<u>**Subgrade improvement using lime powder, sand and rice husk ash**</u>

by

Abdulghani Mohammed AL-HADHEQ

ID:17845

Dissertations submitted in partial fulfilment of

the requirement for the

Bachelor of Engineering (Hons)

(Civil & Environmental Engineering)

Supervisor:Assoc.Prof.Dr.Madzlan B Napiah

September 2017

Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

Subgrade improvement using lime powder, sand and rice husk ash

by

Abdulghani Mohammed AL-HADHEQ

ID:17845

A project dissertation submitted to the

Civil Engineering Programme

Universiti Teknologi PETRONAS

in partial fulfilment of the requirements for the

BACHELOR OF ENGINEERING (Hons)

(CIVIL ENGINEERING)

Approved by,

____

(Assoc.Prof.Dr.Madzlan B Napiah)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

September 2017

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 acknowledgement and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

____

(ABDULGHANI MOAHMMED AL-HADHEQ)

Abstract

Poor subgrade is a common issue In Malaysia that causes the engineers to design thicker highways which considered more costly. However there is different method to improve the subgrade physical methods and chemical methods .in this study add 8% of chemical admixture lime powder, rice husk, and sand is added to stabilize the subgrade .test such as CBR, Proctor compaction test is conducted to determine the strength characteristics and other characteristics tests such as moisture content, plastic, and liquid limit tests. All samples prepared were added with the amount of water at optimum moisture content for CBR testing .for adding the same percentage which is 8% for all samples .all the samples have show incensement for the lime and rice husk ash it was 13.55% and 10.45% respectively as for sand I was 3.1% only.

Table of content:

Contents

List of figures:

List of tables:

Chapter1

Introduction

1.1 Background study:

Highways are the most common travel method. We use highways every day not only for traveling, but also to deliver the food and materials from one place to another. It is not just that the economic benefits from these highways, it is so important for any country to rise because it boosts the industries and makes traveling easier. Moreover, human since the beings they made roads and highways to travel and connect between cities and the knowledge of constructing a better highway have been improving over the past years. However, the functionality of the road depends on the current condition that will affect the safeness of the road users. Therefore, for engineers, one of the main priority is to design roads that keep people safe as much as they can. In addition, one of the most important things is designing a road that is both safe and economic because highway construction industry is a growing industry because cities are extending each day and not only that there are new roads are contracting every day.

Subgrade is the first layer of a highway and its control the strength which means the weakest the subgrade soil the weaker the highway because of that the engineer will have to design a thicker highway to cover the weakness of the subgrade which is more expensive. However, nowadays the researcher have to Improve the subgrade layer by modified and adding chemical, waste materials and other types of stabilizer which solve some problems that have been occurred on the highway because of the weak subgrade. These materials, which is for example lime, rice husk ash, and other materials have improved that it can increase the strength of the subgrade which gives a more economical and effective solution.

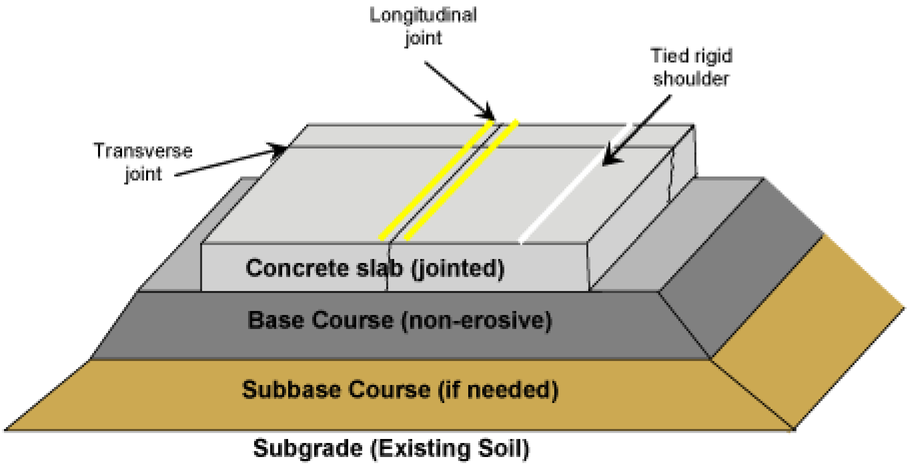


Figure 1: highways layers

In the end, a weak subgrade soil can cause a major problem such as Alligator Cracking, which is a load, associated structural failure. The failure can be due to weakness in subgrade, surface or base that is too thin poor drainage or the combination of all three. It often starts in the wheel path as longitudinal cracking and ends up as alligator cracking after severe distress. Moreover, a weak subgrade can lead to many problems.

Figure 2: example of Alligator Cracking

1.2 problem statement:

Subgrade soil is the base of the highway, which means if it was good, the engineers will not be afraid of the failure to occur in the highway, therefore the engineer can design a better highway, which can save cost and make the highway more economical because it will save more materials. However, Malaysia subgrade soil consider weak because most of the subgrade soil has a low CBR value which makes poor subgrade one of problems that frequently encountered in road construction in Malaysia. Fauzi, A., Fauzi, U. J., & Nazmi, W. M. ((2013). The 2nd International Conference on Rehabilitation and Maintenance in Civil Engineering (pp. 675-689).

Which means that the engineer will design a thicker and more expensive highway in order for them to prevent the failure mechanism in the future, which I have, mention earlier because the main function of the subgrade is to give support to the pavement under adverse climate and loading conditions.

The formation of waves, corrugation, rutting and shoving in blacktop pavement and consequent cracking of the cement concrete pavement are generally happening due to the weak subgrade. However, nowadays we can improve the subgrade using a different type of Materials and the most commonly used one is like that has been proved that it can improve the subgrade soil and give us better results for better highways.

Figure 3: example of highway failure due to poor subgrade

1.3 Objectives:

The research main objectives are:

1. Improve the subgrade soil using a different type of materials.
2. Observe the characteristics properties that each material will add to the subgrade.

1.4 Scope of study

The subgrade soil in Malaysia is mostly weak and because of that in this study, we will use a typical subgrade soil so we can get real and reliable values that represent the Malaysian soil. Anyway, after getting the sample we will start conducting testing which include California bearing ratio (CBR) and Proctor test, which will measure the strength and optimal moisture content for the sample and then test the effect and the improvement that each material will add to the subgrade and observe the characteristics properties that the sample have got such us
Liquid limit, Plastic limit, and specific gravity

Then after the entire laboratory is, done will have to observe the results for each material that will show us how every material have improved the subgrade and add different properties than the other materials.

Chapter 2**:**

Literature Review:

Weakens of the subgrade soil in Malaysia is a common issue that affects the construction industry especially highway contraction because in order to prevent a problem they need to design a thicker and more costly highway. However, by improving the subgrade soil we can have a better highway with less contraction cost and better quality, which can help to avoid the problems that occur because of the weakness of the subgrade and decrees the maintenance cost for the highway. Overall, the subgrade constitutes the foundation material for the pavement structure as highway pavements ultimately rest on the native soil (subgrade). The performance of the pavement is affected by the characteristics of the subgrade. Therefore, the functions of a highway pavement are to reduce the stresses transmitted to the subgrade to a level, which the soil will accept without significant deformation. Which means weak soil makes a weak pavement. Idrus, Singh, Musbah, & Wijeyesekera. (n.d.). Soft Soil Engineering International Conference 2015 (p. 136). Iop.

Clayey soil cover most of Malaysia however, this type of soil is not suitable for roadways construction .clays exhibit swelling characteristics in which clay minerals with expanding lattice are present. The soil become hard when its dry and it exhibit little cohesion and merge strength when they are wet. Due to this, large differential settlement and a decrease in ultimate bearing capacity at saturation occur.anyway, one of the properties of the clayey soil usually has greater plasticity index, this would cause high swelling potential as of subjected to high loading condition. The excessive settlement due to the low bearing capacity of the soil gives serious serviceability problem a the cos of maintains is high.((TAN, Y.C and GUE S.W.2005,"Prevention Of Long-Term Serviceability Problem For Approach Embankment to Bridges and Culverts over Soft Ground", page1-2)).

Therefore there are different methods used to improve and stabilize the weak soil. There are physical and mechanical stabilization and chemical method. For the physical method if there a site that has a weak soil they will remove the unstable soil within the typically localized area and replace it with good quality materials that have high strength .this method can significantly improve the subgrade but the cost to apply this process is too expensive. And for the less costly method, it was done by using a thick granular material layer over poor soil or mixing in better graded granular or recycled material with the poor soil. The traditional compaction method it is a low-cost method, which use various types' rollers to densify the subgrade soil, improve the soil properties, and provide a stable foundation. But it's also required moisture density management and field compaction testing. Finally, for the chemical method, it's done my adding admixtures to the subgrade which and reduces plasticity index and increase strength over time improve the mechanical and properties of the soil.

One of the most commonly used materials is like it has been proved by researchers and in real life projects the lime can improve and stabilize the weak and wet soil. Therefore, in projects where the subgrade is weak and the highways engineer wants to save money and time in the project they use lime, which can improve the subgrade soil in a short period and add properties to the soil such as reducing liquid limits while the plastics limits increase which reduces plasticity indices. Also, gives the soil a better strength and helping compaction process. For wet soil it can decrease the moisture content, therefore, the soil will be dried. In addition, in term of highway project lime can be used to stabilize the clay subgrade soil and increase the CBR (California bearing ratio) penetration resistance and resilient modulus stiffness. And according to (Ario Muhammad and Agus Setyo Muntohar), California bearing ratio (CBR) value are the common method used to evaluate the bearing capacity of a subgrade for the roadway. Subgrade strength is expressed in terms of its CBR value in percentage. And it has been the adding of 10% of lime to a sandy clay soil can improve the CBR value from 4.25 to 16.35 and decrease Plasticity Index from 23% to 3% and increase Optimum Moisture Content from 15.92% to 27.42%.(S.Chakraborty, S.P.Mukherjee, S.Chakrabarti, B.C.Chattopadhyay,2014,11037)

In terms of add admixtures rice, husk considers one of the best materials that we can use to improve not just subgrade but concrete as well. In addition, in terms of cost, it is considered as an economic solution because of it a waste material that produced by the rice milling. According to The International Rice Research Institute (IRRI) Asia alone, produce about 770 million tons of rice husk in every year in rice production industry. Moreover, comparing to lime rice husk ash have less effectiveness on the subgrade for the same type of soil, which is sandy clay, a 9% of rice husk ash improved the CBR value from 4.25 to 14.3 and decrease Plasticity Index from 23% to 20.9% and increase Optimum Moisture Content from 15.92% to 24.2%.(Chakraborty, S.P.Mukherjee, S.Chakrabarti, B.C.Chattopadhyay,2014,11037)

However, lime which is considered as a chemical stabilizer and the rice husk (waste material) have shown a significant improvement in stabilizing sandy clay soil. The using of different percentage of these materials add different strength and Characteristics properties to the sample. However, different type of soil can give different reaction to each stabilizer and as result, the value obtained will be different values .because of that studying the improvement of the local subgrade is very important to understand the behavior of this type of soil to the different materials and what is the improvement that it can add to the subgrade.

Therefore, in this research, the author will test a different type of materials which is a lime powder (chemical material), rice husk ash (waste material) and sand (natural material) and how it improves the local subgrade soil.And observe the changing in the strength which it should be less the 3 in terms of CBR test which consider wake to represent the local subgrade of Malaysia.Also to obtain the changing in the characteristics properties of the soil sample.

2.1 <u>soil classification :</u>

There two types of soil classification system which is :

1-AASHTO Classification System

2-Unified Classification system.

In this project will be using the AASHTO Classification System in classifying the type of soil which is to be used as a sample.

Table 1:AASHTO classification System

AASHTO Soil Classification System

- Classification of Highway Subgrade Materials:

General classification	Granular materials (35% or less of total sample passing No. 200)						
	A-1			A-2			
Group classification	A-1-a	A-1-b	A-3	A-2-4	A-2-5	A-2-6	A-2-7
Sieve analysis (percentage passing)							
No. 10	50 max.						
No. 40	30 max.	50 max.	51 min.				
No. 200	15 max.	25 max.	10 max.	35 max.	35 max.	35 max.	35 max.
Characteristics of fraction passing No. 40							
Liquid limit				40 max.	41 min.	40 max.	41 min.
Plasticity index	6 max.		NP	10 max.	10 max.	11 min.	11 min.
Usual types of significant constituent materials	Stone fragments, gravel, and sand		Fine sand	Silty or clayey gravel and sand			
General subgrade rating	Excellent to good						

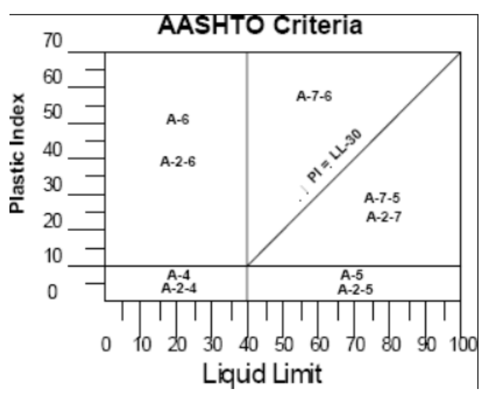


Figure 4:AASHTO Classification System

To classify a soil according to the table we must apply the test data from left to the right.by process of elimination, the first group from the left into which test data fit is the correct classification.In addition, figure4 shows a plot of the range of the liquid limit and plasticity index for soils that fall in each group.((“AASHTO Classification System Description of groups and Subgroups EngineersDaily”))

This classification system is based on the following criteria:

1.Grain size :

a. Gravel: fraction passing the 75-mm sieve and retained on the no. 10 (2mm) US sieve.

b. sand: fraction passing the No. 20 (2mm) U.S sieve and retained on the No.200(0.075mm) U.S sieve.

c. Silt and clay: fraction passing the No. 200 U.S.sieve.

2.plasticity: the term silty applied when the fine fraction of the soil have a plasticity index of 10 or less . the term clayey is applied when the fine fraction has a plasticity index of 11 or more.

Liquid limit and plasticity index are two factors that are useful to know the swelling capacities and the corresponding range of plasticity index are described in the table below:

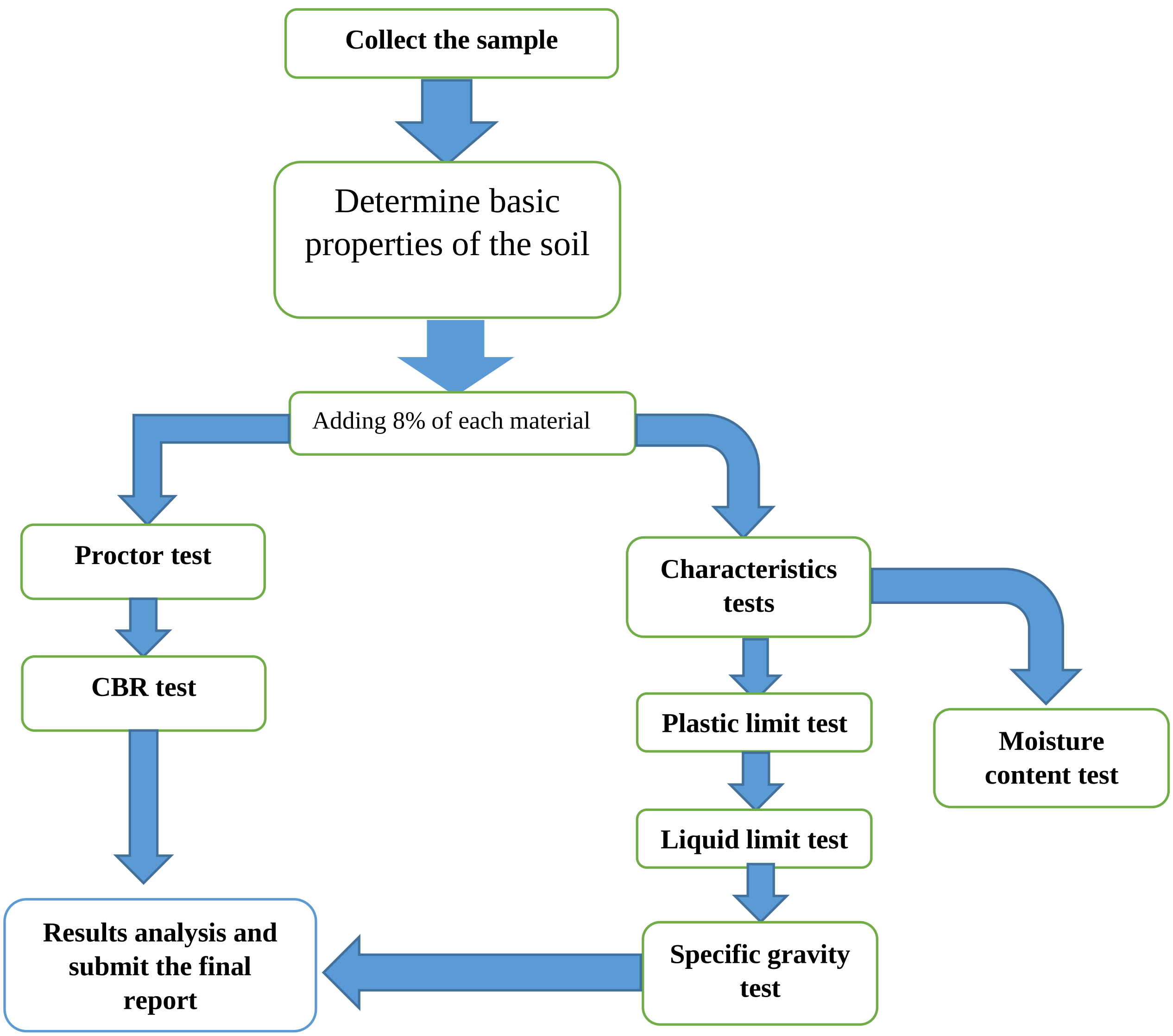
Swelling potential	Plasticity index
LOW	0-15
MEDIUM	10-35
HIGH	35-55
VERY HIGH	55 And Above

Table 2: range of plasticity index

Chapter 3:

Methodology:

To achieve our objective of the project first the author will have to collect a sample from the around area and which its sandy clay type of soil. furthermore after collecting the sample we have to test it wither the value of CBR test is high or low which if it was more than 5% we have to make the sample weaker and if it was less than 5% means it a good sample because according to the JKR manual 5% is the minimum value to resist and support the traffic load. Moreover, after testing the soil without adding any stabilizer we will test the different samples each one of them contains 8% of a different stabilizer. Here is the flowchart of the project:



testing method :

In order for to achieve the objective of this study a laboratory testing that will be conducted in this experiment, a test such as CBR, Proctor compaction test is conducted to determine the strength characteristics and other characteristics tests such as soil classification, moisture content, plastic and liquid limit tests are conducted.

Strength tests:

CBR test**:**

California bearing ratio (**CBR**) test can determine the strength of the subgrade by soil penetration to evaluate the mechanical strength of the subgrade and highway sub-bases. The purpose of test not just determine the mechanical strength also to determine bearing capacity. The test is done in the laboratory by collecting the sample. In this test in the sample is prepared at Proctor's maximum dry density or any other density at which the test is required.

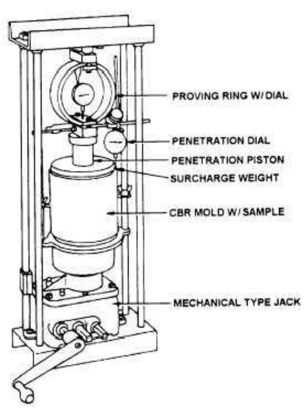


Figure 5: CBR test

A plunger of a standard area is then pushed into the soil at a fixed rate of penetration, and the force required maintaining that rate is measured. The CBR value is then defined as the ratio of the measured force to that required for similar penetration into a standard sample of crushed California limestone rock:

CBR = (F/Fs) x 100%

where F is the measured force and Fs is the force required for similar penetration into a standard sample. Higher values of CBR indicate the harder surface of the material. Typical values of CBR rating for different materials are :

Type of soil	CBR range
Clay	1-3
Sandy clay	4-7
Well graded sand	15-40
Well graded sandy gravel	20-60

Table 3: CBR range

Proctor test:

The proctor compaction test is one of the main tests that for subgrade soil it determine the optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density. The Proctor compaction test consists of compacting soil samples at a given water content in a standard mold with standard compaction energy. The standard Proctor test uses a 4-inch-diameter mold with the compaction of three separate layers of soil using 25 blows by a 5.5 lb hammer falling 12 inches. the soil is first air dried and then separated into 4 to 6 samples. The water content of each sample is adjusted by adding water (3% - 5% increments or more depending on the type of the soil. The soil is then placed and compacted in the Proctor compaction mold in three different layers where each layer receives 25 blows of the standard hammer. Before placing each new layer, the surface of the previous layers is scratched in order to ensure a uniform distribution of the compaction effects.

At the end of the test, after removing and drying of the sample, the dry density and the water content of the sample is determined by each Proctor compaction test. Based overall set of results, a curve is plotted for the dry unit weight (or density) as a function of the water content. From this curve, the optimum water content to reach the maximum dry density can be obtained.

Characteristics tests:

NO	TEST	PURPOSE
1	Moisture content	To determine the moisture content.
2	Atterberg limit	To determine the plastic limit, liquid limit and plasticity index.
3	Specific gravity	To determine the density of the soil
4	Particle size distribution	To determine the classification of the soil according to ASSHTO
5	Hydrometer	To determine the particle size distribution passing 63um sieve

Paperwork methodology:

The literature study is the first step to be taken in a project like this because of it an experimental base project. Therefore, to make sure that we can minimize the error percentage and make sure that the project can succeed interims of the calculation and the laboratory experiments a good literature study is needed to improve the understanding of the project. and enhance the knowledge about the scope of the project.to achieve that a search about journalism and the other research done by others and the method they follow to achieve their objectives is needed to be considered for success with my project. therefore this reference should be from a trusted sources.

The purpose of the literature review:

1. Enhance our knowledge about the existing methods of stabilizing and modifying the soil because there are many different types of methods physical method to improve the soil and chemical methods. In addition, in this study it's the research should be about the methods of stabilizing the soil by using materials such lime and rice husk ash and sand.
2. Study and understand more about how this material can improve the soil and what other advantages that it will add to the material.
3. Study and read information about mixing and compaction as well as the other methods to be used in this study.
4. Observe the results of other researchers and how the achieved this results.
5. Understand and have more knowledge about how to improve this project

With the information gained and the project can proceed with the literature review generally on stabilizing the soil and the three material to be used. Therefore it will include the engineering properties of the material as well as how the tests are conducted. And gain the knowledge of the methodology that has been followed to succeed with these tests.

Sample preparation :

There are four groups of soil samples :

1-control sample

2- control sample+8% of lime powder.

3- control sample+8% of rice husk ash.

4- control sample+8% of sand.

So for the control sample, the soil will be prepared without adding any other material and for the other sample group, it will be prepared with the adding of 8% of each material spritely.

The test that will be carried to measure the strength of the soil sample is the CBR test .but before we can conduct the CBR test we have to determine the optimum moisture content to determine the best amount of water that can fill the voids in the CBR sample.

Therefore we have measured the sample at different water content which in this project will be three samples for each material in order to plot the measurement of the of the dry density and moisture content then so we can proceed to the CBR test .

Material used:

1-local soil sample:

The soil sample was collected in university technology PETRONAS campus the as shown in the figure6 .the soil was collected the dried in the lab then after that broke down and prepared for testing.

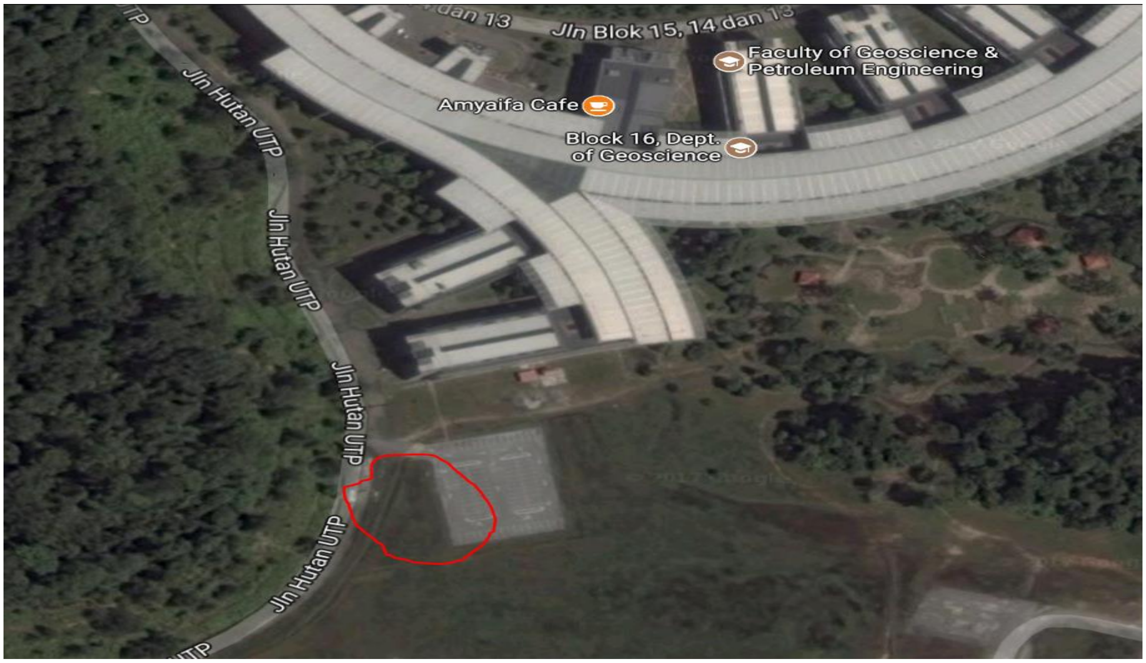


Figure 6: location of soil collecting area

2-lime :

The lime powder in this project was obtained from the geotechnical lab its quicklime powder alkaline crystalize and white in color it was stored there for almost 7 years.

3-Rice husk ash :

The rice husk ash was obtained from the highway lab.

4-Sand :

The sand was obtained locally from Lumut beach.

Chapter 4

Results and discussion:

collecting these results from the soil samples; control sample, lime-treated sample, rice husk ash sample and sand sample; were collected. Each of results is presented in brie and various from either in table, chart or graph.

Results for the control sample without adding any material:

Table 4: the results for the control sample basic properties

NO	Properties	Value
1	Moisture content	31.06%
2	Specific gravity	2.77Mg/m3
3	Atterberg limit:	
	Plastic Limit	28.87%
	Liquid Limit	48.50%
	Plasticity index	19.63%
4	Particle distribution:	Percentage passing(%)
	2.00 mm	99.45
	1.18 mm	97.41
	600 µm	92.01
	425µm	87.77
	300 µm	78.85
	212 µm	65.72

	150 µm 63 µm Pan	53.69 31.13 0
5	Soil classification(AASHTO)	A-7-6 (clayey soils)
6	Optimum moisture content	21%
7	Maximum dry density	1.681g\cm^3

adding 8% of lime powder:

Test	result
Liquid limit	35.5%
Plastic limit	33.08%
Plasticity index	2.42%
Optimum moisture content	17%
Maximum dry density	1.518 g\cm^3

Table 5: results of soil properties after adding 8% of lime

Adding 8% of rice husk ash:

Test	result
Liquid limit	38.4%
Plastic limit	31.91%
Plasticity index	6.49%
Optimum moisture content	14%
Maximum dry density	1.47 g\cm^3

Table 6:results of soil properties after adding 8% of RHC

Adding 8% of sand:

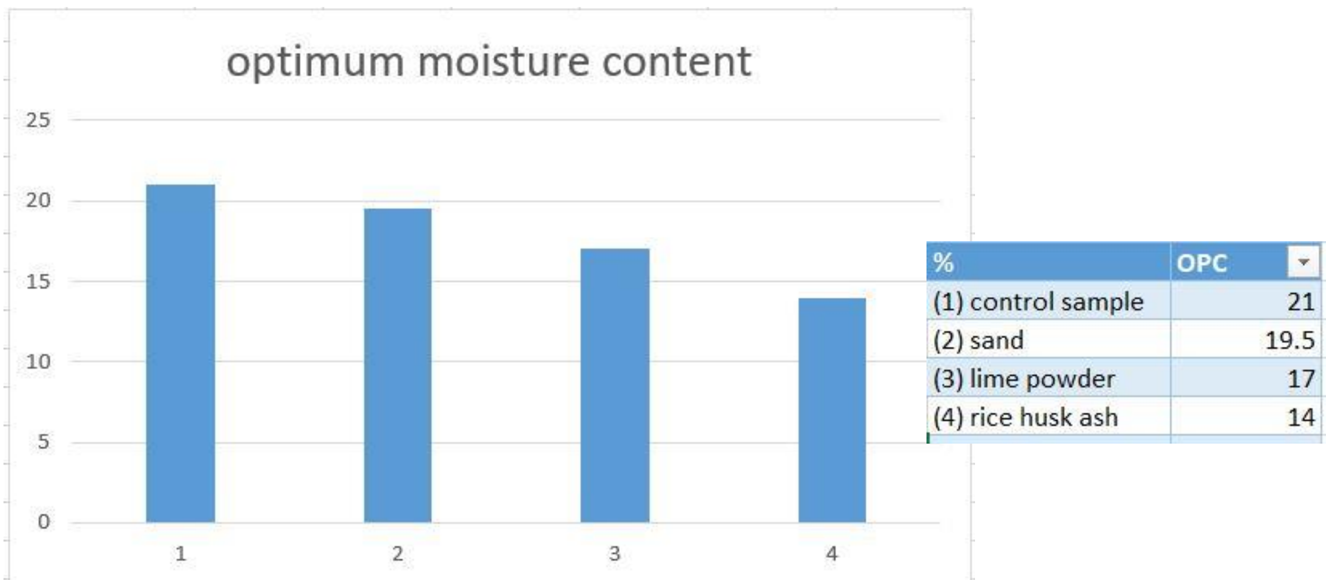
Test	result
Liquid limit	46.6
Plastic limit	30.095
Plasticity index	16.505
Optimum moisture content	19.5%
Maximum dry density	1.646 g\cm^3

Table 7:results of soil properties after adding 8% of sand

From this results we can observe some of the characteristics improvement that each ,material have added to the sample.as for the liquid limit the control sample have a value of 47.5% which have been decreased to 35.5% by adding 8% of the lime powder 38.4% and 46.6% by adding 8% of rice husk ash and sand . as for the plastic limit the original sample has a value of 28.87% which have been increased to 33.08 by adding 8% of the lime powder 31.91% and 30.095% by adding 8% of rice husk ash and sand .therefore we can observe the characteristics change that each material add to the soil.

Proctor test:

The test has been carried for the control sample and the other sample that contain 8% of each material which is lime powder, rice husk ash, and sand. The objective of this test is to determine the optimum moisture content at maximum dry density.



%	OPC
(1) control sample	21
(2) sand	19.5
(3) lime powder	17
(4) rice husk ash	14

Figure 7: optimum moisture content

The graphs of the relationship between the dry density and the moisture content are plotted and attached in the appendices.

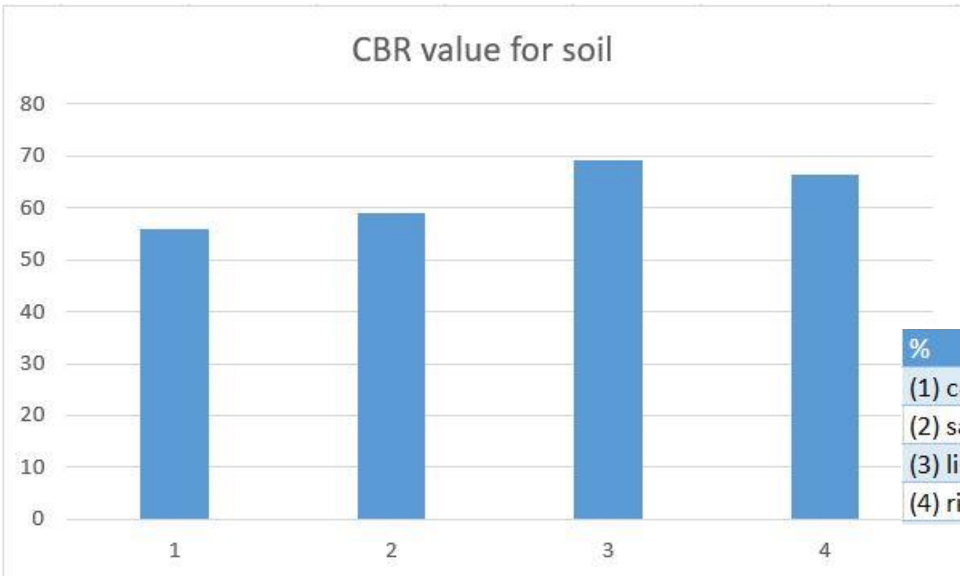
We can summarize the results of the proctor test as follows:

Type of sample	Maximum dry density	Optimum moisture content
Control sample	1.681	21
Control sample + 8% of lime powder	1.518	17
Control sample + 8% of rice husk ash	1.47	14
Control sample + 8% of sand	1.646	19.5

Table 8:summarize of the proctor test results

from this results, we can observe each material have decreased the maximum dry density to 1.518 of the lime powder, 1.47 for the rice husk ash and 1.646 for the sand. And we can assume that these results is because this admixture replace some parts of the soil aggregates and also filling the voids because filling the voids in the untreated soil can decrease the value of the maximum dry density .and in the other part we have observe that each material has decreased the value of the optimum moisture content. And that might because of the hydration process which happened due to the reaction of the pozzolanic materials being mixed with water contrasted and untreated soil which can decrees the heat that generated due to the mixing and that will affect the water consuming because of the less heat the less is the requirement of water before the mixture get stabilized.

CBR test results :



%	CBR
(1) control sample	55.92
(2) sand	59.05
(3) lime powder	69.045
(4) rice husk ash	66.38

Figure 8:CBR test result

the highest improvement value was the lime powder which was 13.55% and then the rice husk ash with 10.45% lastly sand have improved the soil by 3.1% only.

Discussion:

In this research our objective was :

1. Improve the subgrade soil using a different type of materials.
2. Observe the characteristics properties that each material will add to the subgrade.

Therefore to achieve that some soil classification test has been carried out to determine the type of soil and the other tests such as moisture content, liquid limit, plastic limit specific gravity test and sieve analysis test.the soil used in this research was clayey soil and classified as A-7-6 under AASHTO Classification System. And as an overall result, it's found that the soil is suitable for this research.

In order for us to measure the strength of the soil, we had to go through the proctor test to determine the optimum moisture content at maximum dry density. That will allow us to determine the amount of water to added in the CBR test. therefor a different percentage of water have been added to the samples as was showing that the optimum moisture content for the control sample was 21% and for the admixture was 17%,14% and 19.5% for lime powder and rice husk ash and the sand samples.

As of the CBR test, all the admixture have shown an increment of the performance of the mixture with different percentages which mean that the different samples that we have added 8% of each admixture have increased the strength compared to the control sample.

As for a further suggestion for I would suggest adding a different percentage of each material to study the improvement each percent will add to the soil as well as hanging the moisture content by mixing it with different amount of water percentages to study the effect that it will add to the strength.

Recommendation:

1- Avoid taking a sample from a constriction because subgrade might be already stabilized
2- There are three types of rice husk ash which use crystalline-amorphous, partial crystalline, and crystalline and for the best result use crystalline rice husk due to a higher amount of silica that can help stabilize the soil.
3- Use liquid lime for the lab testing because it allows for spreading quickly and act fast, but it does not give the soil the ideal amount of lime it needs. Thus it's not suitable for a real-life project.
4- Make sure that the sand is clean and it's not mixed with any other materials.
5- Make sure that the laboratory equipment is clean and in good condition for the more accurate result.
6- Use a material with CBR value less than 5% so we try to improve it.

Conclusion:

Subgrade strength is one of the most important factors in determining pavement thickness, the composition of layers and overall pavement performance.There are different types of methods to stabilize wake subgrade and in this study, it has been investigated the chemical method to improve the local subgrade by using lime powder, rice husk ash, and sand. Based on the results, we can conclude that:

1. The addition of the lime powder, rice husk ash, and sand in local subgrade increase the CBR value.

2. The treatment of adding the admixture (lime powder, rice husk ash, and sand) decrease in liquid limit and increase in plastic limit and a decrease of plasticity index.

3. After the treatment of stabilizing the subgrade based on the result, we can conclude that the subgrade can resist and support the traffic load.

References:

1. **Jabatan Kerja Raya (JKR) standards**
2. **S.Chakraborty, S.P.Mukher, Chakrabarti, & B.C.Chattopadhya. (2014). Improvement of Sub Grade by Lime and Rice Husk Ash Admixtures. International Journal of Innovative Research in Science, Engineering, and Technology, 4(4), 11034-1040.**
3. **Ario Muhammad& Muntohar, A. S. (2007). USES OF LIME -RICE HUSK ASH AND PLASTIC FIBERS AS MIXTURES-MATERIAL IN HIGH-PLASTICITY CLAYEY SUBGRADE: A PRELIMINARY STUDY. Ilmiah Semesta Teknika, 10, 145-154.**
4. **& Sharma. (2014). Influence of sand and fly ash on clayey soil stability. IOSR Journal of Mechanical and Civil Engineering, 36-40.**
5. **A. El Shinawi, Instability Improvement of the Subgrade Soils by Lime Addition at Borg El-Arab, Alexandria, Egypt, (2017), doi: 10.1016 Journal of African Earth Sciences /j.jafrearsci.2017.03.020.**

   TAN, Y.C, and GUE S.W.2005,"Prevention Of Long-Term Serviceability Problem For Approach Embankment to Bridges and Culverts over Soft Ground", page1-2.
6. **M M Mohd Idrus, J S M Singh, A L A Musbah&D C Wijeyesekera,2016, Investigation of Stabilised Batu Pahat Soft Soil Pertaining on its CBR and Permeability Properties for Road Construction, Soft Soil Engineering International Conference 2015,136.**
7. **Holt, C. (2010). Chemical Stabilization of Inherently Weak Subgrade Soils for Road Construction – Applicability in Canada. Annual Conference of the Transportation Association of Canada. 1-21.**
8. **Fauzi, A., Fauzi, U. J., & Nazmi, W. M. ((2013). The 2nd International Conference on Rehabilitation and Maintenance in Civil Engineering (pp. 675-689).**

APPENDIX

APPENDIX:

Details of Soil Basic Properties:

Moisture Content:

Container (sample)No.	**1**	**2**	**3**
Mass of wet soil + Container (g)	56.4	53.7	57.1
Mass of dry soil + container (g)	47.5	46.2	48.78
Mass of container (g)	19.2	21.5	22.3
Mass of moisture (g)	8.9	7.5	8.3
Mass of dry soil (g)	28.3	24.7	26.5
Moisture content (%)	31.3	30.4	31.4
Average moisture content (%)	**31.06**		

Table 9: moisture content results

Analysis Test:

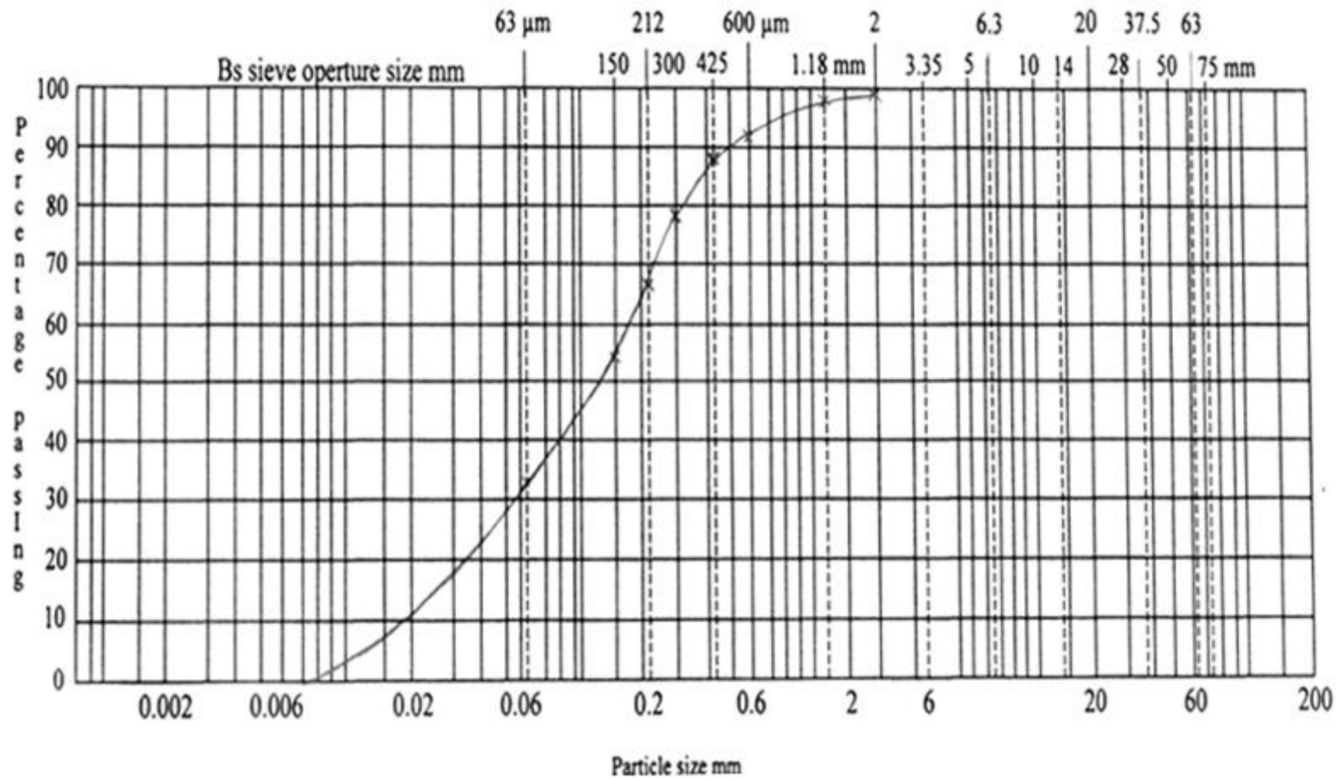
Sieve No	**Opening (mm)**	**Mass Retained (g)**	**% retained**	**Cummulative % Retained**	**% passing**
10	2.00	0.83	0.55	0.55	99.45
16	1.18	3.01	2.04	2.59	97.41
30	0.600	7.95	5.40	7.99	92.01
40	0.425	6.24	4.24	12.23	87.77
50	0.300	13.12	8.92	21.15	78.85
70	0.212	19.35	13.13	34.28	65.72
100	0.150	17.73	12.03	46.31	53.69
	0.063	33.13	22.50	68.81	31.19
Pan		46.22	31.39	100.00	0
Total		**147.57**	**100.0**		

Table 10:sieve analysis results

loss Percentage = [(150.0g - 147.57g) / 150.0g] * 100%

= **1.62%** which is acceptable.

Particle Size Distribution Chart:



Specific Gravity of Soil:

Jar No.	**Unit**	**1**	**2**
Mass of jar + gas jar + plate + soil + water (m3)	(g)	1718.7	1722.1
Mass of jar + gas jar + plate + soil (m2)	(g)	934.5	936.2
Mass of jar + gas jar + plate + water (m4)	(g)	1464.7	1464.7
Mass of jar + gas jar + plate (m1)	(g)	534.5	536.2
Mass of soil (m2-m1)	(g)	400.0	400.0
Mass of water in full jar (m4-m1)	(g)	930.2	928.5
Mass of water used (m3-m2)	(g)	784.4	785.9
Volume of soil particles (m4-m1)-(m3-m2	ML	145.8	142.6
Particle density, Ps	Mg/m^3	2.74	2.81
Average value	**Mg/m^3**	**2.775**	

Table 11:Specific Gravity results

Atterberg's Limit Test:

Test No	**1**	**2**
Average Penetration (mm)	12.47	13.9
Container No.	1	2
Mass of wet soil + Container (g)	44.38	55.63
Mass of dry soil + container (g)	38.02	46.63
Mass of container (g)	20.39	23.30
Mass of moisture (g)	6.36	9.00
Mass of dry soil (g)	17.63	23.33
Moisture content (%)	36.08	38.58

Table 12:liqued limit results

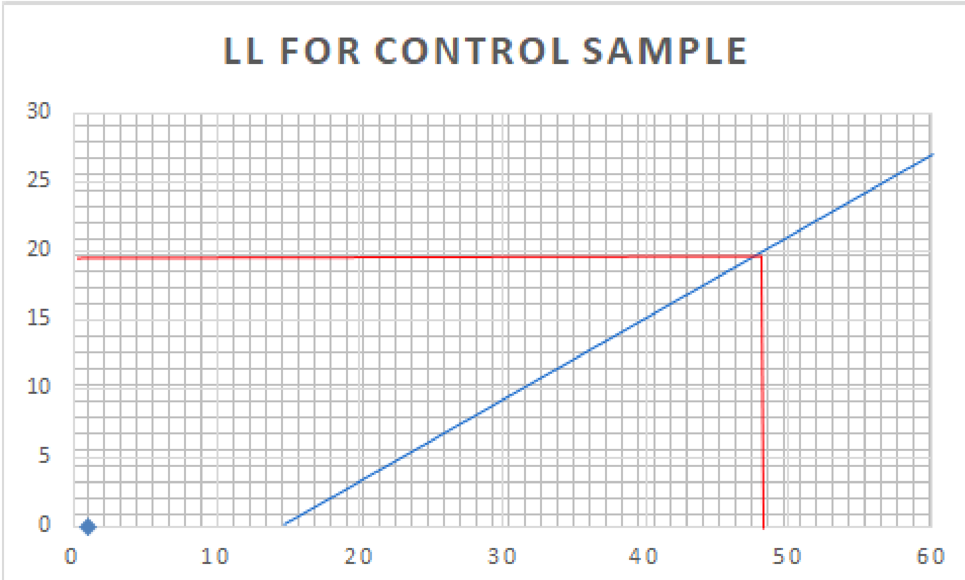


Figure 9: penetration vs moisture content

Liquid Limit = 48.5%at 20mm penetration

Plastic Limit and Plasticity Index:

Test No	1	2	3	4
Mass of wet soil + Container (g)	28.63	28.58	28.29	28.91
Mass of dry soil + container (g)	28.90	26.89	26.49	27.15
Mass of container (g)	20.48	21.09	20.57	21.08
Mass of moisture (g)	1.73	1.69	1.80	1.76
Mass of dry soil (g)	6.42	5.80	5.92	6.07
Moisture content (%)	26.95	29.14	30.41	28.99
Average of moisture content (%)	**28.87**			

Table 13:plastic limit results

Plasticity Index (PI) = LL – PL = 19.63%

Proctor test:

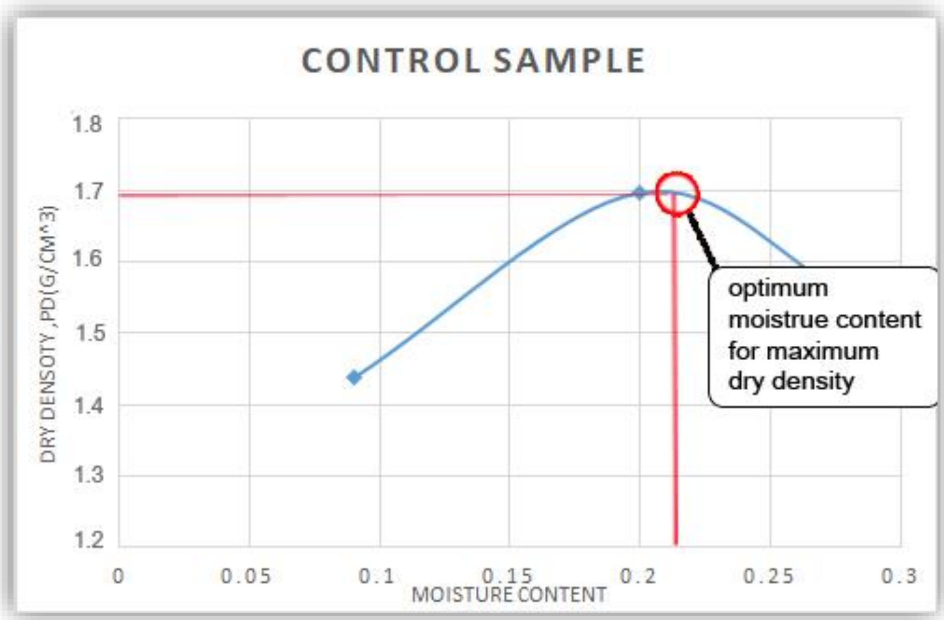


Figure 10:maximum dry density vs moisture content for control sample

performance under unsoaked CBR testing control sample :

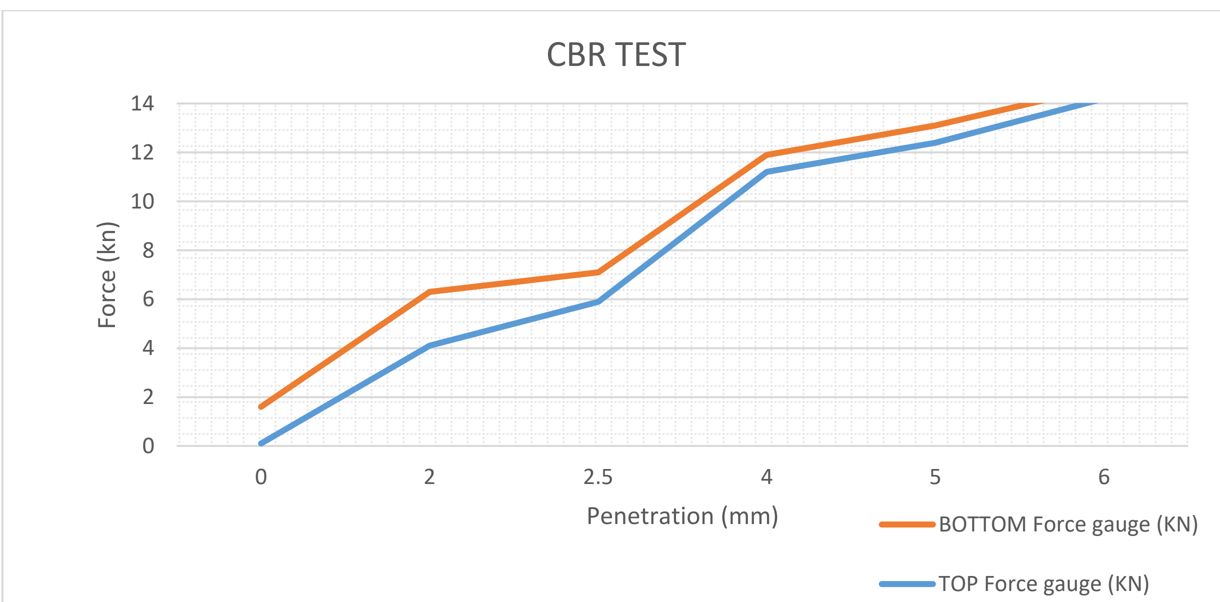


Figure 11:force vs penetration for CBR test for control sample

(Control sample + 8% of lime powder):

Proctor test:

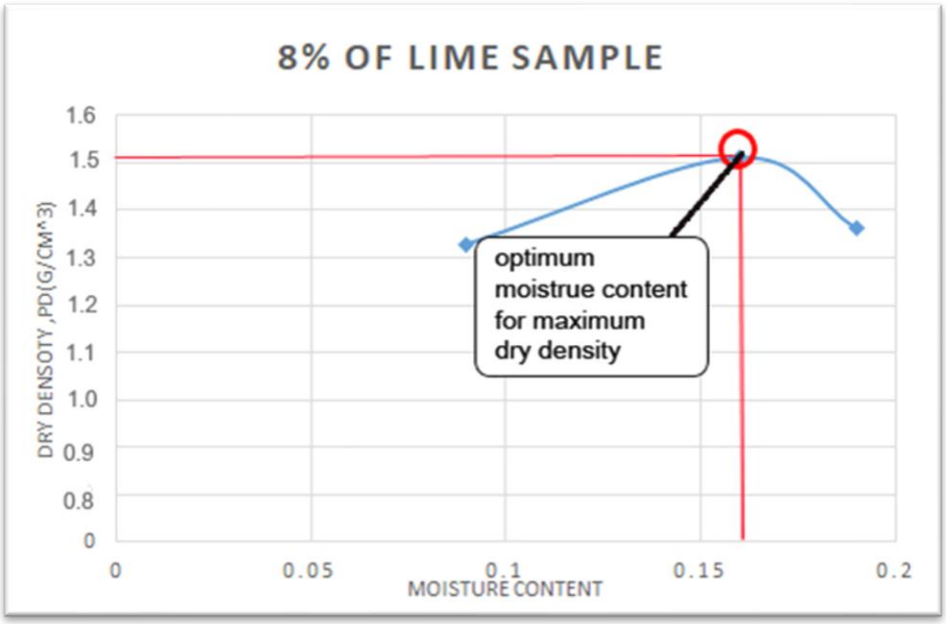


Figure 12:maximum dry density vs moisture content for 8% of lime powder

performance under unsoaked CBR testing 8% of lime powder :

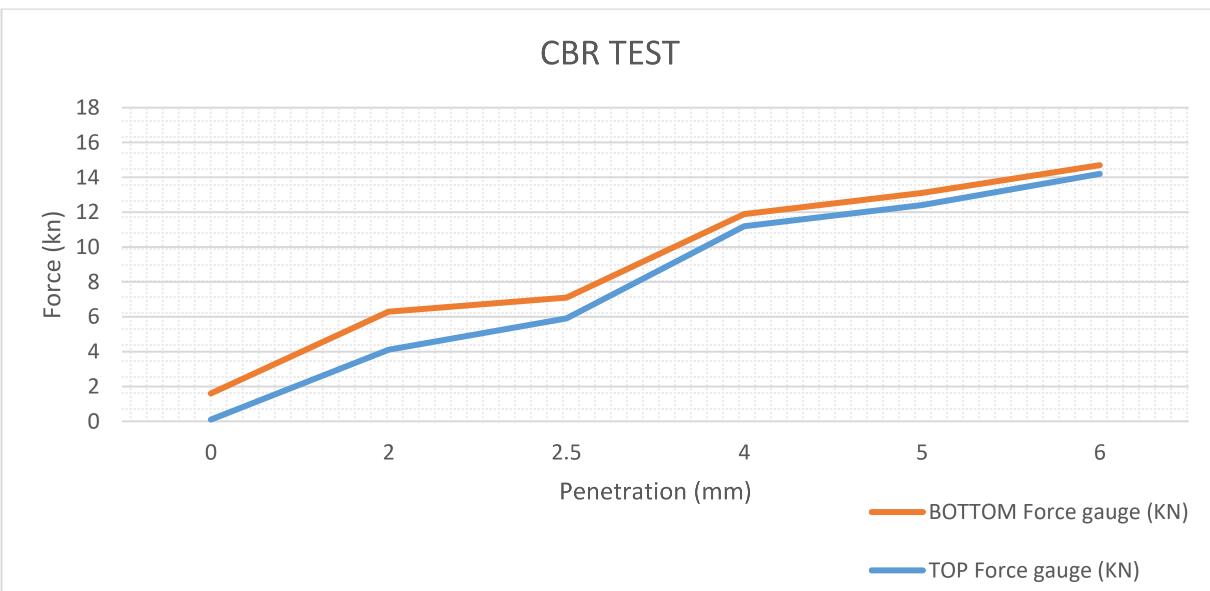


Figure 13:force vs penetration for CBR test for 8% of lime

(Control sample + 8% of Rice husk ash):

Proctor test:

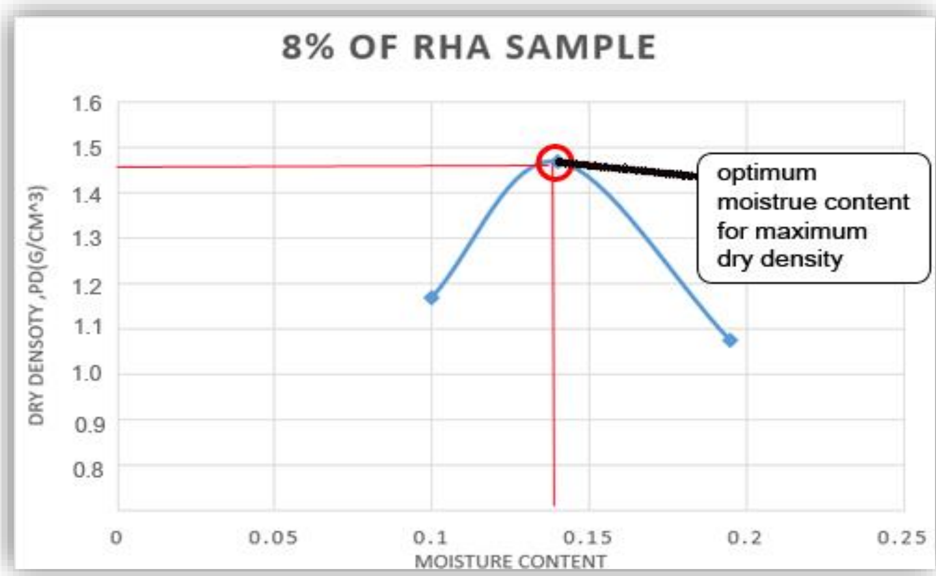


Figure 14:maximum dry density vs moisture content for 8% of RHC

performance under unsoaked CBR testing 8% of rice husk ash :

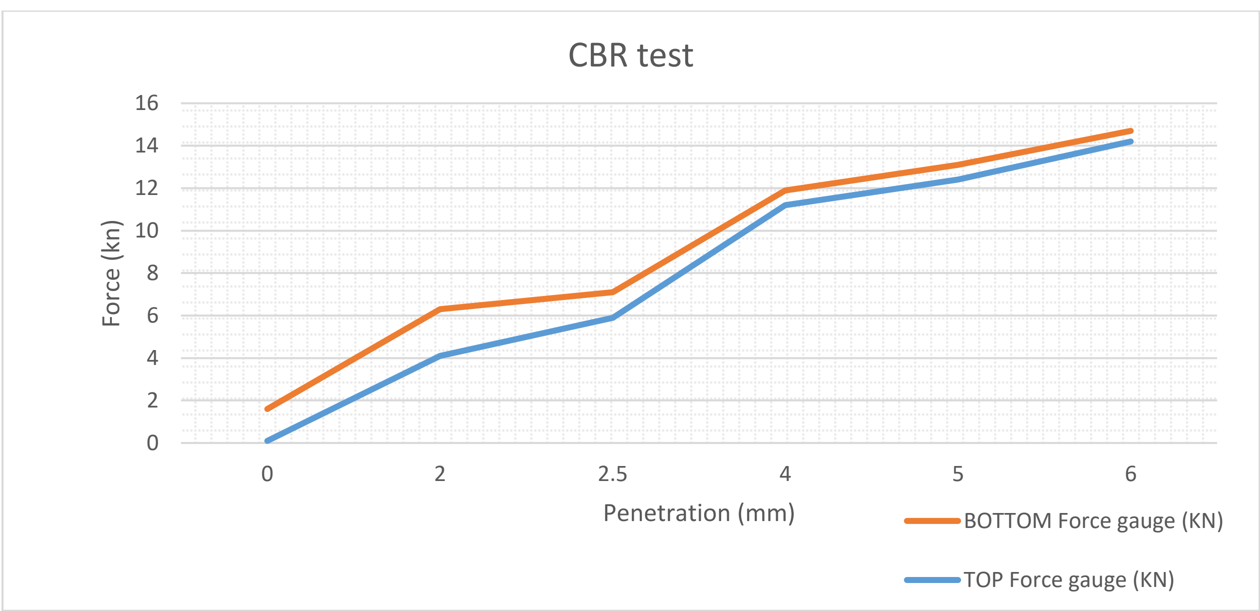


Figure 15::force vs penetration for CBR test for 8% of RHC

(Control sample + 8% of Sand):

Proctor test:

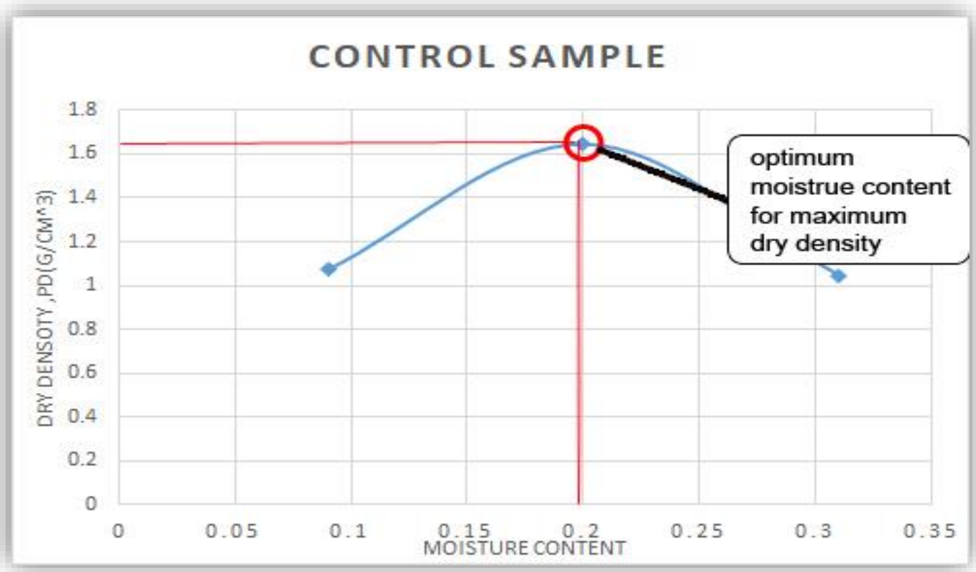


Figure 16:maximum dry density vs moisture content for 8% of Sand

Performance under unsoaked CBR testing 8% of sand:

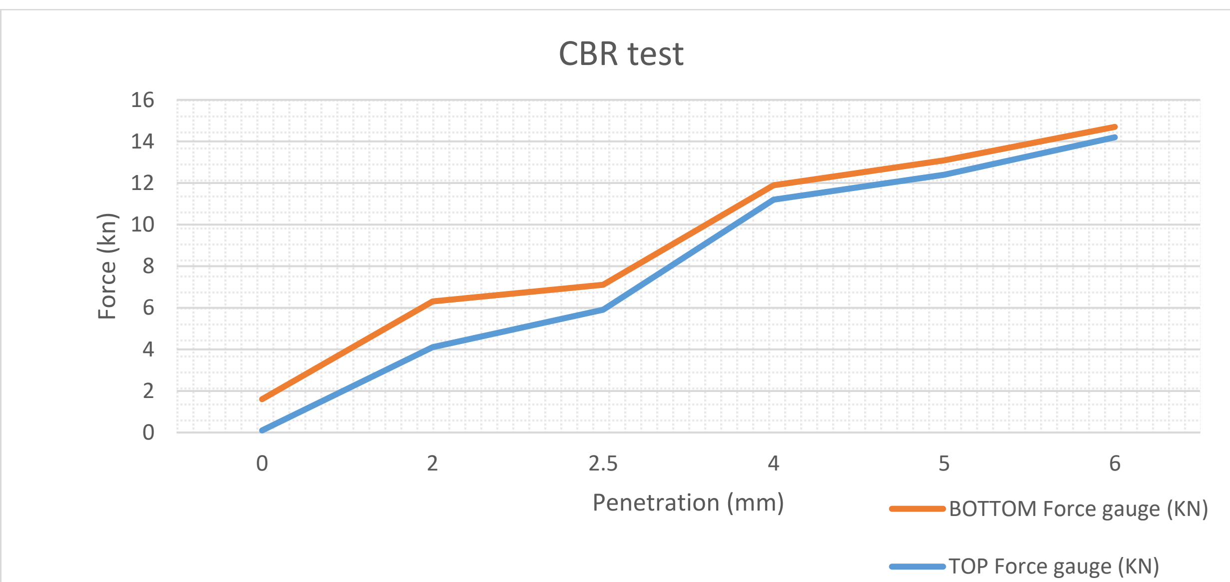


Figure 17:force vs penetration for CBR test for 8% of Sand