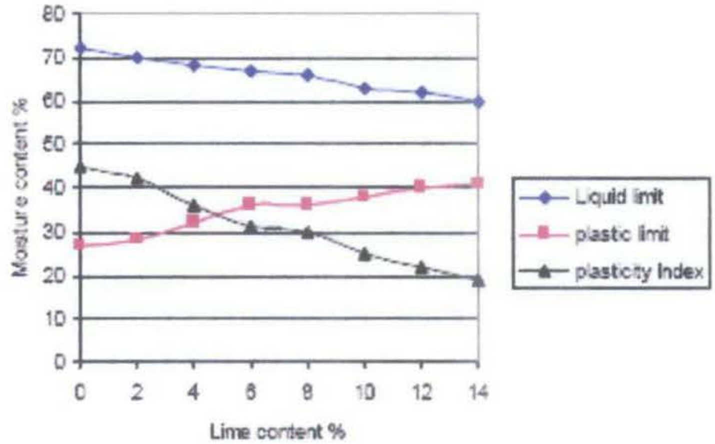

Figure 2. 9: Atterberg limits for Soil Stabilization by using Lime, (Joel Mannaseh and Agbede I.Olufemi, 2008).

Atterberg limits indices variations with lime content were shown in Figure 2.9. From the figure, it can be seen that liquid limit decreased with lime content, while the plastic limit increased with lime content, thereby resulting in a decrease in plasticity index. A possible explanation for the above mentioned trend was not unconnected with the addition of lime, which aids flocculation, and aggregation of the clay particles. The agglomeration of clay particles due to lime addition according to Osinubi (1995) turns a clayey soil to a silty soil and this by itself will decrease the liquid limit of the soil because of the lower surface area, in addition to the highly plastic nature of lime, (Joel Mannaseh and Agbede I.Olufemi, 2008).

Figure 2.10 below showed the characteristic of liquid limit, plastic limit and plasticity index of soil mix with lime which were done by (Emad Akawwi and Atef Al Karabsheh, 2002). He stated that when adding lime or any other soil stabilizers might minimize the plasticity index of the soil by converting the soil to the rigid or granular mass. Moreover, the bonds between the soil particles become stronger due to the cation exchange that takes place between the ions on the surface of clay particles and the calcium ions of the lime. Adding lime stabilizer to the soil decreased the plasticity index of the soil.

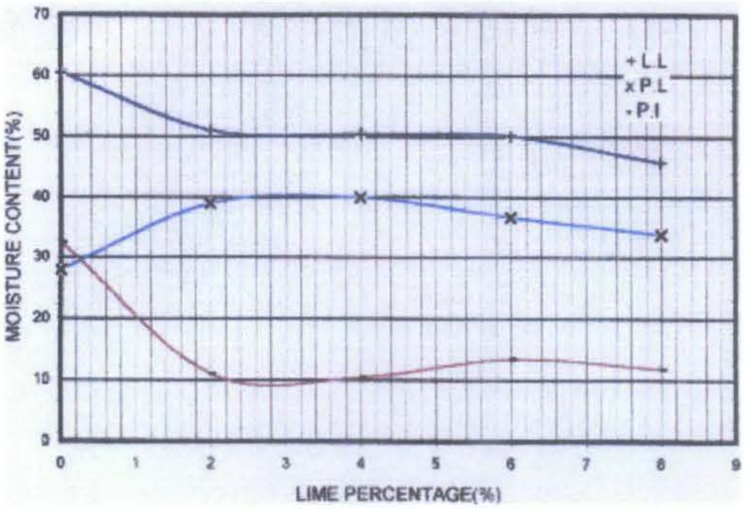

Figure 2. 10: Characteristic of Atterberg Limit by Adding Lime to the soil, (Emad Akawwiand and Atef Al Karabsheh, 2002)

2.6.2 Effect on Compaction on Dry Density and Optimum Moisture Content

Figure 2.11 below showed the variation of the maximum dry density (MDD) and optimum moisture content (OMC) with lime content. The maximum dry density of Igumale shale was substantially reduced from 1.51 Mg/m3 at 0% lime content to 1.35 Mg/m3 at 8% lime content. However, the optimum moisture content increased with lime content. The decrease in density according to Ola (1977) and Lees et al (1982) is as a result of the flocculated and agglomerated clay particles occupying larger spaces leading to a corresponding decrease in dry density. The increasing OMC with increasing lime content was as a result of the extra water required for the pozzolanic reactions. (Joel Mannaseh and Agbede I.Olufemi, 2008).

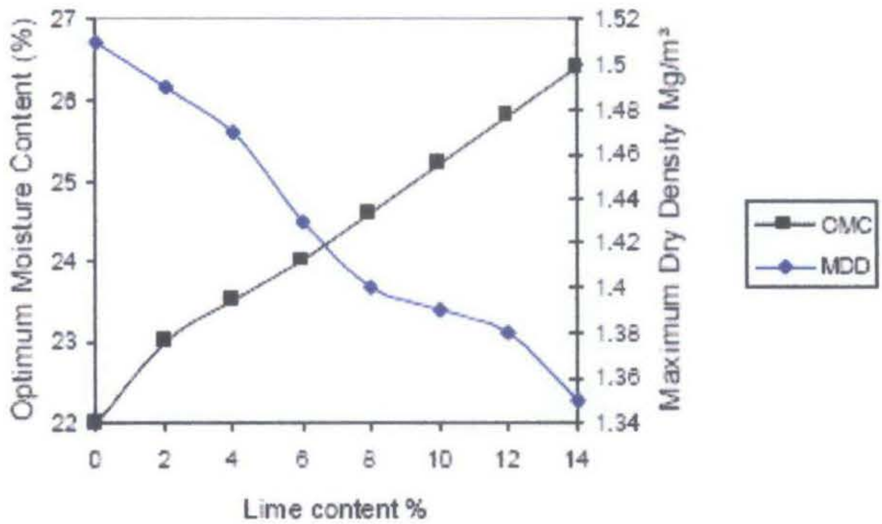

Figure 2. 11: Characteristic of MDD and OCM of soil being stabilized by lime, (Joel Mannaseh and Agbede I.Olufemi, 2008).

2.6.3 Effect on California Bearing Ratio

Figure 2.12 below showed that as amount of lime increased, there were improvements in CBR values. The maximum value of CBR was 37 % at 8 % lime content, (Joel Mannaseh and Agbede I.Olufemi, 2008).

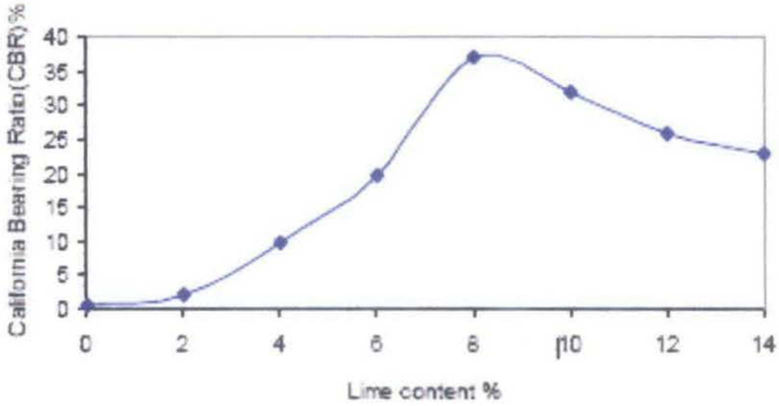

Figure 2. 12: Characteristic of CBR of soil being stabilized by lime, (Joel Mannaseh and Agbede I.Olufemi, 2008).

CHAPTER 3

METHODOLOGY

3.1 Research on Literature Review

At the earlier stage, a lot of readings on the soil stabilization, RHA, and CBR are done to get familiar with terms and general ideas about the research. The reading sources came from books, internet lecturer- given article, journal and many more. After getting exposed to the project term, data collection through Internet, library and journal, the next step is to prove it by using experimental process. The basic ideas that got from those reading sources are fully applied in this experiment.

3.2 Preparation of Soil

The soil sample used for this study was dug from oil palm, Changkat Chermin, Perak at a depth of between 1.5m to 2.5m using the method of disturbed sampling. The soil sample was disturbed. The soil that had been excavated at the site was being stored in the tank within the lorry and then being transferred in container in the laboratory of UTP to make sure that the original moisture content can be maintained. The soil sample used for entire experiment had been oven dried first and being sieved passing through 2mm sieve.

3.3 Preparation of RHA

Rice Husk had been bought from the factory and being incinerated to obtain Rice Husk Ash. The example of incinerator is shown in Figure 3.1 below.

Figure 3. 1: Example of Incinerator

This incinerator contained twelve filters that would filter the ash produced from the burning of rice husk ash. Filtering process would ensure that the ash that release to the environment is safe. The product which had burned by using incinerator was shown in Figure 3.2 below. Then the RHA would be grind by using Los Angles Abbrasion machine to get the ash form. The RHA that used in conducting all experiment in this research had been sieved first through 0.425mm sieve.

Figure 3. 2: Rice Husk Ash

3.4 Mixture of soil with RHA

There are six mixture of soil with RHA used for the entire experiment. All mixture had been summarized in Table 3.1 below.

Table 3. 1: Types of Mixes for Mixture of Soil with RHA

Type of mixture	Amount of RHA used
Mix 1	Raw soil + 12% RHA
Mix 2	Raw soil + 18% RHA
Mix 3	Raw soil + 24% RHA
Mix 4	Raw soil + 30% RHA
Mix 5	Raw soil + 36% RHA
Mix 6	Raw soil + 42% RHA

The percentage of RHA used is based amount of RHA used by previous researcher. However, if referring back to the section 2.2 in literature review, amount used by previous researcher is lower than amount of RHA used in this research. This is because; previous researchers used RHA as secondary additive and add other additive like cement or lime. Nevertheless, for this project, solely RHA used to determine the effect on CBR value.

3.5 Mixture of soil with Lime

For lime, there are 3 mixes of soil and lime. The entire mixes were shown in Table 3.2 below.

Table 3. 2: Types of Mixes for Mixture of Soil with Lime

Type of mixture	Amount of RHA used
Mix A	Raw soil + 2% Lime
Mix B	Raw soil + 4% Lime
Mix C	Raw soil + 6% Lime

The percentage of Lime used is based amount of Lime suggested by Agus Muntohar, (2000) in section 2.3 in literature review. Based on Table 2.2, for soil that classified as sandy clay, the amount of lime recommended was approximately five percent.

3.6 Basic Test for Soil

Basic tests for soil included of:

3.6.1 Chemical composition of soil

X-ray diffraction testing was used to determine the chemical composition of soil. Soil that being used had been sieved passing through 0.075mm.

3.6.2 Sieve Analysis and hydrometer (BS 1337: Part 2: 1990)

British Standard had been used. Dry sieve analysis was done. Sieve size of 2.00mm, 1.18mm, 0.600mm, 0.425mm, 0.300mm, 0,212mm, 0.150mm, 0.075mm and 0.063 were used. Soil was dried in the oven for 24 hour and grind by using Los Angeles machine before sieve.

3.6.2 Atterberg Limit (BS 1337/part 2:4.3/4.4)

British Standard was referred. Three points liquid limit test procedure were used to develop the liquid limit curve. Soil that being used in this test had been sieved passing through 0.425 mm.

3.6.3 Moisture Content (BS 1337: Part 2: 1990: 3.2)

British Standard was followed. Moisture content test had been done just after the soil being transferred in the container in laboratory to obtain the moisture content that quite similar for the soil at site.

3.6.4 Specific Gravity Test (BS 1337: Part 2: 1990: 8.2)

Three pycnometer were used to obtain the average value of specific gravity. Before conducting this experiment, the soil had been sieved through 0.425 mm sieve.

3.6.5 Organic Test (ASTM D 2974)

Determination of organic content was conducted on five different parts of soils. ASTM procedure had been followed. The test used ignition oven to determine the amount of total organic carbon within the sample of soil.

3.6.6 Compaction (BS 1377: Part 2: 1990: 4.3/4.4)

The test conducted according to British Standard. Compaction test for determining the optimum moisture content and maximum dry density was conducted by using 16% of water as a started point. Then, the percentage of water increased with the increment of three (16, 19, 22, 25, 28 and so on) until getting the optimum value of moisture content and dry density. The started percentages of water were obtained based on result of previous researcher .The soil was compacted using 27 blows per layer for three layers. The soil used had passing through 2mm sieve size.

3.7 Basic Test for Rice Husk Ash

There were three different laboratory tests were conducted on the RHA. The laboratories tests were:

3.7.1 Chemical composition of RHA

X-ray fluorescent testing was used. RHA that being used had been sieved passing through 0.075mm.

3.7.2 Sieve Analysis and hydrometer (BS 1337: Part 2: 1990)

British Standard had been used. Dry sieve analysis was conducted. Sieve size of 2.00mm, 1.18mm, 0.600mm, 0.425mm, 0.300mm, 0,212mm, 0.150mm, 0.075mm and 0.063 were used. RHA had grind by using Los Angeles machine before sieve.

3.7.3 Specific Gravity Test (BS 1337: Part 2: 1990: 8.2)

Three pycnometers were used to obtain the average value of specific gravity. RHA that sieve passing through 0.425mm had been used for this test.

3.8 Basic Test for Lime

3.8.1 Chemical composition of Lime

X-ray Diffraction testing was used. Lime that being used had been sieved passing through 0.075mm.

3.9 Test for Mix of RHA and soil

There are three tests that were conducted to determine the effect on adding RHA with soil. Those tests were:

3.9.1 Sieve Analysis and hydrometer (BS 1337: Part 2: 1990)

British Standard had been used. Dry sieve analysis was followed. Sieve size of 2.00mm, 1.18mm, 0.600mm, 0.425mm, 0.300mm, 0,212mm, 0.150mm, 0.075mm and 0.063 had been used. Soil had been mixed with varies percentage of RHA before sieve. The soil used had pass through sieve 2mm while RHA passing through 0.425mm. The mixture that retained in the pan had being used for hydrometer test.

3.9.2 Atterberg Limit (BS 1337/part 2:4.3/4.4)

British Standard had been used. Three point liquid limit test procedure was used to develop the liquid limit curve. Soil and RHA that being used had been sieve passing through 0.425 mm.

3.9.3 Specific Gravity Test (BS 1337: Part 2: 1990: 8.2)

One pycnometer for each percentage of RHA had been used to obtain the value of specific gravity. Soil and RHA that being used had been sieve passing through 0.425mm.

3.9.4 Compaction (BS 1377: Part 2: 1990: 4.3/4.4)

The test conducted according to BS 1377: Part 2: 1990: 4.3/4.4. Compaction test for determining the optimum moisture content and maximum dry density was conducted by using 16% of water as a started point. Then, the percentage of water increased with the increment of three percent until getting the optimum value of moisture content and dry density. The started percentages of water were obtained based on result of previous researcher. Meanwhile, the increment of three percent for water content is based on British Standard. The soil was compacted using 27 blows per layer for three layers. The soil used had passing through 2mm sieve size.

3.9.5 California Bearing Test

CBR testing will be carried out on difference mixes as stated in Table 3.1 in section 3.4. CBR test had been carried out for three different conditions as in Table 3.3 below.

Table 3. 3: Type of CBR Test for Difference Mixture of Soil with RHA

Type	Sample
Unsoaked (3 layer , 62 blows per layer)	Mix 1 to Mix 6
Soaked	Mix 1 to Mix 6
24 hour curing (Room Temperature $27^{0}C$)	Mix 1 to Mix 6

The entire specimens that would undergo the CBR test were compacted at optimum moisture content with 62 blows per layer for three layers. The mixes are based on Table 3.1.

3.10 Test for Mix of Lime and soil

Experiments that being conducted in order to determine the effect of lime on soil stabilization were summarized as follows:

3.10.1 Sieve Analysis and hydrometer (BS 1337: Part 2: 1990)

British Standard had been used. Sieve size of 2.00mm, 1.18mm, 0.600mm, 0.425mm, 0.300mm, 0,212mm, 0.150mm, 0.075mm and 0.063 had been used. Soil had been mixed with varies percentage of lime before sieve. The soil used had passed through sieve 2mm while lime passing through 0.425mm. The mixture that retained in the pan had being used for hydrometer test.

3.10.2 Specific Gravity Test (BS 1337: Part 2: 1990: 8.2)

The procedure is same like conducting Specific Gravity test for mixture of soil and RHA.

3.10.3 Atterberg Limit (BS 1337/part 2:4.3/4.4)

The procedure is same like conducting Atterberg limit test for mixture of soil and RHA. Soil and Lime that being used had been sieve passing through 0.425 mm.

3.10.4 Compaction (BS 1377: Part 2: 1990: 4.3/4.4)

The procedure is same like compaction mixture of soil and RHA. The soil used had passing through 2mm sieve size. Meanwhile lime that being used had been passing through 0.425mm.

3.10.5 California Bearing Test

CBR testing will be carried out on difference mixes as stated in Table 3.2 in section 3.5. CBR test had been carried out for three different conditions as in Table 3.4 below. The entire procedure is same as for CBR test for adding RHA.

Table 3. 4: Type of CBR Test for Difference Mixture of Soil with Lime

Type	Sample
Unsoaked (3 layer , 62 blows per layer)	Mix A to Mix C
Soaked	Mix A to Mix C
24 hour curing (Room Temperature 27^0C)	Mix A to Mix C

The summary of entire procedures for soil stabilization by using lime and RHA are as follow:

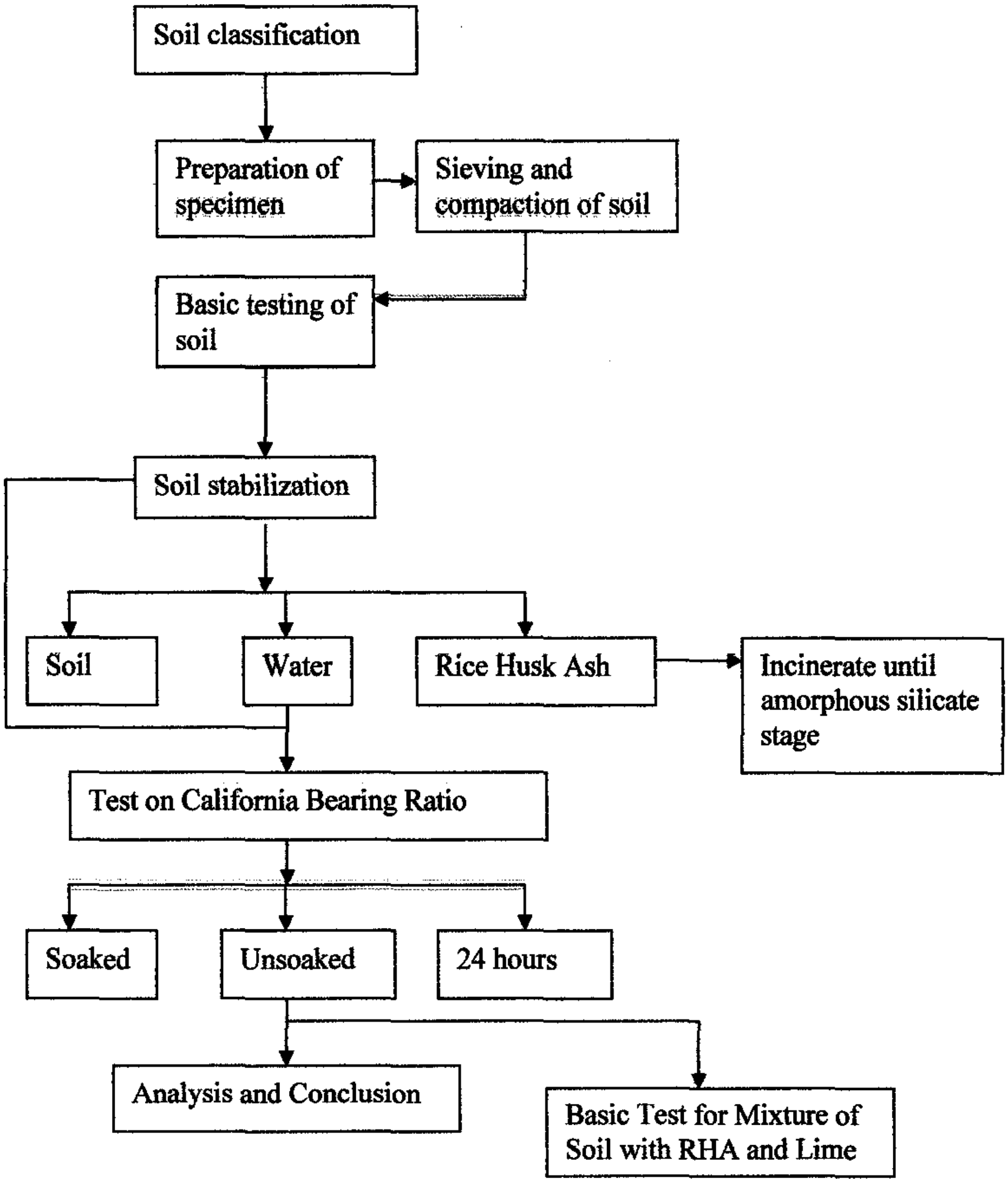

Figure 3.3: Flow diagram for entire procedure of soil stabilization by using Lime and RHA

3.11 Hazard Analysis

Hazard analysis is one of the factored that must be considered in the methodology part of this research since hazard may occur when dealing with material and equipments during conducting the laboratory work.

3.11.1 Equipment

Equipments used included the CBR testing machine, mixer, LA Abrasion machine, sieve, incinerator, and oven .Those description about hazard analysis on machines were summarized in Table 3.5.

Table 3. 5: Description of machine used for Final Year Project

Type of Machine	Description	Hazard	Precaution
Compactor for California Bearing Ratio and Proctor	Compact soil before CBR test	Noise, Dangerous when handle the mould with less care	Wear musk, Careful in handle the mould, glove, and lab coat.
Soil Mixer	Mix the mixture contains soil, rice husk ash and water.	Ash, Dangerous when handle the mould with less care	Wear musk, Careful in handle the mould, glove, and lab coat.
Incinerator	Burn rice husk ash at required temperature	Ash, Noise	Wear musk, goggle, lab coat and glove.
Sieve	Sieve the soil for different type of grain size.	Noise	Wear musk, glove and lab coat.
Oven	Dry the soil before testing and to determine moisture content	Hot surface	Wear musk, thick glove and lab coat.
Los Angeles Abrasion Machine	Grinding larger material into smaller size of material.	Tendency to slip while roll the machine to start the process	Wear musk, goggle, lab coat and glove. Careful in handle the machine.
CBR testing machine	California Bearing Testing	Noise, Dangerous when handle the mould with less care	Wear musk, goggle, lab coat and glove. Be careful when adjust the CBR machine as it is at high place.

3.11.2 Material

Materials used in this final year project also give impact to health safety and environment. Those descriptions about materials used were as shown in the Table 3.6 below:

Table 3. 6: Material Used in Completing Final Year Project

Type of Material	**Description**	**Hazard**	**Precaution**
Rice Husk Ash	Product of Rice Husk that have been burned	Ash that can effect inhalation and can cause hazard on eye	Wear full protection of musk, glove
Lime	Hazardous chemical. Cannot exposed directly to water and touch by using hand.	Handling lime must be trained first and need to wear proper equipment since it can cause hazards on the eye, skin and also inhalation.	Wear special glove and musk.
Soil	Natural material	Ash that can effect inhalation and can cause hazard on eye	Wear full protection of musk, glove

CHAPTER 4

RESULT AND DISCUSSION

Basic testing tests for raw soil like sieve analysis, liquid limit, plastic limit, specific gravity; moisture content, chemical composition, organic content and hydrometer test had been conducted. The results and discussion of the tests are as follows:

4.1 Basic Properties of Soil

4.1.1 Chemical composition of Soil

The chemical composition of soil had been determined by using X-Ray Diffraction and as shown in Figure 4.1 below.

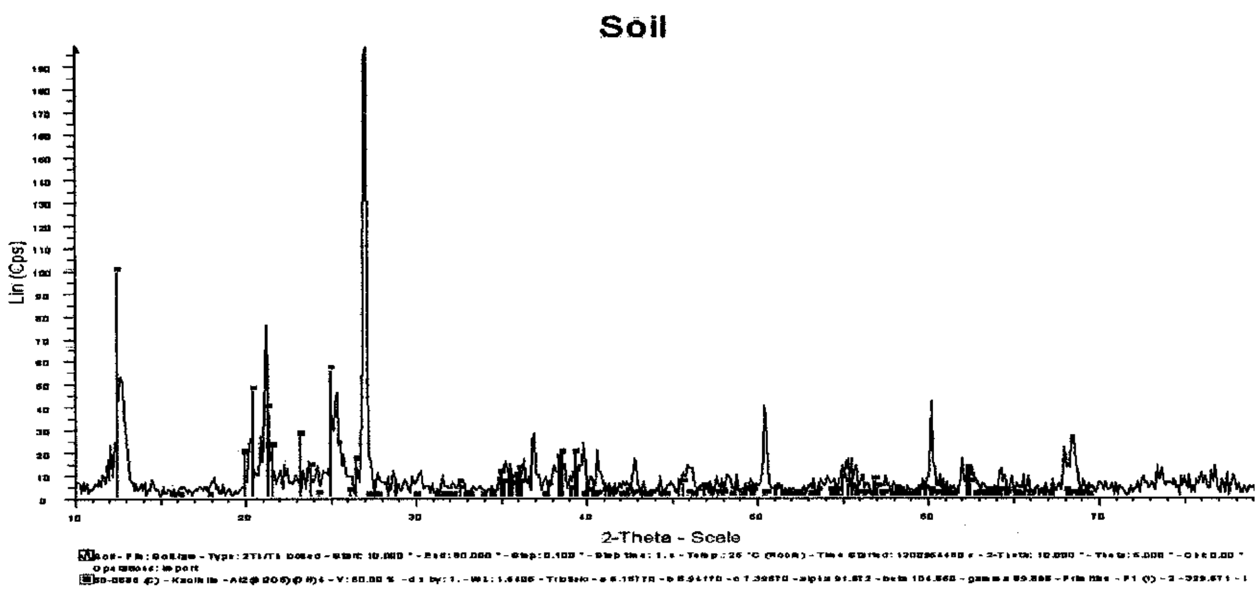

Figure 4. 1: Chemical Composition of Soil from XRD Test

From Figure 4.1 above, it showed there was a lot of kaolinite composition within the soil. Kaolinite which is one type of clay is the principal constituent in china clay and ball clay. It is common in humid tropical region. Subgrade that contains clay amount have tendency to swell when their moisture content is allowed to increase.

Moreover, from Table 4.1 below, it showed that the soil contain high amount of silica dioxide and alumina dioxide.

Table 4. 1: Chemical Composition of Soil from XRF Test

MgO	**Al_2O_3**	**SiO_2**	**SO_3**	**K_2O**	**CaO**	**Fe_2O_3**
7.0ps	470.6	669.5	0.8KCps	62 KCps	0.5 KCps	256.4 KCps
0.351	31.1	63.4	0.0522	1.73	0.014%	1.46 %

These alumina and silica amounts were the reactive composition for soil stabilization which will react with CaO in additive to form pozzolanic reaction.

4.1.2 Physical Properties of Soil

The basic properties of soil were shown in Table 4.2 below.

Table 4. 2: Physical Properties of Soil

Composition and Properties	**Value**
Natural Moisture Content (%)	29.43
Liquid Limit (%)	50.60
Plastic Limit (%)	26.96
Plasticity index (%)	23.64
Maximum Dry Density (Mg/m^3)	16.70
Optimum Moisture Content (%)	20.50
% Passing No.200 BS sieve	38.00
Specific Gravity(Mg/m^3)	2.53
Soil Classification	Clayey Sand

According to this result, it showed that the soil had basic properties mainly towards sand and partially silt. This can be seen as the percentage for silt and clay is about 38%. Amount of silt and clay which more than 35% show the soil can react effectively with lime. Moreover, plasticity index is in the range of 10 to 50% which means that the soil meets the requirement to react with lime. Furthermore, the value of plasticity index showed that the soil act as high plasticity. The term clayey was applied when have plasticity index of eleven or more. Thus, according to USCS method, the soil was classified as clayey sand.

4.1.2 Organic Content Test

The tests were conducted according to ASTM Test Method D 2974, standard test method for moisture, ash, and organic matter content of peat and other organic soil. The result from experiment showed that the organic content varies from 2.61% to 3.51%. Therefore, the result showed that the amount of organic content within the soil is low. (Miura et al, 1987) claimed that if the soil more than 8%, the use of cement instead of lime becomes more advantageous.

4.2 Basic Properties of Rice Husk Ash

4.2.1 Chemical composition and Physical Properties of Rice Husk Ash

Chemical composition, specific gravity and percentage passing No. 200 BS sieve of Rice Husk Ash had been determined and shown in Table 4.3 below.

Table 4. 3: Chemical Composition and Physical Properties of RHA

Composition and Properties	Value
Silicon dioxide (SiO_2), (%)	86.80
Other Oxides (%)	13.20
% Passing No 200 British Sieve	25.00
Specific Gravity(Mg/m^3)	2.43

Based on this result, RHA was composed of mainly silica. The amount of silica is about 86.80%. Chemical analysis of the ash showed high silica (SiO_2) content (more than 50%) which is a requirement for a good pozzolanic material. Therefore, RHA which used in this experiment was a good pozzolanic material. The percentage passing for No 200 sieve is less than 50%, which mean that the RHA as gravelly and sandy behavior in nature.

4.3 Basic Properties of Lime

4.3.1 Chemical composition of Lime

Chemical composition of lime had been shown in Figure 4.2 below:

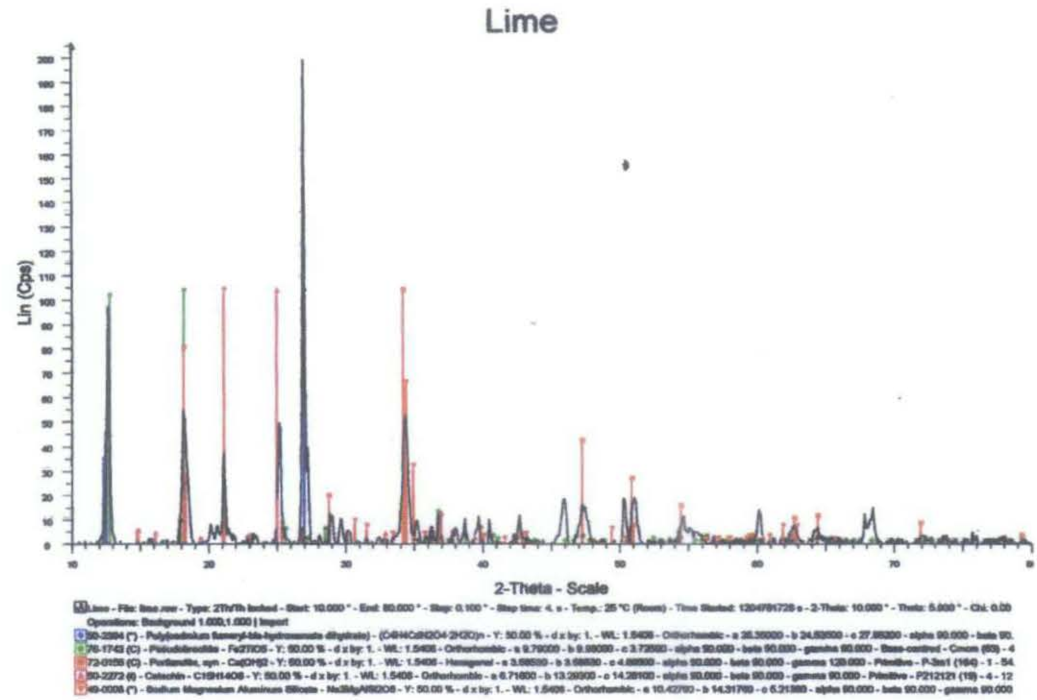

Figure 4. 2: Chemical Composition of Lime

The chemical composition of lime showed that there were a lot of $Ca(OH)_2$ in the composition of lime. (F.G Bell,1993) claimed that $Ca(OH)_2$ classified as hydrated high calcium lime. Hydrated lime or slaked lime is commonly used forms in soil stabilization. The $Ca(OH)_2$ would react with active silica in soil and maybe undergo pozzolanic reaction to form cementations properties that harden the soil and thus, increase the strength of soil.

4.4 Effect of rice husk ash on basic properties of soil

4.4.1 Gradation of Material

The characteristic of gradation for soil with various percentages of Rice Husk Ash (0, 12, 18, 24, 30, 36, and 42) were shown in Figure 4.3 below. This result based on dry sieve analysis.

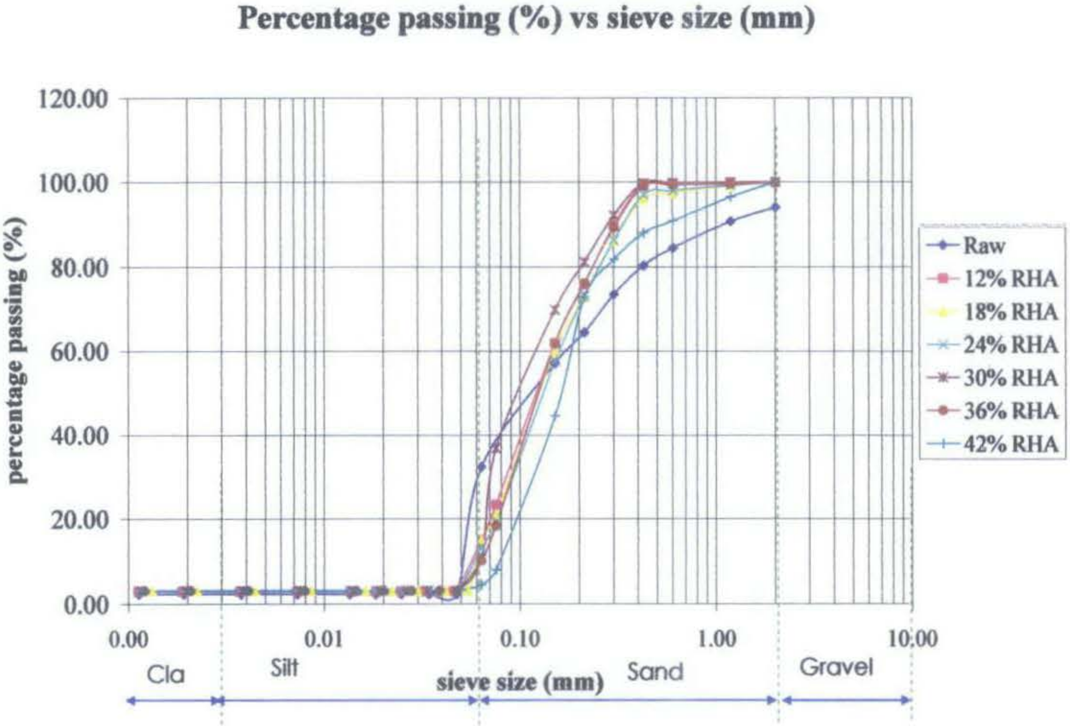

Figure 4. 3: Particle Gradation of Soil and Mixture of Soil and RHA

Figure 4.3 showed that the original soil gradation is poorly graded. However, when the soil had been mix RHA, RHA changed the gradation of particle to well graded soil. Moreover, after being added with RHA, the gradation was more towards sand characteristic. For example, the soil retains after 0.075 mm for raw soil is about 34%, which mean 66% is sand particle. However, when 12% of RHA had being added to the soil, particle retains after 0.075mm reduces to 23.43% which left 76.57% as sand particle. This trend meant that RHA tends to change the soil characteristic from clayey to silty when being added to soil. This was probably due to porous characteristic of RHA.

4.4.2 Specific Gravity

The results of specific gravity test on this soil with various percentages of RHA (0, 12, 18, 24, 30, 36, and 42) are shown in Figure 4.4 below.

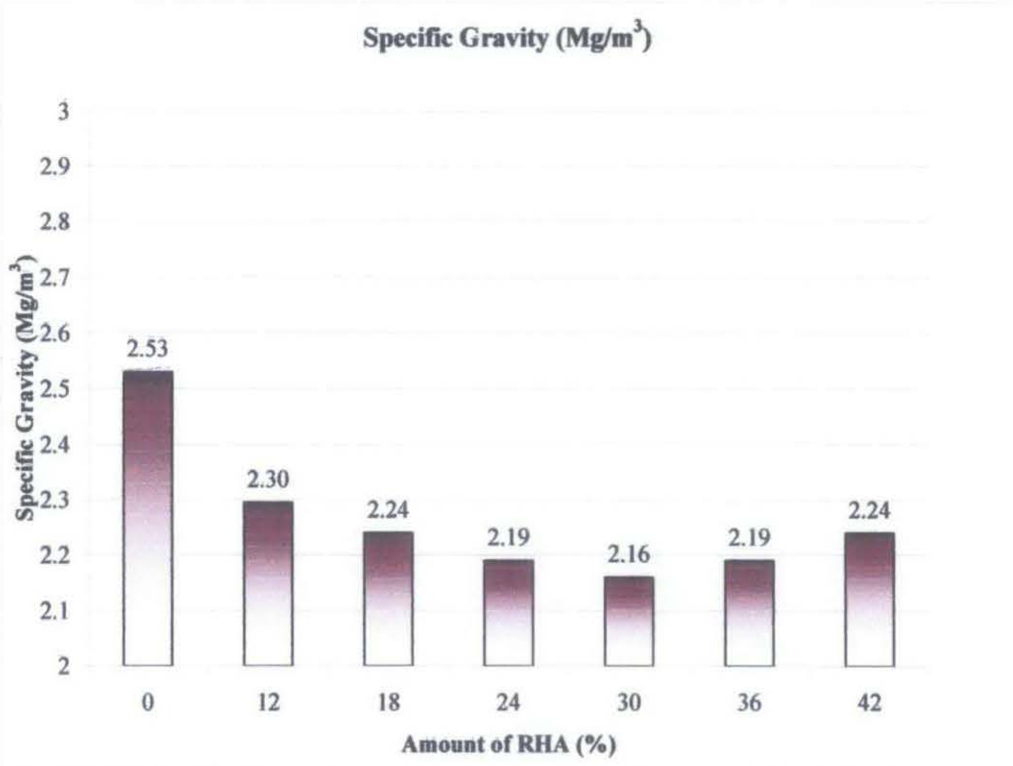

Figure 4. 4: Specific Gravity of Varies Percentage of Soil Mix with RHA

From Figure 4.4, it can be seen that when soil mixed with RHA, the specific gravity of soil reduced. This indicates that the soil was lighter than its natural conditions. The range of specific gravity from 2.0 to 2.55 Mg/m^3 showed that the soil contained halloysite mineral.

4.4.3 Atterberg Limit

The results of Atterberg Limits test on this soil with various percentages of rice husk ash (0, 12, 18, 24, 30, 36, and 42) are shown in Figure 4.5 below.

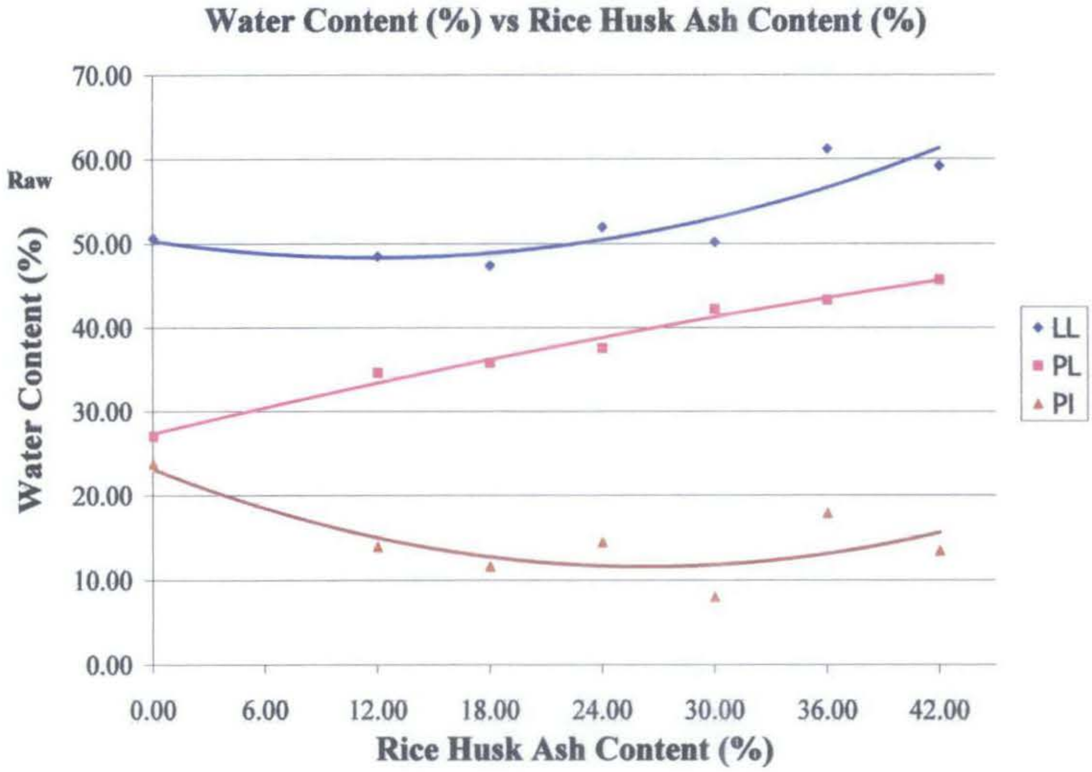

Figure 4. 5: Variation of Liquid Limit, Plastic Limit, and Plasticity Index with Different Content of Rice Husk Ash

Figure 4.5 showed that as percentage of RHA increased, liquid limit and plastic limit increased nonlinearly. Those characteristic probably due to transformation of the soil structure like flocculation and coagulation of soil particle into larger sized aggregates or grains and an association increase in plastic limit of the particle. When soil being mix with RHA, RHA tends to decrease the quantity of free silt and clay fraction and coarser materials with larger surface areas were formed (these processes need water to take place), hence the liquid limit increased.

Meanwhile, plasticity index decreased because of two possibilities which are bonds between the soil particles become stronger as the cation exchange that takes place between the ions on the surface of clay particles and the calcium ions of the RHA and also filler effect of RHA that filled the pore water. Those two causes decrease the amount of water within the soil. Reducing in plasticity index indicate and improvement.

4.5 Effect of lime on basic properties of soil

4.5.1 Gradation of Material

The characteristic of gradation for soil with various percentages of lime (0, 2, 4, and 6) are shown in figure 4.6 below. This result is based on dry sieve analysis.

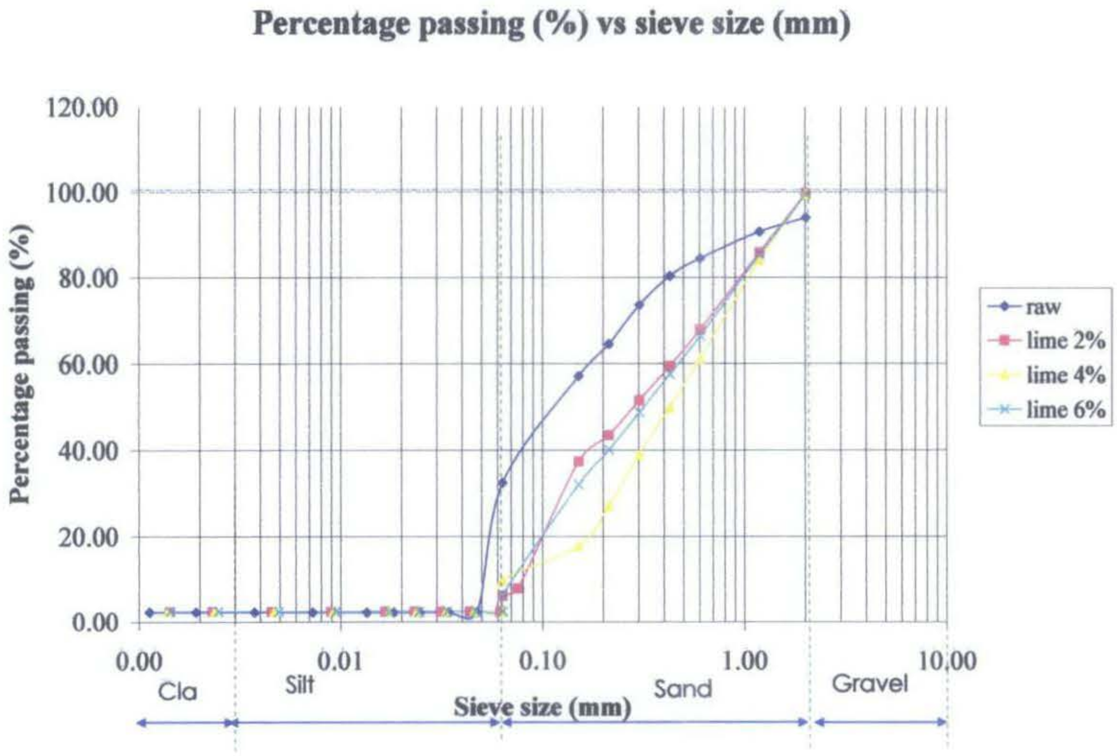

Figure 4. 6: Particle Gradation of Soil and Mixture of Soil and Lime

According to figure 4.6, it can be seen that in the existence of lime, lime changed the gradation of particle to well graded soil from poor graded. When being added with lime, it changed the particle gradation from clayey to silty probably due to agglomeration of clay particles. However, when the amount of lime increased, it increased back the amount of clay particle as lime react as filler to reduce the void and also increase particle bonding by cation exchange.

4.5.2 Specific Gravity

The results of specific gravity test on this soil with various percentages of Lime (0, 2, 4, and 6) are shown in Figure 4.7 below.

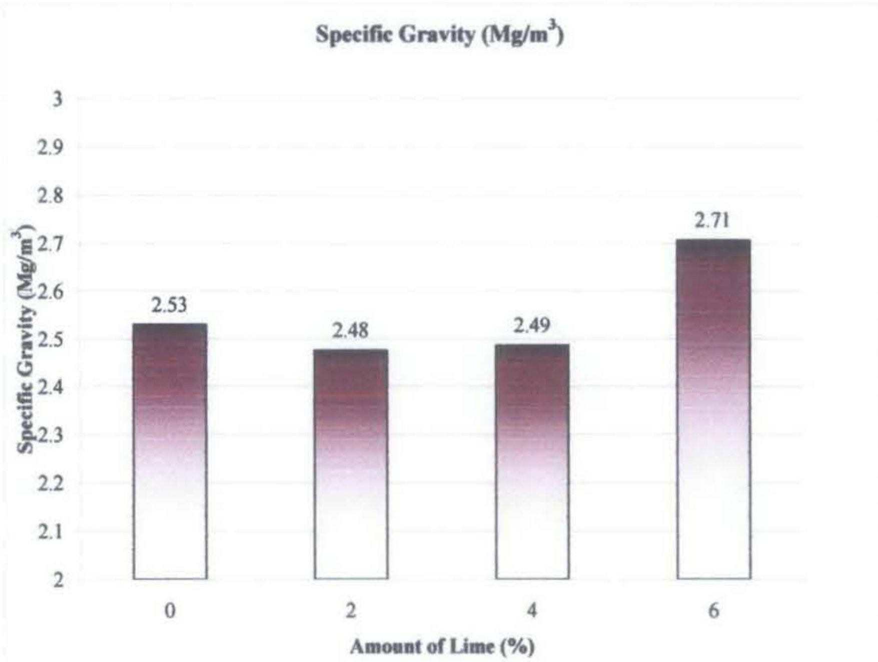

Figure 4. 7: Specific Gravity of Varies Percentage of Soil Mix with Lime

According to Figure 4.7, it showed that when soil was being mixed with lime, the specific gravity of soil increased as amount of lime increased. This was probably because when more lime being added, the bonding between particles increased due to cation exchange and more reduction of void within soil, hence the density increased.

4.5.3 Atterberg Limit

The results of Atterberg Limits test on this soil with various percentages of lime (0, 2, 4, and 6) are shown in Figure 4.8 below.

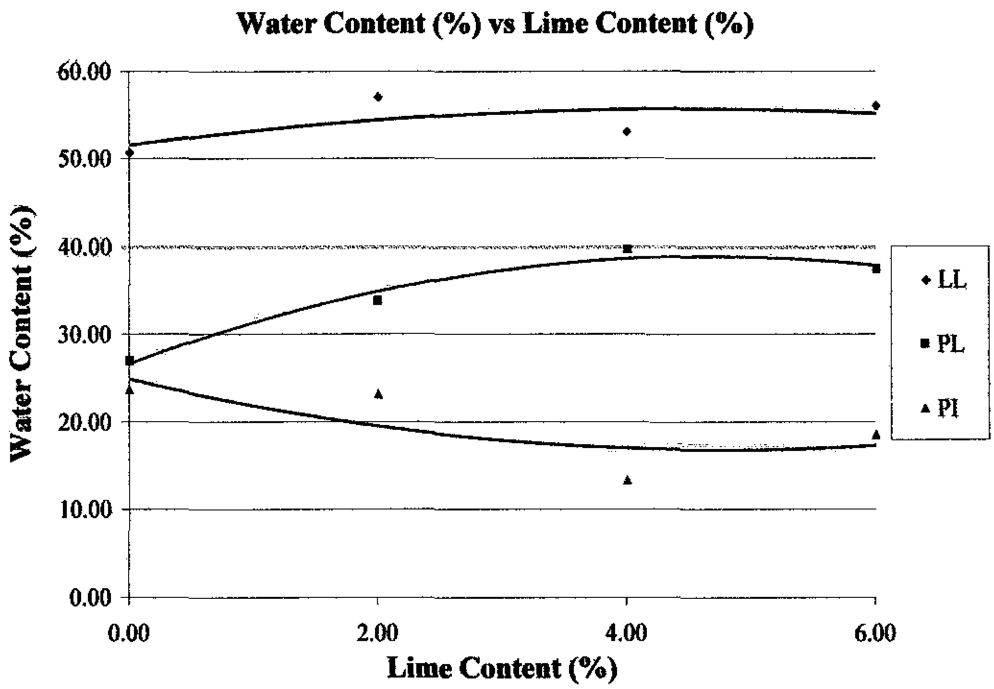

Figure 4. 8: Variation of Liquid Limit, Plastic Limit, and Plasticity Index with Different Content of Lime

Figure 4.8 showed that liquid limit decreased while plastic limit increased as the amount of lime increased. Therefore, the phenomena results in decreasing of plasticity index. This trend was not unconnected with the addition of lime, which aids flocculation, and aggregation of the clay particles. Moreover, the cation exchange between soil particle and lime increased the bonding between particles. The liquid limit decreased probably because when the soil being added with lime, the agglomeration of clay particles turns a clayey soil to a silty soil which produced lower surface area in addition to the highly plastic nature of lime.

4.6 Compaction Characteristic

4.6.1 Added with Rice Husk Ash

The summary of results for compaction by adding Rice Husk Ash had been summarized in Figure 4.9 and 4.10 below.

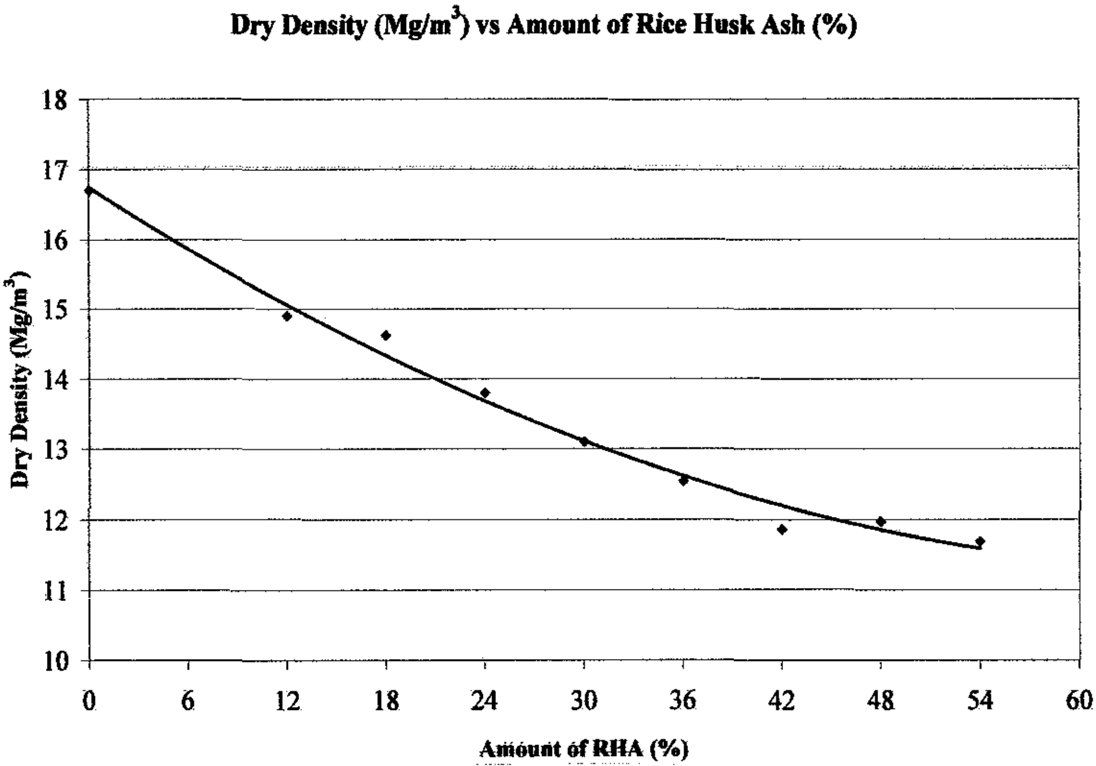

Figure 4. 9: Behavior of Dry Density of Soil Mixes with Different Amount of RHA

From Figure 4.9 above, the value of dry density decreased as the amount of rice husk ash increased. The dry density reduced maybe due to the replacement of soil by RHA which have relatively lower specific gravity ($2.43 Mg/m^3$) compared to the soil ($2.53 Mg/m^3$). Moreover, coating of the soil by the RHA resulted to form large particles with larger voids and hence less density.

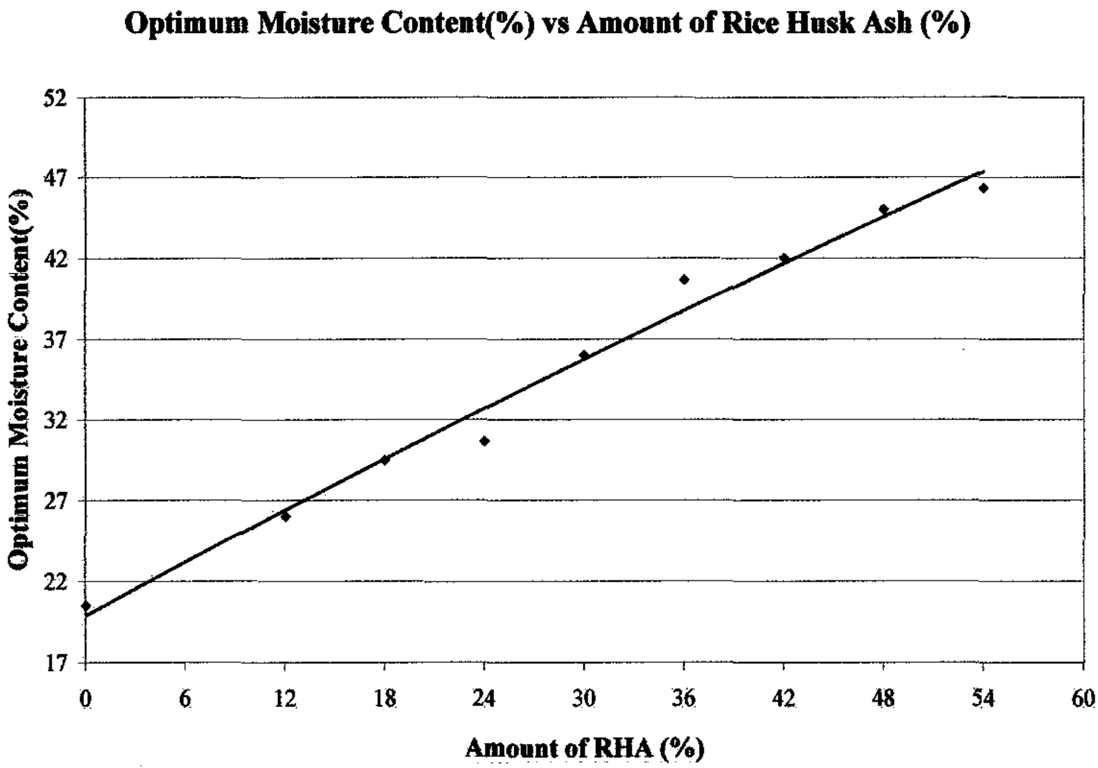

Figure 4. 10: Variation of Optimum Moisture Content for Varies Percentage of RHA

Figure 4.10 showed that optimum moisture content increased as the percentage of rice husk ash increased. The increase in OMC because when RHA added the quantity of free silt and clay fraction decreased. Because of that, coarser materials with larger surface areas were formed. The entire reactions required water to take place. Moreover exceeding water absorption by Rice Husk Ash as a result of its porous properties also resulted on increased of optimum moisture content. This trend had been proved by previous researcher too.

4.6.2 Added with Lime

Value for optimum moisture content and also maximum dry density had been shown below in Figure 4.11 and 4.12.

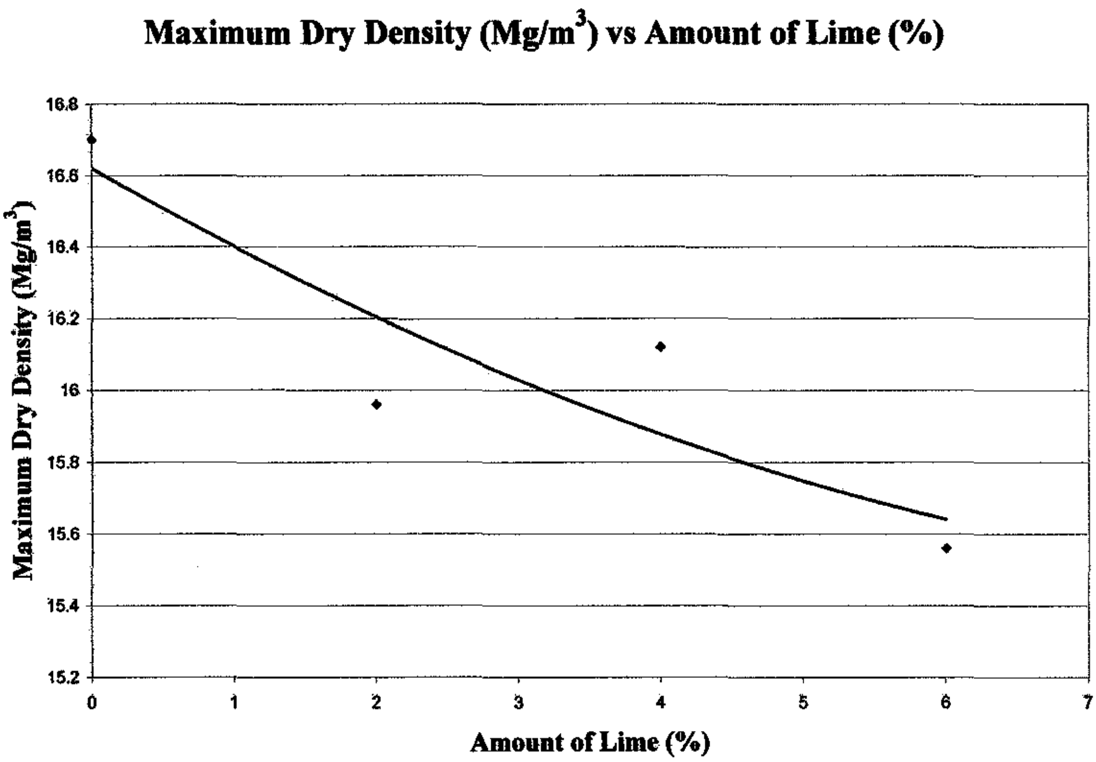

Figure 4. 11: Characteristic of Dry Density of Soil Mixes with Different Amount of Lime

From Figure 4.11 above, the value of dry density decreased as the amount of lime increased. The flocculated and agglomerated clay particles occupying larger spaces which less the density.

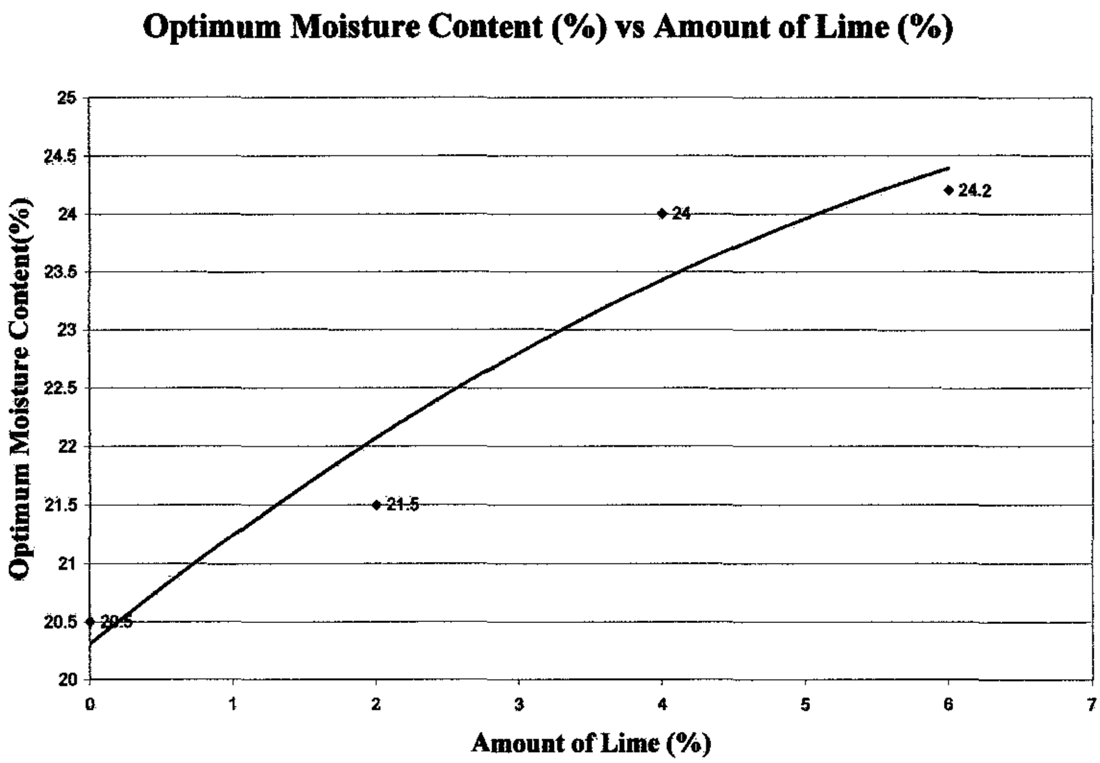

Figure 4. 12: Variation of Optimum Moisture Content for Varies Percentage of lime

Figure 4.12 showed that as amount of lime increased, the optimum moisture content increased. Increasing of optimum moisture content as amount of lime increased because of pozzolanic reaction between lime and soil that required extra water.

4.7 Effect of rice husk ash and lime on California Bearing Ratio

All result for California Bearing ratio of soil that being added with RHA and lime had been shown in Table 4.4.

Table 4. 4: Effect of Rice Husk Ash and Lime on CBR characteristic

Mix Description	Immediate (%)	24hr curing (%)	Soaked (%)	Swell (%)
0%	13.65	10.75	2.5	0.90
12% RHA	17.6	16.80	2.55	1.65
18% RHA	25.15	19.47	2.60	1.865
24% RHA	34.5	19.45	4.55	1.223
30% RHA	6.75	14.45	7.50	0.770
36% RHA	5.80	20.65	5.95	0.924
42% RHA	6.05	10.35	10.40	1.163
2% Lime	36.36	41.97	12.05	0.08
4% Lime	40.76	30.38	13.26	0.04
6% Lime	31.06	25.91	10.50	0.07

Table 4.4 showed that as the amount of lime or RHA increased, the amount of CBR increased for those three conditions. Therefore, it shows there is improvement in the soil properties as lime and RHA being added. The nature of characteristic of soil that being added for different amount of RHA and lime for immediately testing, curing 24 hour, soaked 96 hour and also the swelling result had been shown in Figure 4.13, 4.14, 4.15, 4.16.

4.7.1 CBR Value for Unsoaked

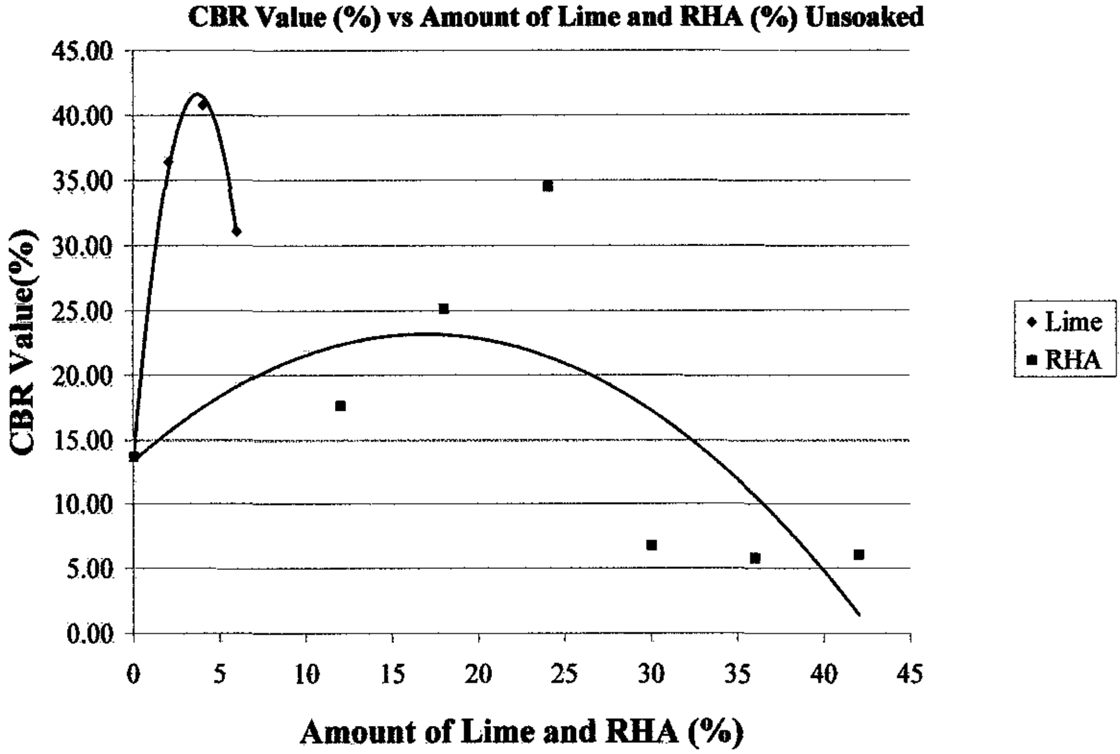

Figure 4. 13: Characteristic of Immediate CBR Value Added with RHA and Lime

From Figures 4.13, the CBR value for lime increase linearly as the amount of lime increased. Meanwhile, for RHA, the CBR value is increases nonlinearly. From the graph, it showed that there was double peak for CBR value when added with RHA. This trend probably due to two reasons which are the nature of soil that contain fine particle of sand and soil contains clay mineral compacted with dry optimum, but low compaction. The characteristic of CBR value with lime and RHA for unsoaked condition had been summarized in Table 4.5 below.

Table 4. 5: Characteristic of CBR value with lime and RHA for unsoaked condition

Stabilizer	Value of Raw CBR	Maximum value of CBR	Percentage increased of CBR value from raw soil
Lime	13.65%	41% at 4% of lime	66.70%
RHA	13.65%	23% at 18% of RHA	40.87%

Percentage difference increment of CBR value between using lime and RHA was about 25.83%.

4.7.2 CBR Value for 24 Hour Curing

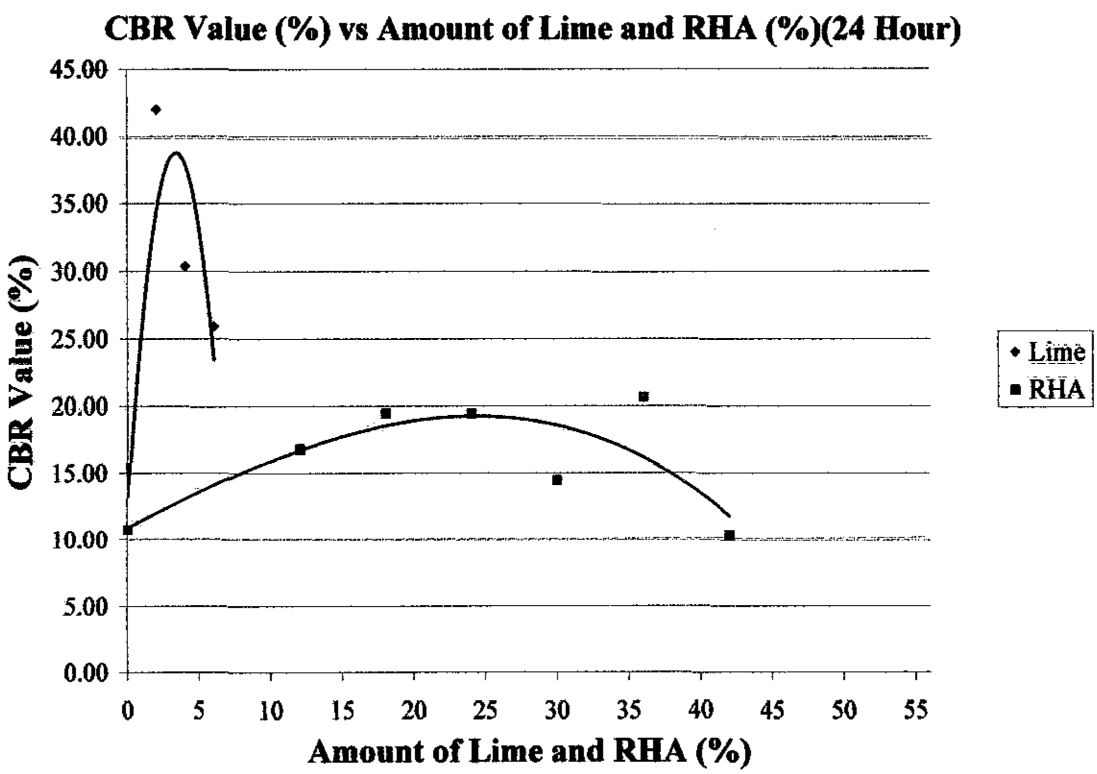

Figure 4. 14: Characteristic of 24 hour Curing CBR Value Added with RHA and Lime

From Figure 4.14, the amount of Lime and RHA used for 24 hour curing is less than for unsoaked and soaked test. During 24 hour curing test, the stabilization gain strength from not only by interlocking of the particle but pozzolanic reaction too. Pozzolanic reaction helps the strength development to achieve the optimum value with less amount of stabilizer. Pozzolanic reaction exists with longer duration of curing time. Amount of CBR values for 24 hour curing RHA were less than immediate testing because during curing process, some of the water hydrates. Therefore, the water leaves the compacted soil with voids which further reduced the strength. The characteristic of CBR value with lime and RHA for 24 hour curing condition had been summarized in Table 4.6 below.

Table 4. 6: Characteristic of CBR Value with Lime and RHA for 24 hour Curing Condition.

Stabilizer	Value of Raw CBR	Maximum value of CBR	Percentage increased of CBR value from raw soil
Lime	10.75%	42.50% at 2.5% of lime	74.71%
RHA	10.75%	19.80% at 25% RHA	45.71%

Percentage difference for increment of CBR value between using lime and RHA was about 29.00 %.

4.7.3 CBR Value for Soaked

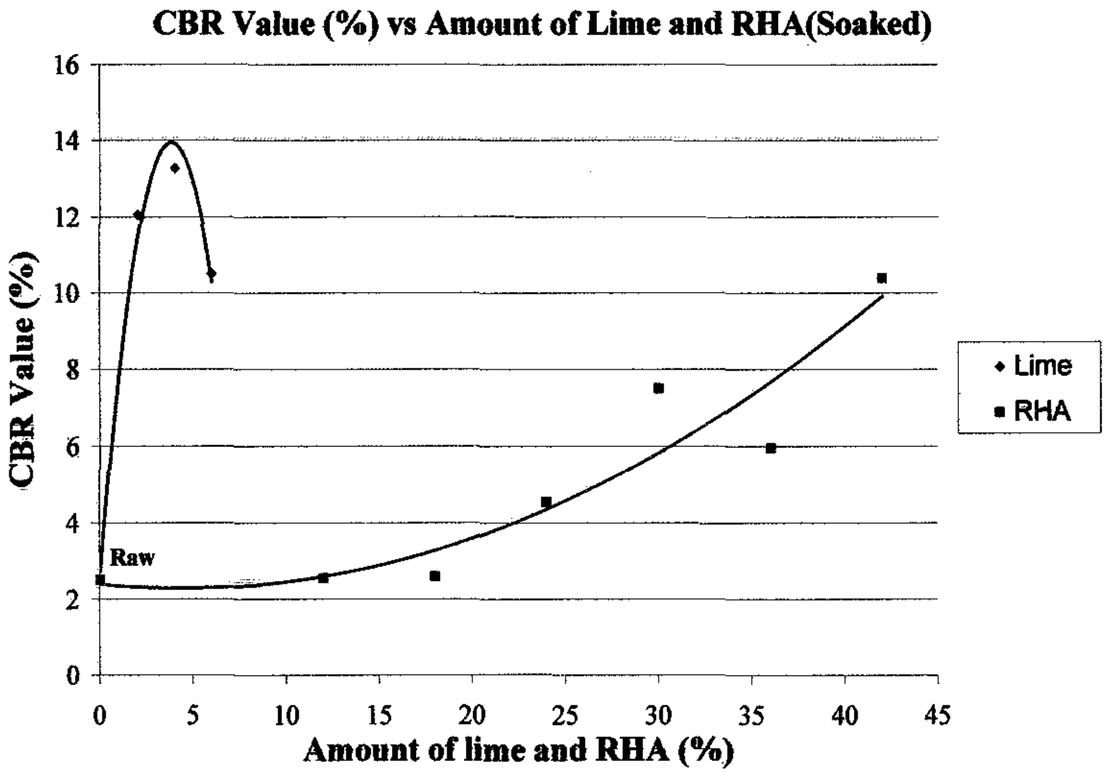

Figure 4. 15: Characteristic of Soaked CBR Value Added with RHA and Lime

Figure 4.15 showed that for soak condition, need more amount of lime and RHA. This is probably because soaking the specimens will produce uneven distribution of moisture content within the specimen. Soil that contained clay mineral had tendency to develop high swelling pressure. During soaking condition, the space of pores become larger as the water tends to seep through the soil particle. Therefore, less strength gained. However, the amount of stabilizer to obtain optimum value was increased. This is due to more amount of stabilizer required in order to contribute to sufficient interparticle bonding that would developed strength and reduce the potential of swelling. The characteristic of CBR value with lime and RHA for soaked condition had been summarized in Table 4.7 below.

Table 4. 7: Characteristic of CBR value with lime and RHA for soaked condition

Stabilizer	Value of Raw CBR	Maximum value of CBR	Percentage increased of CBR value from raw soil
Lime	2.5%	13.25% at 4% of lime	81.13%
RHA	2.5%	10.4% at 42% RHA	75.96%

Percentage difference for increment of CBR value between using lime and RHA was about 5.17%.

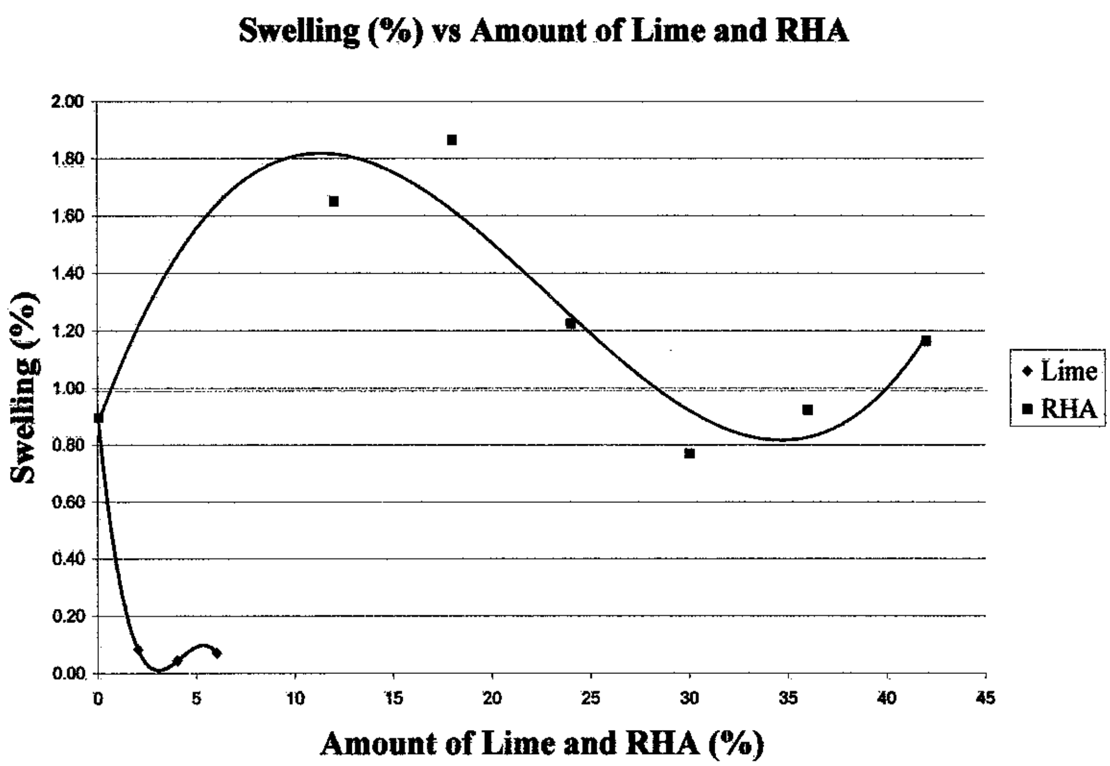

Figure 4. 16: Characteristic of Swell Value Added with RHA and Lime

Figure 4.16 showed the minimum swelling reading is at 35% RHA and 2.5% for Lime as it correlated to value of plasticity index. The swell potential is lesser for lesser plasticity index. The percentage difference between swelling stabilized with RHA and lime was 0.80%.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

Based on the results of the research that had been carried out within the scope of study, conclusion can be drawn as follows:

- The soil had been classified as clayey sand based on USCS classification system.
- RHA was a good pozzolanic material since the amount of silica (SiO_2) is more than 50%.
- Maximum Dry Density decreased as the amount of RHA increased. The Optimum Moisture Content generally increased with increased in the RHA content. Meanwhile, for lime, as the amount of lime increased, Maximum Dry Density decreased and Optimum Moisture Content increased.
- Stabilization by using Rice Husk Ash changed the particle gradation from poor graded to well grade. Moreover, Rice Husk Ash increased the sand characteristic within the soil.
- Atterberg limit for lime showed that liquid limit decreased while plastic limit increased as the amount of lime increased. Therefore, the phenomena results in decreasing of plasticity index. Meanwhile, Atterberg limit for RHA shows that liquid limit and plastic limit increased as the amount of RHA increased. Reduction in plasticity index indicates an improvement.
- There was increase in CBR with increase in RHA with peak values between 18-42% RHA contents. While for lime, the CBR increase with maximum value between 2.5 to 4% of lime.
- CBR value gained for RHA-soil stabilization is less than lime-soil stabilization. However, RHA can be utilized as alternative stabilizer for soil stabilization to improve the environmental impact and reduction of construction cost since RHA can be obtained from BERNAS (Padi Bernas Nasional) as waste material.

RECOMMENDATION

Strength of soil is very important as the soil is the foundation for any construction project. Within the highway project, the value of California is very important because it influences the pavement thickness. As the value in high, the pavement thickness can be reduced, so as a result construction cost can be reduced too. After conducted experiment on California Bearing Ratio test on the soft soil, here are some recommendations:

- Varies the duration for curing and the temperature to see the effect of temperature and duration of curing on the soil stabilization by using Rice Husk Ash.
- Varies the type of soil to see the effect of Rice Husk Ash on different types of soil.
- Mix the RHA and Lime for further increase of strength and reduction of cost.
- XRD or XRF test to determine the molecular arrangement of soil being mixed with RHA
- Economic Analysis on using RHA as soil stabilizer in order to replace Lime stabilization.

REFERENCES

ASTM D 2974-00 Standard Test Method for Moisture, Ash, and Organic Matter of Pear and Other Organic Soils ,West Conshohocken, PA, USA, 2004

BS 1377: Part 4: 1990, (California Bearing Ratio (CBR) Test)

BS 1377: Part 2: 1990: 4.3/4.4, (Determination of Dry Density / Moisture Content Relationship, 2.5kg Rammer Method)

BS 1337: Part 2: 1990: 3.2, (Determination of Moisture Content (Oven – Drying Method)

BS 1337: Part 2: 1990, (Determination of Particle Size Distribution)

BS 1377: Part 2: 1990: 4.3/4.4, (Determination of the Liquid Limit (Cone Penetrometer Method))

BS 1377: Part 2: 1990: 4.3/4.4, (Determination of the Plastic Limit)

BS 1337 : Part 2 : 1990 : 8.2, (Particle Density of Specific Gravity)

BS 1377 : 1990 : 9.6 , (Sedimentation by the Hydrometer Method)

Agus Setyo Muntohar and Gendut Hantoro, G.2000, Influence of Rice Husk Ash and Lime on Engineering Properties of a Clayey Subgrade, Electronic Journal of Geotechnical Engineeering, Vol.5 – 2000, Paper 019,Oklahoma,USA.www.ejge.com.

B.Waswa-Sabuni, P. M Syagga, S. O Dulo and G. N Kamau, 2002, Rice Husk Ash Cement – An alternative pozzolana cement for Kenyan building Industry Journal of Civil Engineering, JKUAT: 2002 8: 13-26.

D.D Bui, J.Hu, and P.Stroeven, (2003) Particle Size Effect on the Strength of Rice Husk Ash Blended Gap-Graded Portland Cement Cocrete, Cement and Concrete Composite, Vol. 27, Issue 3, Science Direct.

Dr. P. Purushothama Raj, (1999), Ground Improvement Techniques, First Edition, Laxmi Publication (P) Ltd, New Delhi.

D.T. Bergado et.al (1996), Soft Ground Improvement in Lowland and Other Environments, American Society of Civil Engineers, United State of America.

E.A Basha , R.Hashim, H.B Mahmud and A.S Muntohar, (2005), Stabilization of Residual with Rice Husk Ash and Cement,Volume 19, Issue 6, Construction and Building Materials, Science Direct.

Emad Akawwiand and Atef Al Karabsheh,(2002), Lime Stabilization Effects on Geotechnical Properties of Expansive Soils in Amman, Jordan, Electronic Journal of Geotechnical Engineeering.

F.G Bell, (1993), Engineering Treatment of Soils, Spon Fres,London.

F.G Bell, (2000), Engineering Properties of Soils and Rocks, Fourth Edition, Blackwell Science Ltd.

F. Haji Ali, A. Adnan and Chew Kam Choy, (1991) Geotechnical Properties of a Chemically Stabilized Soil from Malaysia with Rice Husk Ash as an Additive, Geotechnical and Geological Engineering.

G.C Isaia, A.L.G. Gastaldini, R. Moraes, (2001) Physical and Pozzolanic action of Mineral Additions on the Mechanical Strength of High-Performance Concrete, Cement and Concrete Composites , pp 69-76, Elsevier.

John D.Nelson and Debora J. Miller, (1992), Expansive Soils, Problem and Practice in Foundation and Pavement Engineering, Willey Interscience INC.

K.H Head,(1992), Manual of Soil Laboratory Testing, Vol 1 & Vol 2, Second Edition, Pentech Press.

Musa ALHASSAN and Alhaji Mohammed MUSTAPHA, (2007) Effect of Rice Husk Ash on Cement Stabilized Laterite, Leonardo Electronic Journal of Practices and Technologies.

Nicholas J.Garber and Lester A.Hoel, (2002), Traffic and Highway Engineering, Third Edition, Brooks/Cole Thomson Learning, United State of America

Public Work Department of Malaysia, Manual on Pavement Design

Rahman, M.A , 1987, Effect of Cement-Rice Husk Mixtures on Geotechnical Properties of Lateritic Soils, Journal of Soils and Foundations, Vol. 27 (2), pp. 61-65

S. Charoenvai, J.Khedari, J. Hirunlabh, M. Daguenet, D Quernard, (2005) Impact of Rice Husk Ash on the Performance of Durian Fiber based Construction Materials, International Conference on Durability of Building Materials and Component LYON (France).