EVALUATING THE EFFECT OF COFFEE HUSK ASH USED AS A SOIL STABILSER

FINAL YEAR PROJECT REPORT SUBMITTED TO SCHOOL OF ENGINEERING AND APPLIED SCIENCE AT KAMPALA INTERNATIONAL UNIVERSITY IN PARTIAL FULLFIILLMENT OF THE REQUIREMENT FOR THE AWARD OF DEGREE

Of

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DECLARATION

We entirely certify that the work produced in this Final Year Project Report is solely our own and that it has never been produced in any institution or university by any person. It is being submitted in partial fulfillment of requirements for the award of the Bachelor of Science degree in Civil Engineering at Kampala International University.

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Date………………

APPROVAL

I hereby certify that this final year project titled "Evaluating the effect of coffee husk ash used as a soil stabiliser" has been prepared under my supervision. The work was carried out under my supervision until final presentation and submission to the School of Engineering and Applied Sciences (SEAS) of Kampala International University (KIU) in partial fulfillment of the requirement for the award of Bachelor of Science in Civil Engineering.

Sign: ……………………………………........

Date: ……..……………………....................

MR. BAHATI MUSIIME ENOS

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May God reward each ones contribution abundantly.

ABSTRACT

This project report titled "evaluating the effect of coffee husk ash used as a soil stabilizer" majorly aimed at reducing the cost of soil stabilization in that the usage of a cheaper alternative stabilizing agent was undertaken by assessing the properties of soil free of CHA and a mixture of soil and CHA of varying amounts. The tests carried out on its properties including grading, Atterberg limits, MDD, and CBR tests which proved that the properties of the soil improved with increasing amounts of CHA up to the optimum of 10% and past that the properties deteriorated as fully elaborated in this report.

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LIST OF ACRYONMS/ABBREVIATION

CHA	Coffee Husk Ash
RHA	Rice Husk Ash
MMD	Maximum Dry Density
CBR	California Bearing Ratio
BS	British Standard
GI	Grading Index
LL	Liquid Limit
OMC	Optimum Moisture Content
PI	Plasticity Index
PL	Plastic Limit
AASHTO	American Association of State and Highway Transportation Officials

CHAPTER ONE

1.1 INTRODUCTION

1.1.1 Background

Having a developed road network is one of the basic requirements for the development of any country. However, during road construction, sometimes the existing soil material is found unsuitable for the proposed construction because it does not meet the required minimum standards, in which case the material has to either be stabilized or replaced with better quality material to improve its engineering properties, a process known as stabilization. Ideally, replacing of the soil has always been expensive and therefore the use of stabilizers is normally adopted as a more economical option where by the properties of the poor soil are improved, with a particular stabilizing agent, to meet the minimum specification or road construction.

In Uganda, a lot of road construction projects involving stabilization of the sub-grade material is mainly done using the common soil stabilizers like lime and cement which costly. In turn, the use of these stabilizers has increased construction costs resulting into project delays (Dr. Umaru Bagampadde). Basing on that fact, the need to come up with a new, cheaper and readily available soil stabilizer like coffee husk ash is rising.

1.2 Problem Statement

Uganda is the second largest producing country of coffee in Africa (International Coffee Organization, Aug 2018), during the processing of its products from the coffee beans, the by-products (coffee husks) are rejected which in turn is becoming a worrying factor for environmentalists since Coffee husk contains some amount of caffeine and tannins ,which makes it toxic in nature, resulting in disposal problems which makes them not eco-friendly to some extent. During road construction, sometimes the existing soil material is found unsuitable for the proposed construction because it does not meet the required minimum standards and hence calling foe the need to be stabilized. Based on the above fact, this study seeks to evaluate the effect of coffee husk ash when used as a soil stabilizer.

1.3 Objectives of the study

1.3.1 Main objective

To evaluate the effect of coffee husk ash used as a soil stabilizer.

1.3.2 Specific Objectives

- To examine the variation in grading of both soil and soil coffee husk ash mixture.
- To examine the variation in maximum dry density (MDD) between soil and soil coffee husk ash mixture.
- To examine the variation in Atterberg limits between soil and soil coffee husk ash mixture.
- To examine the variation in bearing capacity between soil and soil coffee husk ash mixture.

1.4 Scope

This research focused on examining the variations in the engineering properties of soil when mixed with coffee husk ash and all the tests were carried out from the Soil mechanics laboratories. It ran in the time frame of October 2018 to May 2019.

1.5 Justification

In Uganda, engineering works are currently ongoing like construction of roads, and others like railway lines are proposed in the near future in different parts of the country. However, some of these projects like road construction find the existing soil material unsuitable for the proposed construction because it does not meet the required minimum standards, in which case the material has to either be stabilized use with cement or lime or replaced with better quality material to improve its engineering properties which are expensive options, therefore, this research study draws the possibility of the use of the coffee husks to be used as the stabilizer to improve the engineering properties of the soil which tends to be a cheaper option than the earlier mentioned stabilizers and leads to full utilization of this natural resources which has always been a waste in Uganda.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

Sub-grade soils are a very essential component of the road pavement and as such, inadequate sub-grade performance is the cause of many premature pavement failures. The quality and stability of the sub-grade soil is a major factor responsible for the adequate performance and service of the road during its lifespan. The physical properties of the sub-grade soil determine the total thickness requirement of the pavement structure which it supports and the life of the structure in good working conditions. Generally, Sub-grade performance depends on three basic characteristics

2.1 Strength

The sub-grade must be able to support loads transmitted from the pavement structure. This load-bearing capacity is often affected by degree of compaction, moisture content, and soil type. A sub-grade having a California Bearing Ratio (CBR) of 10 or greater is considered essential and can support heavy loads and repetitious loading without excessive deformation (Spangler, 1982).

2.2 Moisture content

Moisture tends to affect a number of sub-grade properties, including load- bearing capacity, shrinkage, and swelling. Moisture content can be influenced by a number of factors, such as drainage, groundwater table elevation, infiltration, or pavement porosity (which can be affected by cracks in the pavement). Generally, excessively wet sub-grades will deform under load.

2.3 Shrinkage/swelling

Some soils shrink or swell, depending upon their moisture content. Additionally, soils with excessive fines content may be susceptible to frost heave in northern climates.

Shrinkage, swelling, and frost heave will tend to deform and crack any pavement type constructed over them.

Whether it will be a temporary access road or a permanent road built over a soft sub-grade, large deformations of the sub-grade will lead to deterioration of the paved or unpaved surface. Clay sub-grades in particular may provide inadequate support, especially when saturated. Soils with significant plasticity may also shrink and swell substantially with changes in moisture conditions.

These changes in volume can cause the pavement to shift or heave with changes in moisture content and may cause a reduction in the density and strength of the sub-grade, thereby accelerating pavement deterioration.

The available soil need not always have adequate strength to support the wheel loads. Sometimes, this can be rectified by borrowing soil having better strength characteristics from nearby sites and replacing the weak soils or by improving the available soil with or without help of admixtures, thereby increasing its strength. There is substantial history of the use of soil stabilization admixtures to improve poor sub-grade soil performance by controlling volume change and increasing strength.

The main objective of stabilization is to improve the performance of a material by increasing its strength, stiffness and durability. Generally, the performance of the stabilized material should be at least equal to, if not better than that of a good quality natural material.

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2.5 The role of sub-grade

The importance of soil as a highway sub-grade lies in the fact that it acts as an integral part of the road pavement. The soil, as a highway sub-grade, serves the following functions;

- Provides stability to the road pavement.
- Provides adequate support to the road pavement.
- Provides good drainage of rain water percolating through the road pavement.
- It has substantial impact on base and subsurface drainage requirements and on long-term pavement ride quality and overall performance.

The sub-grade in flexible pavements is more vulnerable to failure under the vehicular traffic loading due to non-uniform distribution of the load from overlying layers and presence of high moisture content. Ironically, the sub-grade layer gets less emphasis compared to the other layers of the pavement, despite the fact that most of the pavement failure is caused by the bearing capacity failure of the sub-grade layer. Some sub-grade soils, especially clayey soils, have great strength at low moisture content. However, they become very weak and less workable with the increase in water content beyond the optimum value. Such soils require to be either replaced with superior quality fill material or to be stabilized with a suitable stabilizing admixture to attain the required specifications.

Figure 1: fine grained soil difficult to compact, slow drying and poor working platform

Figure 2: sub-grade failure cracks.

2.6 Soil stabilization

There are many different reasons for stabilization of materials for road construction, ranging from lack of good quality materials to a desire to reduce material usage by reducing the thickness of the pavement layers. Ultimately, stabilization will usually result in cost saving. The engineer is trying to build a problem-free pavement that will last for its intended design life for the most economic price. The cost savings associated with stabilization can take many forms such as reduced construction cost, reduced maintenance costs throughout the life of the pavement or even an extension of the normal pavement life.

Additionally, the location of suitable materials for road construction is becoming increasingly difficult as convectional high-quality materials are depleted in many areas. Also, the costs of hauling materials from farther away add to the cost of construction. One solution to this problem is to improve the locally available materials that presently may not conform to the existing specifications.

From the point of view of bearing capacity, the best materials for road construction are those that derive their shear strength partly from friction and partly from cohesion. For stabilization to be successful, the material should attain the desired strength, i.e., should be capable of sustaining the applied loads without significant deformations and should retain its strength and stability indefinitely.

(Spangler, 1982), Noted that it is crucial for highway engineers to develop a sub-grade with a CBR value of at least 10. Research has shown that if a sub-grade has a CBR value of less than 10, the sub base material will deflect under traffic loadings in the same manner as the sub-grade and cause pavement deterioration.

It is important to note that not all materials can be successfully stabilized. For instance, if cement is used as the stabilizer, then a sandy soil is much more likely to yield satisfactory results than soft clay. It is therefore paramount that the material to be stabilized be tested to ensure that it is compatible with the intended stabilizer.

2.6.1 Types of stabilization

There are a number of different types of stabilization, each having its own benefits and potential problems. Some of the most frequently used types of stabilization include the following;

a) Mechanical stabilization

Mechanical stabilization of a material is usually achieved by adding a different material in order to improve the grading or decrease the plasticity of the original material. Normally, this type of stabilization is achieved in the absence of any chemical reaction. The mixing/blending of the two or more materials may take place at the construction site, a central plant or at a borrow area. The blended materials are then spread and compacted to required densities by the conventional methods. The benefits and limitations of mechanical stabilization, however, are well understood and so they will not be discussed farther in this project.

b) Cement stabilization

The addition of cement to a material, in the presence of moisture, produces a hydrated calcium aluminate and silicate gels, which then crystallize and bind the materials together. The reaction can be represented in the following equation.

Ca3SO2+ H2O Ca3S2H3 +Ca(OH)2

Ca2SO2+H2O Ca3S2H3+ Ca(OH)2

Generally, most of the strength of a cement stabilized material comes from the physical strength of the matrix of hydrated cement. A chemical reaction also takes place between the material and lime, which is released as the cement is hydrated, leading to a farther increase in strength. Since this project does not focus on the use of cement in stabilization, the benefits and limitations of cement stabilization will not be discussed farther.

c) Lime stabilization

The stabilization of pavement materials using lime is not new, with examples of lime stabilization being recorded in the construction of early roman roads. Lime stabilization involves the addition of lime to the soil, especially clayey soils, to trigger an exchange of cations that eventually result in a decrease of the plasticity of the soil. Lime is produced from chalk or limestone by heating and combining with water. Generally, the term „lime" is broad and covers the following main types;

- Quicklime- calcium oxide (CaO)
- Carbonate of lime-calcium carbonate ($CaCO3$)
- Slaked or hydrated lime- calcium hydroxide ($Ca(OH)2$

Lime stabilization will only be effective with materials that contain enough clay for a positive reaction to take place. Attempts to use lime as a general binder in the same way as cement will therefore not be successful. It is also important to note that only quicklime and hydrated lime are used as stabilizers in road construction.

Hydrated lime is used extensively for the stabilization of soil, especially soils with high clay content. Its main advantage is raising the plasticity index of the clayey soil. Small quantities of lime may result in small increase in CBR strength although no significant increase in compressive or tensile strength should be expected. Generally, the strengthening effect of lime is significantly less than an equivalent quantity of cement, unless the host material contains very high quantities of clay. The lime can added in solid form although it can also be mixed with water and applied as slurry.

d) Pozzolanas

A pozzolan can be defined as a finely divided siliceous and/or aluminous material, which in the presence of water and calcium hydroxide will form a cemented product. The cemented products are calcium based hydrates which are basically the same hydrates that form during the hydration of Portland cement. Examples of pozzolanas include fly ash and Rice Husk Ash.

e) Lime-pozollana stabilization

A pozzolanic reaction occurs when lime reacts with soluble silica from the clay or if the material does not have adequate pozzolans, the reactive silica from pozzolanic materials such as Rice Husk Ash and fly ash. The reaction produces calcium-silicate hydrates and calcium-aluminate hydrates, which are essentially the same as the cemented products responsible for strength and durability of convectional cement. The pozzolanic reaction can be illustrated by the following equations;

$Ca2+ + OH-+$ soluble silica calcium-silicate hydrate

$Ca2+ +OH-+$ soluble aluminate calcium-aluminate hydrate

2.7 Previous studies on soil stabilization using other means than cement and lime.

Over the years research communities have studied the possibility of the use other alternative ways of soil stabilization and examined the techniques of improving the properties of such soil and some the studies conducted earlier on as shown below;

(Bell, 1999), investigated damage due to the shrink–swell characteristics of soils on civil engineering infrastructures and estimated that it costs billions of dollars. Due to a large extent of damage and an increase in a construction project cost, engineers and researchers carried out many investigations to figure out the possibility of using an increasing amount of solid waste to improve the soils properties.

(Nyankson, 2013), explored the effect of lime contained in eggshell and its application in the stabilization of shrink–swell soils and the sample mixed with 8% eggshell powder showed a decrease in the plasticity index (PI) and free swell index (FSI) and a high silt/clay fraction.

(Mousa, 1998), reported the possibility of using olive waste, finding that the addition of 2.5% by weight of burned olive waste increases the unconfined compressive strength and the maximum dry density, while the addition of 7.5% olive ash by weight minimizes the swelling pressure of the soil.

(Haji Ali, 1992), found that the addition of rice husk ash (RHA) enhances not only the strength development but also the durability of lime-stabilized residual soil. Stabilized soil with the optimum RHA content suffers the least detrimental effects of saturation.

Therefore, it can be inferred that the use of RHA in the chemical treatment of residual soil for construction of roads, airfields, etc.

(Kiran, 2013), Soil stabilized with the addition of bagasse ash gave good improved strength but the one blend with cement and lime gave more increased strength values.

(Satyanarayana, 2013), identified that the addition of fly ash to expansive soil increases the strength and decreases the swelling characteristics.

(Abd El-Halim, 2014), concluded that sawdust has the potential to improve the hydro-physical properties of expansive soils, especially when added to soil in between one to two percent on dry weight basis. Above this percentage the improvement was much less significant and warranted by the clay content decrease. In addition, fine sawdust can be used to minimize the development of desiccation cracks and the shrinking behavior of expansive soils. Moreover, the sawdust waste material can potentially reduce stabilization costs by utilizing waste in a cost-effective manner.

Properties of coffee by-products are less known and less research has been conducted on how to use these waste materials in an effective manner. Coffee husk contains some amount of caffeine and tannins, which makes it toxic in nature, resulting in disposal problems. However, it is rich in organic matter, which makes it an ideal substrate for microbial processes for the production of value-added products, such as fertilizers, livestock feed, compost, etc. However, these applications utilize only a fraction of available quantity and are not technically very efficient (Ashok pandey, 2000). Combustion of this type of waste material is a common practice in farms; the coffee husk ash reject is becoming a worrying factor for environmentalists. Coffee husk ash reject is constituted mainly of calcium and potassium, making it possible and interesting to investigate the possibility of using this material as a raw material in the ceramic formulation. It has been found to have a positive effect (Acchar, 2013). No study has been reported on the usage of CHA for soil stabilization. Its use will however potentially improve the soil properties and reduce the environmental impact caused by this waste material. Therefore, the aim of this research is to evaluate the effect of coffee husk ash in improving the engineering properties of the soil.

CHAPTER THREE
METHODOLOGY

3.0 Introduction

This chapter gives the description of what was involved during the study so as to meet the earlier stated objectives in sections. An extensive review of the literature was obtained from existing relevant data in journals, textbooks, published research reports and proposals, internet and any other source of data as regards the use of cane molasses stabilization in road construction.

3.1 Materials

The materials that were used to achieve the set objectives were obtained and assessed accordingly. These materials are soil and coffee husk ash

3.1.1 Soil

The soil samples were obtained from a borrow pit from Kiigo-Busabala in the suburbs of Kampala. The soil of 200kg was picked then put in sacks and well covered to prevent contamination and excessive moisture loss. This representative sample of the gravel was then taken to the laboratory for the different tests.

3.1.2 Coffee husk ash

The natural coffee husks were obtained from factories and farms well dried and placed in an oven at a temperature of 110^0C for 24hrs, they were then grinded and the resulting ash was Coffee Husk Ash (CHA).

Figure 3: CHA prepared and ready for use.

3.2 Tests that were carried out

- Particle size distribution (grading) of the soil samples were determined in accordance with the test procedure described in BS 1377: part 2: 1990 test 9.2. The test helped to determine the particle size distribution for neat soil that was compared with that mixed with coffee husk ash.
- The Atterberg limit tests (liquid limit, plastic limit and plasticity index) were carried out following procedures detailed in BS 1377: part 2: 1990: clauses 4.3 and 5.3. The casagrande test method was used. Using this test, the consistence and comparison of the results of plasticity index from neat soil with those of the one mixed with coffee husk ash. Liquid limit is the moisture content at which soil begins to behave like a liquid material and begins to flow. Plastic limit is a moisture content at which soil begins to crumble when rolled into a thread of 3mm
- The Maximum Dry Density (MDD) of the samples were determined as described in BS 1377: Part 4: 1990 .These test results helped to compare the improvement in the density of mixture of soil and CHA with that of neat soil.
- The CBR test was carried out as specified in BS1377: part 4: 1990: clause 7. Three point method was used. This test enabled to compare the changes in swell and soil strength of both neat soil and mixture of neat soil and CHA.

Tests	**References**	**Materials to be tested**
Moisture Content Determination	BS 1377: Part 2: 1990	Soil
Particle size distribution	BS 1377: Part 2: 1990	Soil, Soil- CHA mixture
Dry Density- Moisture content relationship (MDD)	BS 1377: Part 4: 1990	Soil, Soil- CHA mixture
Atterberg limits	BS 1377: Part 2: 1990	Soil, Soil- CHA mixture
California Bearing Ratio (CBR)	BS 1377: Part 9: 1990	Soil, Soil- CHA mixture

Table 1: Test that were carried out

CHAPTER FOUR

RESULT ANALYSIS AND DISCUSSION

4.0 Introduction

The Procedure of Data analysis was carried out after collecting all the data from the laboratory tests ensuring quality control right from the sampling stages up to the time of receiving results from the laboratory. With the help of the specifications, data was analyzed by comparing the results from the tests that were carried out with those of the specifications which led to comparisons of tests carried out on CHA.

4.1 Result analysis

4.1.1 Particle size distribution

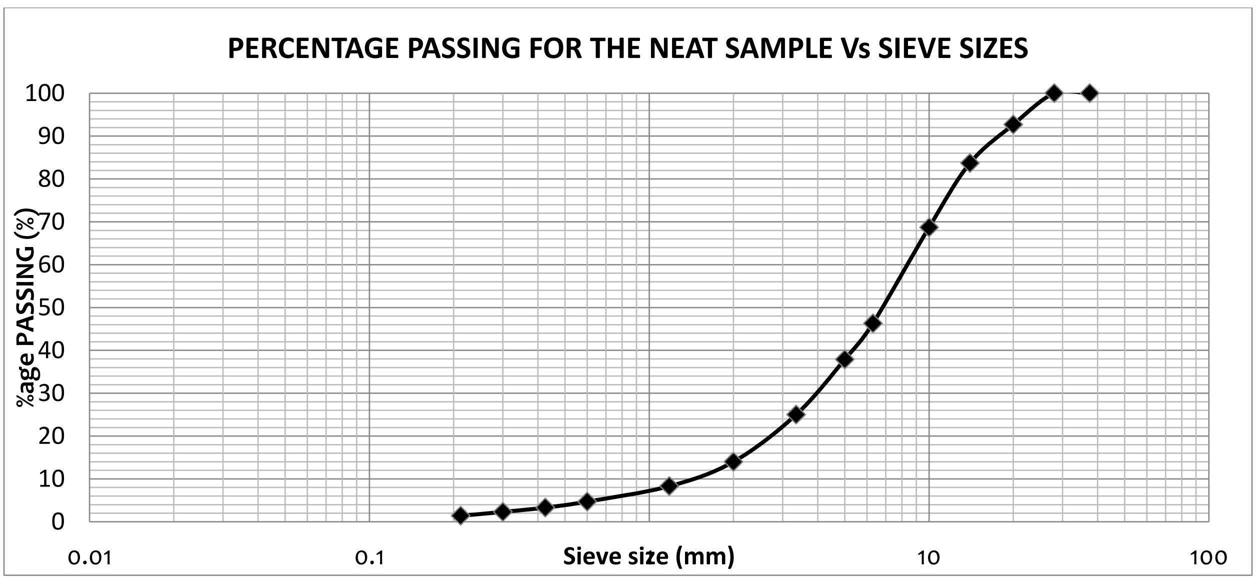

Figure 4: sieve analysis of the neat sample soil.

This shows the comparison of Particle Size Distribution for the neat gravel. It was realized that the material was uniformly graded, fell within the grading envelope for gravel ranging between 0.1 to 60.

AASHTO CLASSIFICATION OF SOIL	
%age Passing Sieve No. 200	0.00%
Liquid Limit	48.9 %
Plasticity Index	21.1 %
Group classification	A-2-7
Group index (GI)	2

Table 2: AASHTO classification of soil

Group classification of A-2-7 indicates a material with less than 35% passing the No. 200 sieve (0.075mm), Liquid Limit more than 40% and Plasticity Index more than 10%. Group Index of 2 indicates a material of high performance as subgrade material. The group index is inversely proportional to the performance of the material. The GI ranges from 0 to 20. A soil with a GI of zero is considered the best material for subgrade.

GI is given by the formula; GI=$0.01(F-15)(PI-10)$

Where; PI = Plasticity Index and F = % of neat gravel material passing sieve No.200.

This is evidenced that the material is suitable for the research.

4.2.2: Plasticity index

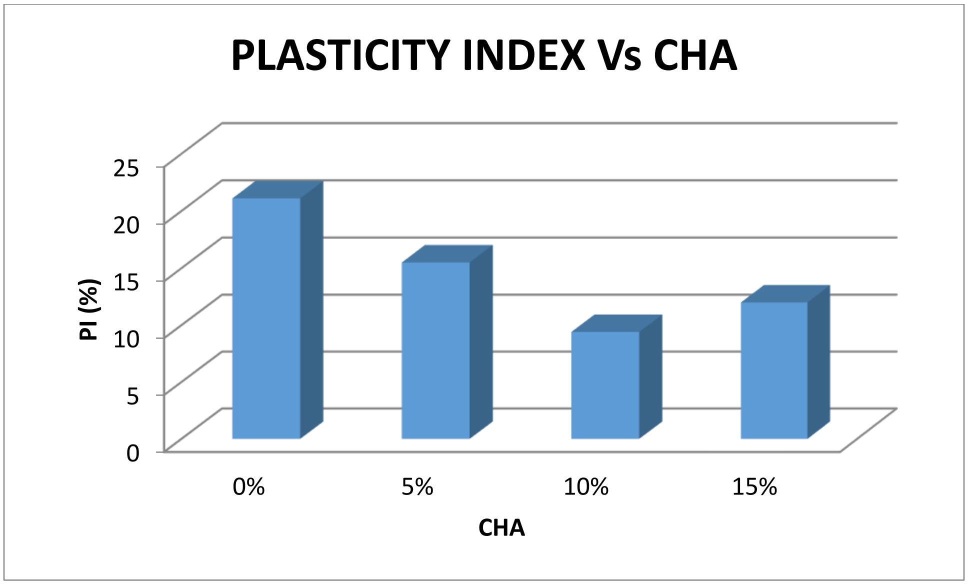

Figure 5: Plasticity Index Vs CHA chart

Plasticity Index (PI) decreases with increasing percentages of CHA content. This means that the using CHA as a stabilizing agent gives better results for plasticity.

4.2.3 Maximum Dry Density

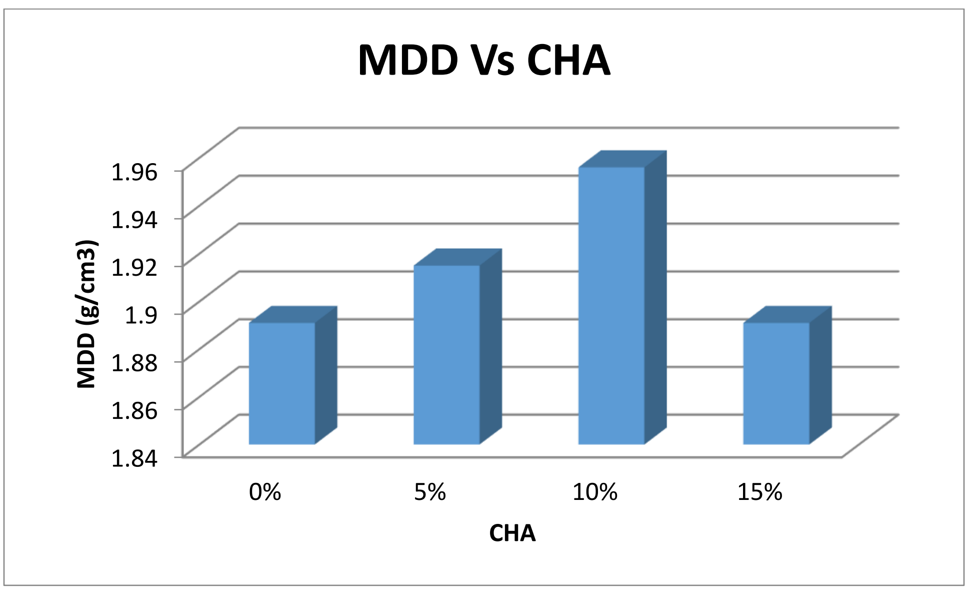

Figure 6: MDD Vs CHA chart

The Maximum Dry Density (MDD) increases with an increasing percentage in CHA .It was also observed that optimum moisture content deceases with an increasing percentage in cane molasses. This means that the voids are further reduced with increasing percentage of CHA signifying higher Compatibility.

0:2.4 California Bearing Ratio

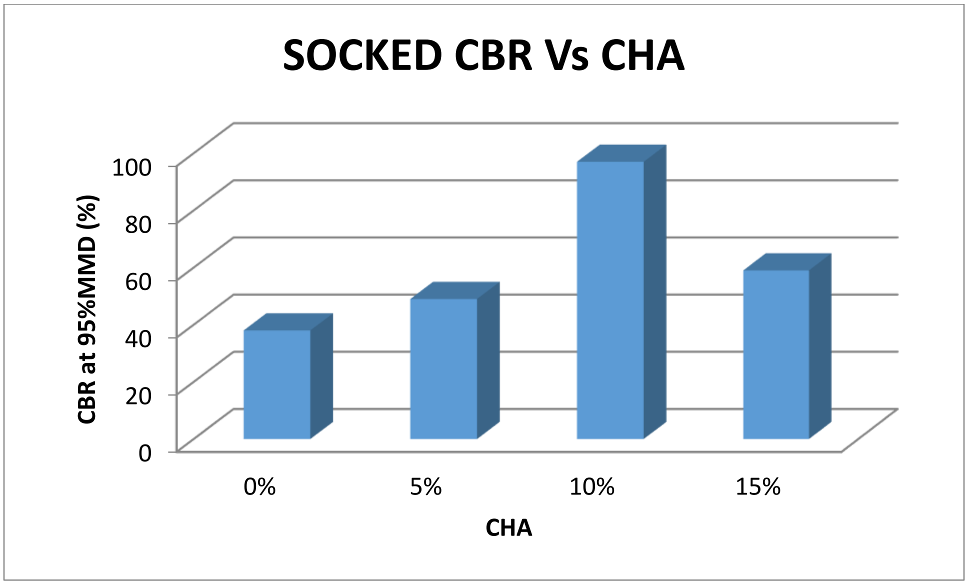

Figure 7: Socked CBR Vs CHA chart

It was observed that the bearing capacity (Socked CBR) in response to the 95% MDD of the Soil mixed with CHA, increases with an increase of cane molasses up to 10% after which it falls. After that, the strength of the material starts weakening. Comparing with the neat sample, there is a significant increase in the strength of the stabilized material.

CHAPTER FIVE

CONCULSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

This conclusion was particularly based on the test results for neat soil mixed with CHA at 10% as compared to the specifications.

MATERIAL PROPERTY	SUBGRADE LAYER SPECIFICATION	RESULTS OBTAINED AT 10% CHA
Liquid Limit (%)	Maximum 45	37.2
Plasticity Index (%)	Maximum 16	9.4
MDD (gcm^{-3})	Minimum 1.8	1.956
CBR (%)	Minimum 30	97

Table 3: comparison of the results obtained with 10% CHA addition with the minimum requirements of the subgrade

We found out that the usage of 10% CHA by mass with soil to work as a stabilizing agent for subgrade satisfied the minimum requirements for subgrade as follows;

Liquid Limit reduced from 48.9% to 37.2%.

Plasticity Index reduced from 21.1% to 9.4%.

The MDD value increased from $1.891gcm^{-3}$ to $1.956gcm^{-3}$.

The CBR value increased from 38% to 97%.

5.2 RECOMMENDATIONS

We recommend that further studies should be done on the possibility of the use of CHA in the stabilization of sub-bases and road-bases since our study focused on its application on the subgrade.

REFERENCES

Retrieved from www.ricehuskash.com/details.htm

Agricultural transformation agency. (2014). Retrieved from Ethiopian coffee exports to hit record in 2015: http://ethioagp.org/ethiopian-coffee-exports-2-hit-record-in-2015

Abd El-Halim, e. a. (2014). Influence addition of fine sow dust on the physcial properties of expansive soil in the middle delta. *Egypt* .

Acchar, e. a. (2013). Thermal analysis and X-ray diffraction of untreated coffee ash reject and its potential use in ceramics. *Theromal analysis and calorimetry*, 111:1331-1334.

Ahamed, e. a. (2014). stabilition of clay and residual soils using cement-rice husk ash mixtures . *teknik sipiel, volume 5, no 1*, 1-84.

Al-Hassan. (2008). potentials of rice husk ash for soil staiblisation. *AUJ.T.11(4)*, 246-250.

Amadi. (2014). Enhancing durability of quarry fines modified black cotton soil subrage with cement klin dust stabilisation. In *Transportation geotechnics, volume 1, issue 1* (pp. 55-61).

Ashok pandey, e. a. (2000). biotechnological potential of coffee pulp and coffee husk for bioprocess. *biochemical engineering 6*, 153-162.

Balemi. (2012). effect of integrated cattle manure and inorganic fertilisers of tuberyield of potato in Ethiopia. *soil science and plant nutrition*, 2:257-265.

Bell, e. a. (1999). geogolocial hazards: thir assessment, avoidance and mitigation. *London and New York, E and FN SPON*.

Brooks. (2009). soil stabilisation with fly ash and rice husk ash. *international journal of research and reviews in applied sciences, volume 1, issue 3*, 209-217.

BS-1377. (1990). *Metods of testing soils for engineering purpose.* London, UK: British standard institute.

Fekerte, e. a. (2009). quatifying engineering parameters of expansive soils from their reflectence spectra. *enginneering geology*, 105:151-160.

Gourley, e. a. (1993). expansive soils: TRL's research strategy. In *first international syposium on engineering characteristics of Arid soils, volume PA 1301/93* (pp. 247-260). city unviserty, london .

Gromko. (1974). review of expansive soils. *geotechnical engineering division, ASCE, Vol 100, no.6*, 667-687.

Haji Ali, e. a. (1992). geotechnical properties of chemical stabilised soils from Malaysia with rise ash as an additive. *geotechnical and geotechnical engineering*, 117-134.

Kavish, e. a. (2014). Analysis of engineering properties of black cotton soil and stabilisation using by lime. *engineering research and application*, 25-32.

Kevish. (2014). cccccc. *vvv*.

Kiran, e. a. (2013). Analysis of strength characteristics of black cotton soil using bagesse ash and additives as stabilisers . *international journal engineering research and technology (IJERT), ISSN* , 2278-0181.

Mousa, e. a. (1998). soil stabilisation with burned olive waste. In *applied clay science volume 13* (pp. 219-230).

Muntoha, e. a. (2000). Influence of rice husk ash and lime on engineering properties of clayey subgrade. *electronic journal of geotechnical engineering, vol 5*.

Nyankson, e. a. (2013). characteristics of stabilised shrink-swell deposit using eggshell powder. In *G.J.E.D.T,volume 2(3)* (pp. 1-7).

Ogato. (2013). the quest for main streaming climate change adoptationinto urban development planning of Ambo town Ethiopia. *America journal of human ecology*, 2:103-119.

Sabat, e. a. (2011). effect of marble dust on strength and durability of rice husk ash stabilised expansive soil. *international journay of civil and structural engineering, volume1, no.4*, 939-948.

Satyanarayana, e. a. (2013). study on strength characteristics of expansive soil-fly ash mixes at various molding water contents. *internatioinal journal of recent technology and engineering (IJRTE), ISSN* , 2277-3878.

Sear. (2005). "should you be using more PFA" in "cement combition for durable concrete". *preceeding of the international cofference held at the university of Dundee .* scotland, UK.

Spangler, e. a. (1982). soil engineering.

Tariful, e. a. (1999). a modified technique for measuring shrinkage of clay soils. *Pertanika J. trop. agric. sci 22(1)*, 25-32.

Yulianto, e. a. (2010). mixing of rice husk ash (RHA) and lime for pit soil stabilisation. *proceedings of first Makassar international conference on civil engineering.*

APPENDICES

APPENDIX I: PHOTOS TAKEN

Borrow pit at Kiigo

Riffling the soil sample

Oven used in CHA making

Performing CBR test

APPENDIX II: LAB TESTS