

**ASSESSING THE USE OF RIVER SAND AND SAWDUST ASH IN THE STABILIZATION OF
WEAK SUBGRADE SOILS**

JUSTINE SHILLA NAMBOOZE

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ABSTRACT

Expansive soils usually have a high compressibility they also have a tendency to shrink upon drying and swelling when wet, and high-water absorption. These expansive soils make it impossible to build civil engineering projects without adequate stability due to a number of issues they cause. In places where these soils exist, before construction of any structure, various techniques are frequently used to enhance their engineering qualities. Traditionally, common additives for stabilizing soil have included cement and lime.

But in Uganda, where there is a lot of waste from the agricultural sector, and the increasing prices of these additives, there is need to use the locally available materials to stabilize these weak soils. Thus, the purpose of this study was to determine whether river sand and sawdust ash (SDA) were suitable for stabilizing expansive soils.

Through carrying out experiments, the percentages of river sand and saw dust ash were varied in the following ranges; 0% river sand and 0% saw dust ash and 100% soil, 0% river sand and 12% saw dust ash, 15% river sand and 9% saw dust ash, 30% river sand and 6% saw dust ash, 45% river sand and 3% saw dust ash, 60% river sand and 0% saw dust ash with varying percentages of soil which were varied by mass. The tests were carried out which include classification tests, durability tests and strength tests. The results showed that the neat soil was a highly plastic clay soil which was poor to be used for road construction and therefore required stabilization. On addition of river sand and saw dust ash in the above proportions showed a notable decrease in the plasticity index from 30.4% for the neat soil to 5.2% at 45% river sand and 3% saw dust ash. However, at 60% river sand and 0% saw dust ash the soil matrix was non-plastic. The maximum

dry density was also seen to increase until it reached its highest of 1.898 g/cm³ and a reduction in optimum moisture content to 8.1%. The results reveal the potential for the use of the combination of river sand and saw dust ash to stabilize the weak subgrade soils. The research also adds to the existing body of knowledge in that it addresses the problem of poor soils and also environmental waste concerns brought about by the agricultural sector.

DECLARATION

I hereby declare that this is my original work, is not plagiarized and has not been submitted to any other institution for any award.

Signed:

Date:

.....

.....

NAMBOOZE JUSTINE SHILLA

S20B32/214

APPROVAL

I therefore attest that NAMBOOZE JUSTINE SHILLA, reg no. S20B32/214, conducted her research study at Uganda Christian University from September 2023 to April 2024. Thus, this report accurately documents the job she was able to do under my guidance, and it is now prepared for submission to Uganda Christian University's Department of Engineering and Environment.

SUPERVISOR

SEJJEMBA HENRY

Signature:

Date:

DEDICATION

I dedicate this report to all of my well-wishers, my sponsor, and my beloved parents. I am thankful for your unwavering support and encouragement, both financially and emotionally, over the years. As a family, you are remarkable and an inspiration. I really appreciate and love what you've done. May you continue to be blessed by the Almighty God.

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GOD BLESS YOU ALL

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LIST OF ABBREVIATIONS

AASHTO	American Society of State Highway and Transport Official
ASTM	American Society for Testing and Materials
BS	British Standard
CBR	California bearing ratio
LAB	Laboratory
LL	Liquid limit
MC	Moisture content
MDD	Maximum dry density
MoWT	Ministry of Works and Transport
OMC	Optimum moisture content
PI	Plasticity index
PL	Plastic limit
SD	Saw dust
SDA	Saw dust ash
USCS	Unified Soil Classification System
UCS	Unconfined compressive strength

CHAPTER ONE: INTRODUCTION

1.1 Background

Soil refers to sediments and a collection of mineral particles that are created when water and air physically or chemically break down rocks. Variations in density and moisture content have an impact on the engineering behavior of this non-homogeneous porous material (Tisdall, 2010). It can either be organic or inorganic in nature. Organic soil is formed when plants die and decay and also the buildup of skeletons and shells however, the breakdown of rocks leads to the formation of inorganic soil, this breakdown can either be mechanical or chemical. The occurrence of expansive soils is a result of these variances in the processes by which soil forms as well as variances in local climates.

Because of these expansive soils, civil engineers have encountered numerous difficulties over the years when doing their construction works (Dennis, 2018). Some of the countries that are most impacted by these soils include China, Spain, Argentina from South America, the United States, and Canada in North America. Semi-arid locations are home to certain sorts of soil (Christos, 2022). They can be found in Uganda's Albertine region as well as in certain areas of the country's east and west (Gitta, 2019). The figure 1 below shows the coverage of the expansive soils in Uganda.

shrinkage fractures and enabling water to seep deeper, desiccation of these soils during the dry season contributes to swelling even more. Soils lose their bearing ability due to significant volume changes brought on by the cyclic process of swelling and shrinking. Additionally, heaving and differential settlement cause structural damage as a result of excessive strains brought on by expansive soils' shrink-swell characteristic. It is therefore, important that the subgrade layer on which other layers are constructed is strong (Kumar, 2022).

The bottom layer on a road structure is the road subgrade typically composing of native soil that has been compacted to support loads from overhead traffic. Sound material must therefore be used in the construction of the subgrade to guarantee a sturdy and long-lasting roadway (Ministry of Rural Rehabilitation and Development, 2020). Additionally, it's critical to maintain roads especially the unpaved roads to keep them in original shape. This will guarantee road user safety, save vehicle running costs, and enable convenient road travel. Unmaintained roads pose a serious risk to the safety of drivers, resulting in delays, financial losses, and occasionally even fatalities.

The government has made an effort to periodically maintain the roads throughout the years, but complaints and public outrage regarding the poor condition of these dirt roads and the declining quality of the work being done have persisted (Christos, 2022). Soil is a necessary building element for most construction projects, including building roadways. Most construction works requires soil to be used. An example is on road projects and some of these soils that are encountered are not exactly suitable to be used due to their poor strength. When this happens, the engineer can choose to replace the material entirely or work on strengthening the weak soil (Jadeja *et al.*, 2021).

1.2 Problem statement

Over the years, development through urbanization has taken place creating more employment opportunities for the people and because of this, many roads have been constructed and they ought to be properly constructed. Expansive soils are seen to be a major problem on the 29 km stretch of Kisamba Road in Busunjju where very many jobs for the people in the neighbouring districts have been created. (MoWT, 2022). Some major section of the road that pass-through swamps undergo heaving when the vehicles pass at these points. This has left the road in a very sorry state. It has increased the time road users spend traveling and the vehicle operating costs as vehicles are seen to break down often. Heaving occurs when the soil's water content varies and its volume changes. When the soils take in water they are seen to expand and when they lose water they shrink. There is heavy settlement in the case that heavy vehicles use the road which comes about due to shrinkage and swelling. The road develops potholes, and cracks continuously (Thomopoulos *et al.*, 2010).

Therefore, there is need to stabilize expansive soils to overcome this problem. The purpose of this study is to evaluate the effectiveness of sawdust ash and river sand as expansive soil stabilizers.

1.3 Research objectives

1.3.1 Main objective

Assessing the use of river sand and sawdust ash as a stabilizing material for weak subgrade soils.

1.3.2 Specific objectives

1. To determine the engineering properties of the neat soil.
2. To determine the engineering properties of river sand and sawdust ash to be used as a stabilizer.
3. To determine the variation in strength values with different percentages of river sand and sawdust ash added to the soil.

1.4 Research questions

1. What are the engineering properties of the neat soil?
2. What are the engineering properties of river sand and sawdust ash to be used as a stabilizer?
3. What is variation in strength values with different percentages of river sand and sawdust ash added to the soil?

1.5 Justification

Given that river sand is granular and inert by nature, it can be used as a filler material when combined with expansive soil because of its strength under confined conditions (Ministry of Rural Rehabilitation and Development, 2020). In order for the composite mix to have both cohesion and friction, there should be a consistent gradation of coarser components throughout the stabilization of fine-grained soils. Sand particles have angular shaped particles therefore, they interlock with soil particles when mixed in different proportions, making sand an admixture to cohesive soils (Rodriguez, 2020). Particle interlocking alters the soil's flexibility, compaction, and bearing capacity, among other characteristics. However, in wet conditions, the high clay content in the soil makes it difficult for the soil to remain effectively bonded with the sand therefore

there is need to add sawdust ash to the mixture as a chemical stabilizer (Imafidon, Ogirigbo and Ehiorobo, 2021).

The saw dust ash is pozzolanic in nature. When sawdust ash is combined with expansive soil in the presence of water, its pozzolanic nature allows it to exchange cations (Mohamed *et al.*, 2023). It contains around 65.31% silica, 6.08% alumina, and 10.36% calcium oxide. Particle agglomeration and flocculation form cementitious materials that increase the strength of the soil and the materials formed are calcium silicate hydrate and calcium aluminate hydrate (Butt, Gupta and Jha, 2016). The particles are then firmly bound together to create a uniform soil mixture and reduce the Atterberg limits. The importance of river sand is for uniform gradation of the soil since the sawdust ash increases the percentage fines. The voids in the soil are properly filled hence resulting into a more compact soil sample increasing the soil density (Ohio Department of Natural Resources, 2012).

1.7 Scope of study

1.7.1 Geographical scope

The study was carried out on Kisamba Road in Busunjju and this was where the neat soil samples were obtained and then transported to Stirling laboratory for testing. The river sand which was a mechanical stabilizer was obtained from Lwera and the sawdust was obtained from Mukono carpentry workshop and burnt to ash from the UCU furnace at 500°C.

1.7.2 Time scope

The study was conducted from August 2023-April 2024.

1.4.3 Content scope

The study was looking at river sand stabilizing the neat soil mechanically and the saw dust ash also enhancing on the bonding properties of the soil due to its pozzolanic nature. The study therefore looked at comparing the strength characteristics of the stabilized soil with the one stabilized with different percentages of river sand and saw dust ash added to it. Also, a mix design was formed and the results obtained were compared according to the standards.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Previous scholars have made significant efforts to strengthen and stabilize expansive soils. The modification of soils to strengthen their physical characteristics is known as soil stabilization (Michael, 2021). The most popular chemical admixtures are cement and lime, which are very expensive (Huat, 2006). To handle this issue, numerous researches has been conducted to evaluate the effectiveness of using sawdust ash to enhance the engineering properties of soil.

This chapter summarizes several research projects on sawdust ash, river sand, and poor subgrade soil stabilization. A detailed investigation of the viability of utilizing river sand mixed with sawdust ash for the stabilization of weak subgrade soils was carried out based on the challenges noted in other reports. The investigations aid in determining the gaps that need to be filled to better improve on the weak and expansive soils. In order to comprehensively understand the study and accomplish the stated objectives, the literature has been revised in accordance with the study proposal's objectives. The qualities of the materials (river sand, sawdust ash, and neat soils) utilized in this study are also covered in this chapter, along with their suitability for achieving soil stability. The key concepts covered include; characteristics of expansive soils, how to choose a stabilizer, various stabilization mechanisms utilized in road construction, and how each stabilization technique improves the qualities of the soil.

2.2 Theoretical review

2.2.1 Soil classification

Classifying the soil is crucial before stabilizing it, as it helps determine whether stabilization is necessary. Sorting soils according to similar properties into groups is the process of soil classification (khoerul ummah, 2022). While there are other ways to categorize soil, USCS and AASHTO are the most often utilized approaches.

2.2.2 According to Unified Soil Classification Systems (ASTM D2 487 2004)

USCS states that after estimating by weight, a representative sample of soil maintained on sieve No. 200 which removes particles larger than 75 mm which are taken and classified as either fine-grained and those retained on the same sieve as coarse-grained. When more than 50% of the particles in the soil is retained the soil is categorized as coarse-grained soils, whereas less than 50% of the particles in the soil is retained the soil is classified as fine-grained soils (Trans, 2016).

When the soil mainly comprises of coarse-grained particles, it can be identified as a sand or gravel material having estimated whether more than 50% of the particles pass through the sieve number 4.

For a gravel soil, it is a clean soil if it has very little fines in it that are usually less than 5% and it is dirty if the fines are less than 12%. Clean gravels that are well graded are classified as GW, those that are gap graded are classified as GP soils.

The dirty ones are in two categories and they include; the silty fines which are non-plastic and these are denoted as the GM and the plastic are the clayey soils denoted as GC.

For sands the same procedure is followed as that of the gravels and the well graded sands are denoted by SW and those that are poorly graded are denoted as SM. The sand that contains clay fines in it is denoted as SC.

Fine grained materials are usually classified as the following: ML, OL, CL, CH, MH, OH having estimated it's dilatancy and determined whether it is inorganic or organic in nature.

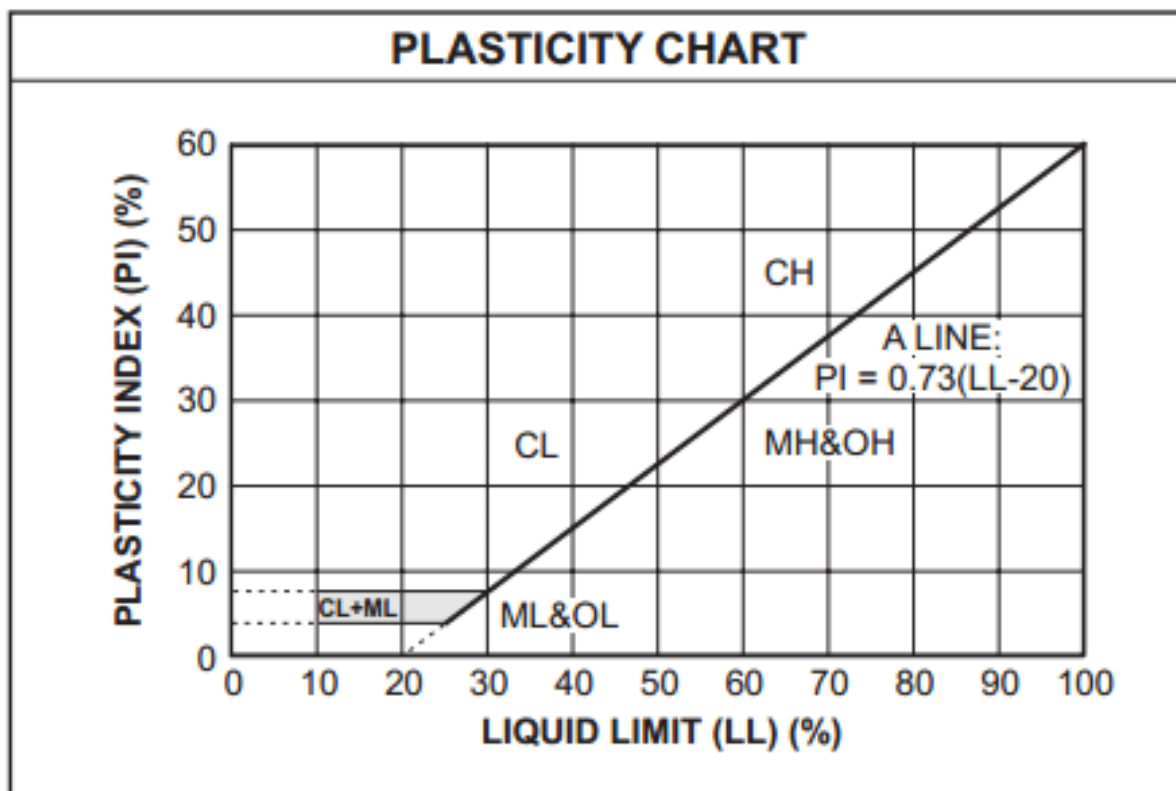


Figure 2: Shows plasticity chart

2.2.3 Expansive soils

Because expansive clay soils naturally have the ability to experience volume fluctuations in response to variations in moisture content, they can be troublesome soils. The alternating swelling and shrinking characteristics harm engineering structures

by forming cracks. The mineral montmorillonite clay, which is found in expansive soils, has the ability to absorb water and hold onto it for extended periods of time (Ikeagwuani and Nwonu, 2019).

Illites and vermiculites are part of the Mica-like group, which can be widespread but usually does not cause much trouble. Weak bonds hold the alumina sheet sandwiched between two silica sheets (Bauluz, 2015).

Engineering structures are limited by the montmorillonites clay minerals, which are part of the smectite group. They have alternating silica and alumina sheets and because there is less connection between succeeding units, water can easily displace them, thus weakening the binding and causing expansion. According to a 2016 study by Fajardo, the inter layers created in the montmorillonite clay or smectites are hydrated and expansible, and this can vary up to 30% of the original volume depending on the amount of moisture present in the soil.

2.2.4 Swelling mechanism of clay soils

The phenomenon of soil expanding when water is present is known as swelling. Clayey soils have a net negative charge on its surface and when in contact with water which contains the positive ions, The molecules of the water are attracted to these surface charges and therefore there is absorption of the water molecules. The distance between the adjacent clay particles reduces and hence the soil mass increases in volume and hence forming a double play that makes it hard for the soil to easily loose water (Bala, 2023).

2.3 Empirical review

2.3.1 Soil stabilization

The modification of soils to strengthen their physical characteristics is known as soil stabilization. It improves the performance of the soil by strengthening its engineering properties (Onyelowe, 2012). Additionally, it can reduce the soil's tendency to swell and contract, enhancing the shear strength of the soil and its ability to support more weight. Research has been done on the various types of stabilization and that different materials that can be used some of which include; cement, lime, plastic, fly ash and many other additives (Kobbail, 2022). The most common way for stabilizing expansive soils is to combine the natural expansive soil with various stabilizers. This has inspired research into the use of unconventional stabilizers such ash of rice husks, sugarcane bagasse, cow dung, fly ash, saw dust ash, and waste from plastics among others to stabilize expansive soils whose disposal would otherwise be troublesome.

Stabilization involves several techniques but they can broadly be classified into 2 types:

1. Mechanical stabilization
2. Chemical stabilization

2.3.2 Mechanical stabilization

The main aim of mechanical stabilization is to redistribute the traffic loads that are applied on the soil by increasing the bearing capacity of the soil. This is usually done by changing the natural soil's physical characteristics and hence the soil is be stabilized.

Physical processes such vibration of the soil, compaction, or the addition of extra physical elements like aggregates, barriers, and nails can be used. This is mechanical stabilization additional fines or aggregates may be added to produce a properly graded soil-aggregate mixture therefore densifying the soil. The engineering qualities of the soil can also be improved by using geotextiles (Akudike, 2020).

2.3.3 Chemical stabilization

In this kind of stabilization, a chemical compound is introduced to the soil, and the chemical composition of the compound reacts with the soil's constituent elements to enhance the soil's qualities. Cement, lime, fly ash, and rice husk ash are the most used elements for chemical stabilization. Other pozzolanic materials or a mixture of these materials with the soil whose engineering properties are to be stabilized (Pushpakumara and Mendis, 2022). The subsequent chemical reactions are what lead to the soil's engineering properties improving. For a given type of soil, there may be more than one potential stabilizer that can be used, however there are some general rules that make certain stabilizers more desirable based on soil properties such as the granularity, fluidity, or texture of the soil. Traditionally, the 2 mostly used chemical stabilizers are cement and lime (Stakland, 2010).

2.3.4 River sand as a soil stabilizer

The coarser sand admixture particles replace the finer soil particles in accordance with stabilizing processes used to improve the soil. Because the sand particles are angular in shape, this produces a regular gradation of particles in the soil and a composite mix that is cohesive and frictional (Karimi, 2011). They will make it possible for the fine-

and coarse-grained particles to adequately interlock, resulting in a homogeneous mixture (Washino *et al.*, 2023).

The following percentages of river sand were applied to the soil in a series of laboratory tests: 4.68%, 10.16%, 24.6%, 35.84%, and 56.9 by Hussein. The experimental results demonstrated a considerable improvement in reducing the swelling potential of expansive clay soil reinforced with sand since the plasticity index decreased from 25% to 18% (Hussein, 2021).

Another researcher experimented with expansive soils by stabilizing it using sand and cement. Minimum amounts of 2% cement and 10% sand were added to the soil at intervals of 10% to 30%. According to the CBR test results, the value of the CBR decreased by 20% and increased by 30% (Nigitha and Prabhanjan, 2022).

2.3.5 Sawdust ash as a soil stabilizer

Sawdust ash is one type of biomass waste ash (SDA). In technical terms, sawdust, also known as wood dust, is a waste by-product produced during woodworking processes such as sawing, milling, drilling, and sanding of timber in the timber industries that process timber to supply various related manufacturing industries. When trees are cut, we usually obtain around 78% of their weight; sawdust makes up the remaining 22% of the entire weight of the trees. While sawdust can also be used to make wood pulp, compost, charcoal briquettes, and fuel, particle boards are the main usage for it (Jamaluddin and Munirwan, 2022). They are also employed in sawdust burners in sawmills, where they are produced in large quantities, to provide heat for milling processes. Wood ash, or SDA, is the final product that is produced (WA) (James, 2019).

SDA has been used in concrete manufacturing and, more recently, in stabilization of soil. A number of researchers have investigated the use of SDA alone as a stabilizer and in conjunction with primary binders such as lime and cement. Several researchers have examined the geotechnical characteristics of burnt clay bricks, highway subgrade stabilized with SDA (Shawl, Praksh and Kumar, 2017). However, because of its high siliceous content, others suggest that that SDA is a pozzolanic material. A pozzolan is a finely divided siliceous or aluminous substance that, when combined with calcium hydroxide and water, generates cemented products (Makusa, 2012). Therefore, according to them, it is important to use the saw dust ash combined with a granular material to improve the engineering properties of the soil.

John Bosco Niyomukiza conducted systematic experimentation and found that when different amounts of sawdust ash (from 0% to 10%) were added to the soil matrix, the soil's engineering qualities improved (Niyomukiza, Wardani and Setiadji, 2021).

With higher percentages of SDA, there was a steady increase in values for the California Bearing Ratio (CBR), with the maximum CBR value of 14.4% occurring when 6% SDA was used. The Kitgum region of Uganda's ideal SDA concentration for soil stabilization is found to be 6% based on this data. In addition to providing a sustainable solution that takes into account both the economic and environmental issues in construction practices, this research makes a significant contribution to the field of soil stabilization (Raheel, 2017).

Therefore, there is need to study the use of both river sand and saw dust ash in the stabilization of expansive soils since they both show potential to greatly improve the engineering properties of the soil.

CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter provides an explicit description of how the study was conducted. Not much literature has been done on the use of river sand and sawdust ash as a stabilizing material of expansive soils. Hence in the present study an attempt was made to proportion river sand and sawdust ash stabilized soils with an objective of obtaining a cost-effective mixture that is suitable to be used as a subgrade material where the river sand is abundantly available.

The tests were carried out in accordance to BS 1377 from Stirling laboratory located in Malaba. Tests were initially carried out on the neat soils which is the un-stabilized soil sample, on the stabilization materials which are river sand and sawdust ash and finally on the stabilized soil sample which comprises of the neat soils and varying percentages of river sand and sawdust ash added to the soil these were varied by weight.

The tests were carried out according to the methodology in order to determine the physical and engineering characteristics of the different combinations discussed as follows;

3.2 Materials

3.2.1 Neat soil

The materials used in this study were the weak subgrade soils, river sand and sawdust ash. The weak subgrade soils were obtained from Kisamba Road in Busunjju which passes through a low land in a swampy area. The neat soil was collected as a disturbed sample at a depth of no less than 1 meter along the road, chainage 00+29km left hand

and 00+35 km on the right side of the road. The sample was collected in disturbed conditions to be used mainly for classification tests and compaction tests. In sample collection spades were used and the sample was placed in airtight sacks in its disturbed state. It was then transferred to the laboratory for testing. For consistency in results the tests were carried out in duplicates. The sample was greyish in color with very fine particles. Labels were placed on it to indicate the sampling date and soil description then it was left outside for air drying.

3.2.2 River sand

It was obtained from Lwera and placed in sacks to prevent any kind of contamination from the atmosphere and then transported to the laboratory for testing.

3.2.3 Sawdust ash

Sawdust ash is made of particles that are loose from wood that is burnt to form ash at temperatures of about 500 degrees under controlled conditions to ensure that all the organic matter has been removed from it. It was ensured that the ashes were able to pass the 0.075mm sieve and then stored in airtight containers to prevent any moisture loss or gain and any form of contamination.

3.3 Sample preparation

Sampling

Having air dried the soil sample collected. Here representative sample of the neat soil was collected in the lab using a riffle box and the processed for testing. To thoroughly mix the sample, two riffle boxes were used and the sample allowed to run through a

splitter. The riffle box is constructed in such a way that it evenly separates the materials. The samples attained here were the ones used for testing.

3.3.1 Particle size distribution

This is carried out with reference to **BS1377: Part 2: 1990** which calls for using both dry sieving of the coarse fraction and sedimentation analysis.

This analysis was done to find out how much of the grain sized particles were in the soil. Sieve analysis was used to assess the distribution of larger, coarser particles. The distribution of various finer clay and silt particles affects the engineering qualities of soil. Wet sieving was first carried out by washing the sample as it passes through BS sieve No. 200, the retained sample was then be oven dried and allowed to pass through the remaining sieves as the percentage retained is recorded. This test was carried out on the neat soil, on the river sand and on the stabilized soil (Astm, 2021).

Data analysis

To obtain the sample retained on each sieve the weight of each of the sieves;

sample retained

= weight of the sieve with the sample

– weight of the sieve without the sample

The total of these retained masses roughly matches the initial mass of the sample.

To obtain the percentage retained on each sieve this was obtained by dividing the weight retained by the initial sample mass expressing it as a percentage.

$$\text{percentage retained} = \frac{\text{mass retained}}{\text{initial sample mass}} \times 100$$

To obtain the cumulative the retained percentage is subtracted from 100%. This is important to determine the percentage passing each.

3.3.2 Moisture Content

This was carried out with reference to **BS1377: Part 2: 1990** to determine the natural moisture content in a soil sample. To increase accuracy, it was done in triplicates. The weight of three empty containers was first obtained and then a freshly obtained sample was placed on each of the containers and the weight measured. The containers with the sample were then placed in the oven for 24 hours to dry the soil sample. Then the resulting weight for each of them was measured and recorded.

To calculate moisture content, the weight of the sample placed on the container before oven drying was subtracted from the weight of the container to obtain the weight of the wet soil sample. Then the result of this was then divided by the weight of the dry soil sample.

Moisture content

$$= \frac{\text{weight of the sample placed on the container before oven drying} - \text{weight of the container}}{\text{weight of the sample placed on the container after oven drying} - \text{weight of the container}}$$

3.3.3 Atterberg Limits

The fundamental gauge of a fine-grained soils is the Atterberg limits. Depending on the amount of water in the soil, it can exist in one of four states: solid, semi-solid, plastic, or liquid. A soils engineering properties vary as it changes from state to state. This is

due to the soil's consistency. Therefore, the boundary between each condition can be identified by a change in the soil's behavior. In addition to differentiating between clay and silt, the Atterberg limits can be used to discriminate between different silts and clay kinds. These are the liquid limit, shrinkage limit and plastic limit. These tests will be carried out on the neat soil and on the stabilized soil to be able to show the change in the values obtained.

3.3.3.1 Liquid limit

This was carried out with reference to **BS1377: Part 2: 1990** where 200g of air-dried soil sample was passed through a 425- μ m sieve and obtained for testing using cone penetration test. Water was added to the sample to obtain the reading for the dry side. The procedure repeated with varying amounts of water added for the wet side too. The relationship between the penetration of the cone and the corresponding moisture contents obtained was plotted. The liquid limit of the soil was determined to be the water content that corresponds to 20mm reading on the graph.

3.3.3.2 Plastic limit

This was carried out with reference to **BS1377: Part 2: 1990**. The plastic limit is the water concentration at which soil begins to behave plastically. The proportion of the material that could pass through a sieve with a 425 μ m aperture, which was initially used to calculate the liquid limit, was also used to calculate the plastic limit. Hands were used to mold a sample as water is added to it. The sample was rolled until it attains a 3mm thickness and began to crack. The weight of the rolled samples placed on a mold was recorded and the sample was then oven dried for 24 hours. The final weight after

oven drying was also noted and the water added was calculated and recorded as the plastic limit.

3.3.3.3 *Plasticity index*

The difference between the liquid limit and the plastic limit was calculated as the plasticity index.

Plasticity index = liquid limit – plastic limit

3.3.4 Proctor compaction test

This was carried out with reference to **BS1377: Part 4: 1990** where a proctor mold was used. The sample was placed into the mold in five layers with each of the layers receiving 27 blows from a 4.5 kg rammer. Having completed the test, the sample was removed and oven dried for a period of 24 hours. The weight of the dry sample was recorded and the dry density was calculated for the corresponding moisture content. This was repeated several times and a graph is plotted of dry unit weight and water content. From the curve attained, the optimum moisture content was determined which gives a maximum dry density.

3.3.5 California bearing ratio

This is carried out with reference to **BS1377: Part 4: 1990** and must comply with AASTHO, which requires that the sample is disturbed and using the optimum moisture content from the proctor test a sample was prepared in a mold and compacted. The sample was then soaked in water for four days after which its surface was dried and prepared for penetration. The CBR machines obtained the penetration levels and therefore, the CBR value of the soil determined. The swell was also attained after the

four days of soaking. This test was carried out on the neat soil and on the stabilized soil it will be carried out in order to show the change in the values obtained.

3.6 Chemical tests

3.6.1 X-ray fluorescence test

This was carried out with reference to **ASTM D5381-93 (2021)** to be able to obtain the chemical composition of the saw dust ash. This was first initially burnt under controlled conditions of about 320 to 350 degrees. The saw dust that is burnt but not under controlled conditions forms ash with low silica content in it. It was ensured that dust was formed therefore increasing the surface area for chemical reaction between the saw dust ash and the neat soil. About 15g of uniformly fine saw dust ash were weighed and placed in a plastic cup with a support film made of plastic to ensure that the surface for analysis is flat and is correctly placed in line of view with the x-ray. They were then finely crush to ensure that voids are thoroughly removed and the particles are homogeneous. Then the chemical composition obtained and recorded. The composition and properties of the ash obtained largely depend on whether or not the saw dust was fully burnt to form ash.

3.7 Strength tests

3.7.1 Unconfined Compressive Strength

The Unconfined Compression Test is a strength test carried out in the lab. It shows the maximum axial force that a soil sample can withstand under zero confinement.

When carrying out the UCS test, plates on which the sample is to be tested are cleaned and then subjected to a continuous load at 0.5 MPa/s until 1.0 MPa/s until

the sample was seen to fail. The values of the normal force and resultant shear stress were noted and recorded.

3.7.2 Direct shear box test (BS 1377-7 1990)

Objective

The direct shear test shows the relationship between the shear stress and the normal stress that is applied that would cause the soil to fail. Its main objective is to determine the cohesion and angle of friction of the soil.

Main Principles

A square prism of soil was restrained laterally and a force was applied along the horizontal plane and a pressure at the top normal to the prism. The horizontal force caused the sample to shear along the horizontal plane and the resistance recorded in intervals. When the maximum resistance of the shear was attained, then the sample was seen to fail.

Three tests are carried out on the soil sample subjected to a normal pressure and the shear stress at which the soil fails was attained. From the results obtained, a graph of shear stress against normal stress was plotted and the cohesion obtained as the point where the line of best fit meets the y-axis. The angle of friction was also attained.

The relationship between the angle of friction θ and the cohesion of the soil directly proportional.

$$\tau = C + \sigma \tan \theta$$

Where C is the cohesion

θ is the angle of friction.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

Objective one: To determine the engineering properties of the neat soil.

4.1 Introduction

This chapter examines and discusses the findings from the various tests and investigations carried out in a laboratory setting for both stabilized and non-stabilized soil samples. The tests include the Atterberg tests and sieve analysis for soil classification; proctor compaction and California bearing ratio tests (CBR) for strength; and the Unconfined Compressive Strength test (UCS) for durability.

The results were compared to the standard values specified by AASHTO and the Ministry of Works' 2005 General Specifications for Roads and Bridges.

4.2 Classification of un- stabilized soils

4.2.1 Physical property of the soil sample.

The soils were analyzed at the Stirling Laboratory in Malaba, Mukono, after being collected from Kisamba Road in Busunju. The soil was greyish in color and several tests were carried out on it and these include; particle sieve distribution, Atterberg tests, compaction tests and CBR test. The characteristics of the neat soils in the analysis are displayed in the table below.

Table 1: Summary of test results in accordance with BS1377: Part 2 :1990 and BS1377: Part 4 1990

LL %	PL %	PI %	LS %	Soil class	GM	Compaction	CBR %	CBR Swell

50.6	20.2	30.5	15	A-7-6	0.678	MDD	OMC	6	1
						1.807	14.4		

4.2.2 Engineering properties of neat soils.

4.2.2.1 Particle size distribution

Table 2: Summary of PSD results for neat soil

Sieve sizes	63	37.7	20	5	2	0.425	0.075
Percentage passing (%)	100	100	100	99	99	92	57

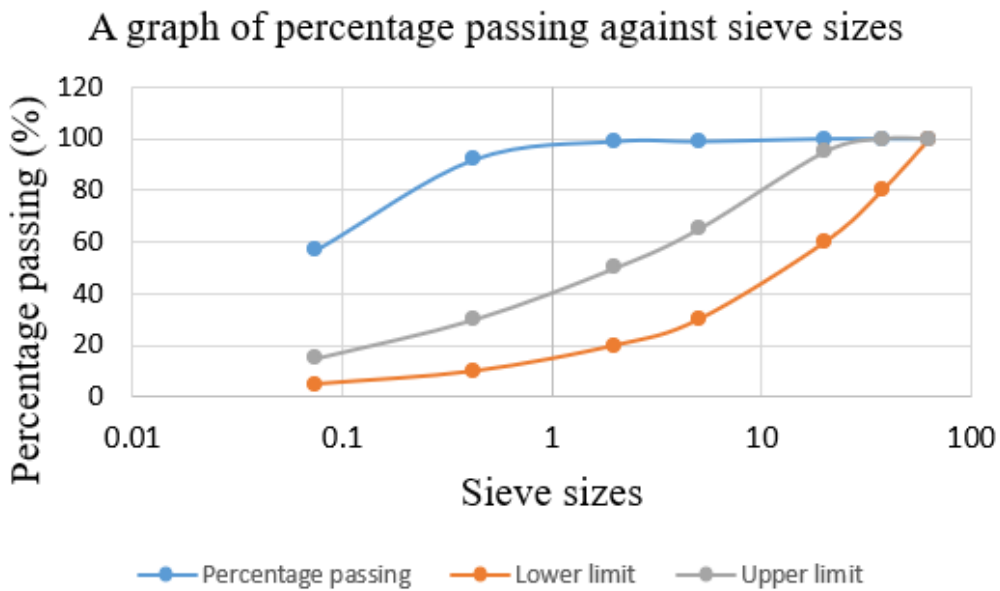


Figure 3: Shows PSD of the soil

According to USCS soil composition analysis, the sample had 43% coarse grained particles, and 57% fines (with 57% passing through a 0.075 mm screen). The gradation

is primarily composed of silt and clays, as indicated by the significantly high percentages which can be justified from its location where it was obtained in a swampy area. The numerous fine particles in the soil are a reason to the swell and shrinkage properties of the soil since fine grained soils tend to be more sensitive to water content, hence referred to as cohesive soils. Also, the distribution of these particles in the soil indicates a lot about the strength properties of the soil.

From the graph, it can be observed that majority of the particles of the expansive soils are small in size since their distribution range is mainly between 0.075mm and 1mm sieve sizes and this is why there is a gradual increase in the curve initially before it becomes constant. Hence comprises of mainly silt, clay and some small sand and since most of the grains are almost the same size, then the soil is poorly graded as the one shown in figure 2 below.

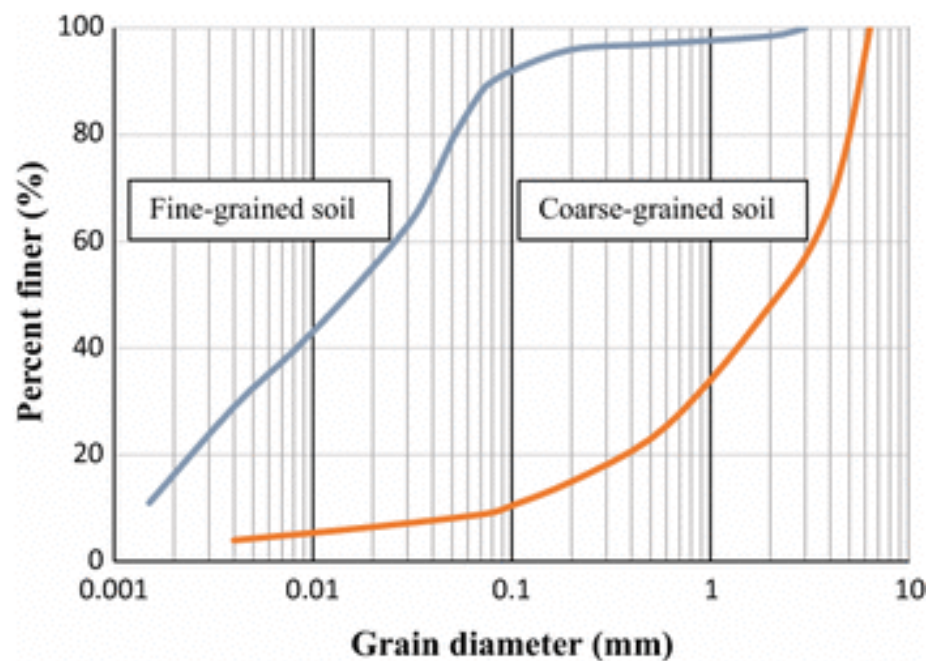


Figure 4: Shows curves for well graded soils

However, for a soil sample to be well graded it should consist of particles distributed over a wide range hence consists of both coarse-grained particles as well as the fine-grained particles to fill in the voids that would be caused by the larger particles hence resulting into a material of high density, and increased strength, therefore good engineering properties.

Also, based on the collected results, the soil's grading modulus was determined to be 0.678. The soil's grading modulus shows whether the uniform distribution of particle sizes or a wider range of particles fall into the gravel range. However, the Ministry of Works states that a subgrade material must have a minimum of 1 and a subbase material must have a minimum of 1.5.

4.2.2.2 Atterberg limits

A graph of cone penetration against moisture content

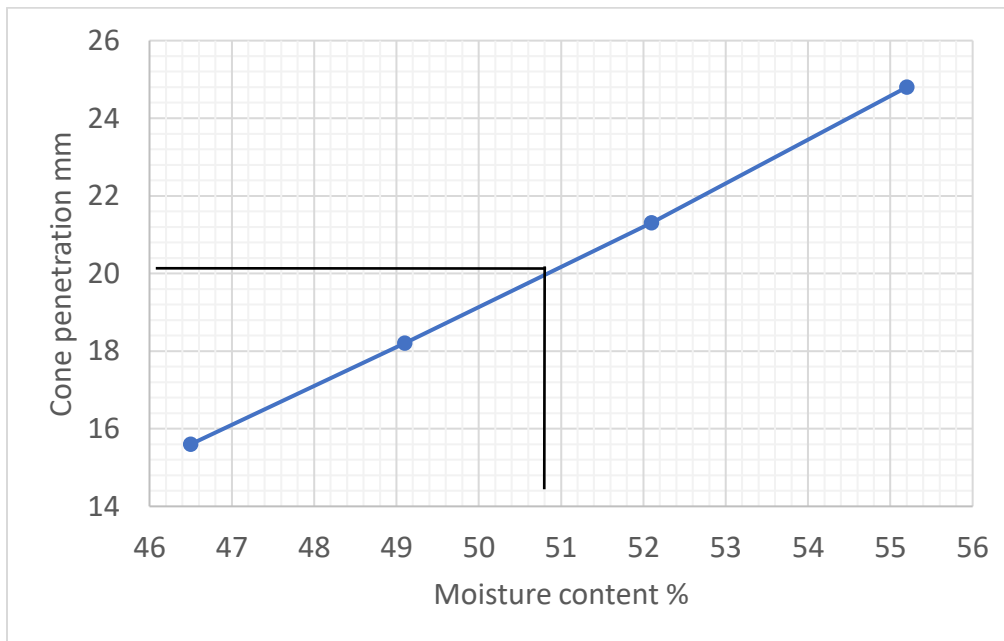


Figure 5: Shows a graph of cone penetration against moisture content

The liquid limit of the neat soil was found using the cone penetrometer test. The liquid limit was obtained at 20 mm penetration of the sample in the cone as shown in figure 2 and found to be 50.6%. The plasticity index which was the difference between the liquid limit and the plastic limit, was determined to be 30.5%. The plasticity chart showed that the soil had a high plasticity. This indicates a highly plastic clay with significant potential for shrinkage and swelling. This analysis reveals that the soil exhibits a notably high degree of plasticity. Given the plasticity index of 30.5%, it is evident that the soil's potential for swelling is extremely high.

Based on the findings from the particle size distribution and the Atterberg tests, the neat soils from the study are classified as poor soils, which fall under the A-7-6 category for both sub-grade and sub-base materials because they have a proportion greater than 35% passing the sieve No. 200, according to the AASHTO soil classification for highways (1967) hence indicating that the sample is dominated by fines group of silt clay materials. Subgroup A-7-6 includes those materials with high plasticity indexes and relation to liquid limit, those which are subject to extremely high-volume changes. This confirms the soil's poor drainage and low bearing capacity.

AASHTO soil classification chart

Table 1—Classification of Soils and Soil-Aggregate Mixtures

General Classification Group Classification	Granular Materials (35 Percent or Less Passing 75 µm)			Silt-Clay Materials (More Than 35 Percent Passing 75 µm)			
	A-1	A-3 ^a	A-2	A-4	A-5	A-6	A-7
Sieve analysis, percent passing:							
2.00 mm (No. 10)	—	—	—	—	—	—	—
0.425 mm (No. 40)	50 max	51 min	—	—	—	—	—
75 µm (No. 200)	25 max	10 max	35 max	36 min	36 min	36 min	36 min
Characteristics of fraction passing 0.425 mm (No. 40):							
Liquid limit	—	—	—	40 max	41 min	40 max	41 min
Plasticity index	6 max	Nonplastic (NP)	^b	10 max	10 max	11 min	11 min
General rating as subgrade	Excellent to Good			Fair to Poor			

^a The placing of A-3 before A-2 is necessary in the "left to right elimination process" and does not indicate superiority of A-3 over A-2.

^b See Table 2 for values.

Table 2—Classification of Soils and Soil-Aggregate Mixtures

General Classification Group Classification	Granular Materials (35 Percent or Less Passing 75 µm)							Silt-Clay Materials (More Than 35 Percent Passing 75 µm)			
	A-1		A-3	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5, A-7-6
Sieve analysis, percent passing:											
2.00 mm (No. 10)	50 max	—	—	—	—	—	—	—	—	—	—
0.425 mm (No. 40)	30 max	50 max	51 min	—	—	—	—	—	—	—	—
75 µm (No. 200)	15 max	25 max	10 max	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min
Characteristics of fraction passing 0.425 mm (No. 40):											
Liquid limit	—	—	—	40 max	41 min	40 max	41 min	40 max	41 min	40 max	41 min
Plasticity index	6 max	—	NP	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11 min ^a
Usual types of significant constituent materials	Stone fragments, gravel and sand		Fine sand	Silty or clayey gravel and sand				Silty soils		Clayey soils	
General rating as subgrade	Excellent to Good							Fair to Poor			

^a Plasticity index of A-7-5 subgroup is equal to or less than $LL - 30$. Plasticity index of A-7-6 subgroup is greater than $LL - 30$. (See Figure 2.)

Figure 6: Shows a graph of cone penetration against moisture content

Having classified the soil using USCS with more than 50% passing sieve No. 200, the soil sample is classed as CH soils which are inorganic clays with high plasticity of 30.5% and since it is above the A line on the soil classification chart as shown below. Plotting the full Casagrande plasticity chart revealed that every soil located between the A and U lines falls under the clay boundaries. CH soils present challenges for engineering projects.

USCS soil classification system chart

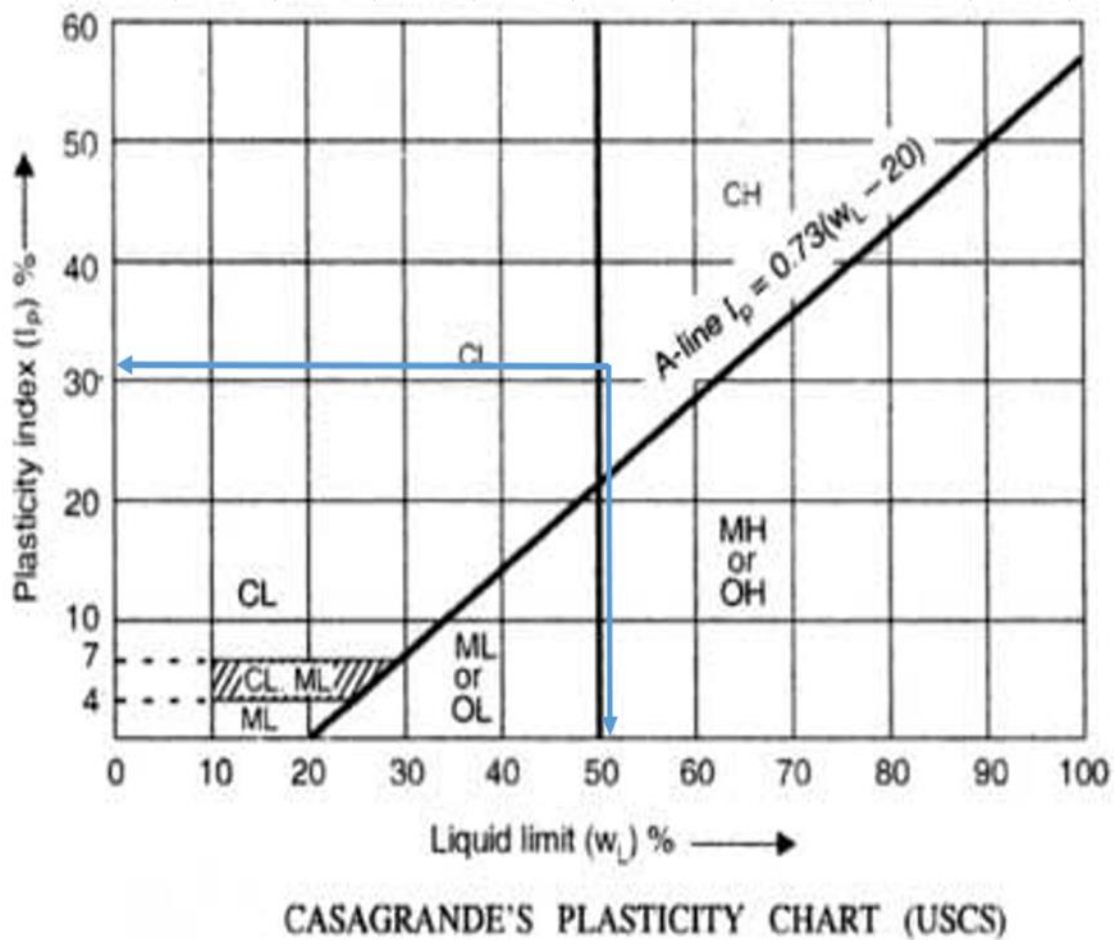


Figure 7: Shows USCS soil classification chart

Since the liquid limit of the neat soil was 50.6% this indicates that the soil sample is weak. It also exceeds the requirement liquid limit which is 41% and can therefore not be used as a sub-grade material unless it is stabilized. The plasticity index was 30.5% it is above the required which is supposed to be <41% and <25% respectively to meet the standards. This shows the soils contained a lot of the clay and are highly plastic therefore, not suitable for use as a subgrade material. Madedor (1983) recommended that linear shrinkage should be less or equal to 10% for subgrade soils however, for the

analyzed sample, the linear shrinkage was found to be 15. The soil is therefore not suitable to be used as a subgrade material.

When a material is clayey, there is need to determine the group index, GI before stabilization of the soil for use as a subgrade material. Therefore, to obtain the GI the following equation was used; Where F is the percentage fines that pass sieve No. 200

$$GI = (F - 35)[0.2 + 0.005(LL - 40)] + 0.01(F - 15)(PI - 10)$$

$$GI = (57 - 35)[0.2 + 0.005(50.6 - 40)] + 0.01(57 - 15)(30.5 - 10)$$

$$GI = 9$$

However, according to the standards, the group index of the soil standards indicates the soil type as the follows to be used as a subgrade material.

Table 3: Standard ranges for GI values

Type of subgrade soil	Group index
Good	0-1
Fair	2-4
Poor	5-9
Very poor	10-20

Since the $GI = 9$ therefore the soil is a poor and therefore needs to be stabilized to improve it.

Linear Shrinkage of 15.0%: This further confirms the high plasticity, exceeding the typical limit of 8% for acceptable construction soils. A Linear Shrinkage of 15.0% lies within the marginal chance for cracking due to swelling and shrinking.

The material therefore does not meet the requirements for construction of a subgrade layer on the road according to the Ministry of Works, Housing and Communication, General Specifications for National Roads of 2004 in reference to Atterberg limits.

4.2.2.3 Compaction test

This test was performed to obtain the optimum moisture content and the maximum dry density of the soil. The Maximum dry density was determined to be 1.807 g/cm³ while the optimum moisture content was 14.4%. This implies that since the value of the MDD is small, more water is still present in the soil sample which contributes to swelling and settlement of the natural soil as shown the figure below.

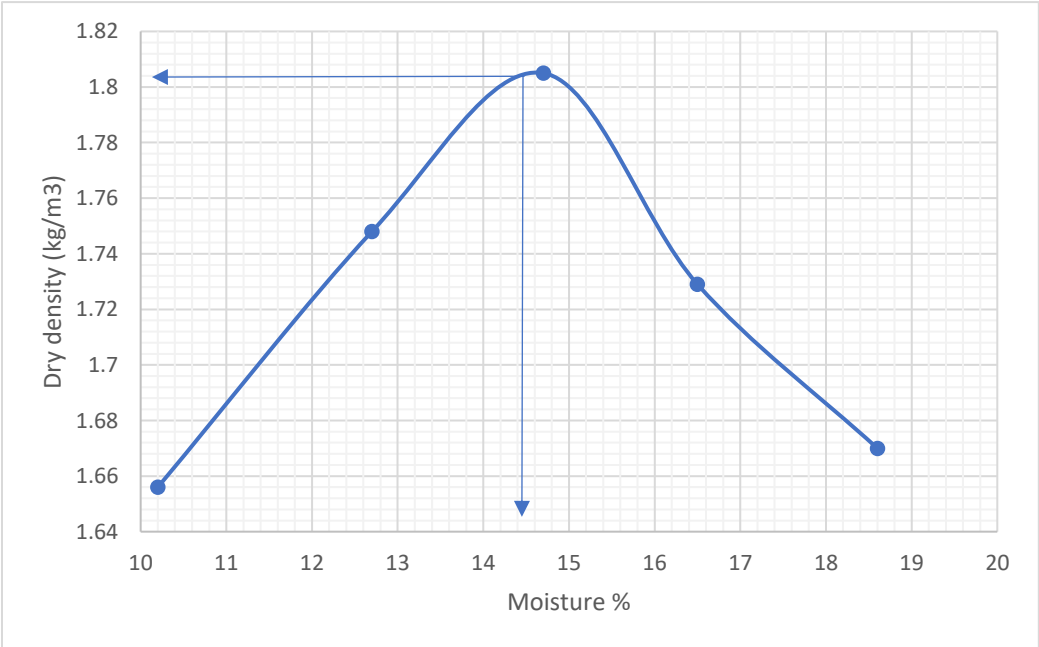


Figure 8: Shows a graph of dry density against moisture content

OMC is the moisture content at which the soil can be compacted to achieve the maximum dry density which is the maximum mass of the soil that can be compacted to a unit volume of soil.

4.2.2.4 California Bearing Ratio (CBR)

This test was carried out in accordance with the BS 1377: Part 4: 1990. Its main objective was to determine the strength of the subgrade materials to be used in the road pavement. The sample was first soak for four days before the test was carried out. The CBR value of the neat sample was found to be 6%. However, based on Asphalt Institute (1962), the soil is very poor when the CBR is 0-3, poor to fair when the CBR is 3-7, fair when the CBR is 7-20 and good when the CBR of the soil is 20-50. The soil sample analyzed indicated the soil is poor to fair basing on the CBR value since it has a low CBR value and yet the higher the CBR value the stronger the soil. This CBR value indicates that the soil has a low bearing capacity and is therefore, incapable of bearing heavy traffic loads.

Also based on the MoWT (2005), the minimum standard required CBR value after the 4 days is expected to be above 15 for a suitable subgrade material, however, the sample under analysis was found to have a CBR value of 6. It therefore, cannot sustain traffic on the road.

From the analysis carried out, there is need for stabilization of the soil to improve its engineering properties.

4.3 Engineering properties of river sand and sawdust ash

4.3.1 Chemical composition of saw dust ash

Table 4: SDA chemical composition

Chemical composition	Percentage composition
Silicon dioxide	67.87
Calcium oxide	10.47
Aluminum (III) oxide	8.63
Iron (III) oxide	4.54
Manganese (II) oxide	4.53
Potassium oxide	2.80
Phosphorus pent oxide	0.19
Titanium dioxide	0.07

According to the above table, which shows the chemical composition analysis, SDA is a viable pozzolanic material since it has a significant amount of silica (67.87%), ferric oxide (4.54%), and alumina (8.63%). Materials are categorized as pozzolans when the combined percentage of silica, ferric oxide, and alumina is beyond 70%, according ASTM C 618-15 criteria. The total percentage of these components in the context of this investigation is 81.04%. This description clearly designates SDA as a pozzolanic substance, indicating its possible use in stabilizing soil. There is also no particular value for the amount of calcium oxide that needs to be present in a sample for it to be pozzolanic however following the ASTM standard, for the sample or material to be

called a pozzolan, it should have the following characteristics as seen in the table below.

Table showing types of pozzolans in accordance to ASTM C618

Properties	Class N type pozzolan	Class F type pozzolan	Class C type pozzolan
Min. $\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}$ (%)	70.0	70.0	50.0
Max. Sulfur trioxide (SO_3) (%)	4.0	5.0	5.0
Max. $\text{Na}_2\text{O} + 0.658 \text{K}_2\text{O}$	1.5	1.5	1.5
Max. loss on ignition	10.0	6.0	6.0

Figure 9: Shows requirements for a pozzolanic material

4.3.2 Physical properties

Appearance

Saw dust ash has a white color which indicates that there is low amount of carbon in the ash hence indicates the presence of amorphous silica in the ash. It is therefore pozzolanic in nature.

4.3.3 Specific gravity of saw dust ash

Research by Naik et. al (2017) shows that saw dust ash has a specific gravity that ranges between 2.27 and 2.60. He also noted that the unit weight of the saw dust ash ranges between 162 and 2376 kg/m³.

4.3.4 XRF test for neat soil

Chemical composition of neat soils

Table 5: Neat soils chemical composition

Chemical composition	Percentage composition
Silicon dioxide	41.50
Calcium oxide	19.85
Manganese (II) oxide	15.45
Aluminum (III) oxide	10.9
Iron (III) oxide	8.78
Potassium oxide	1.25
Phosphorus pent oxide	1.05
Titanium dioxide	0.02

The XRF test was also carried out for the neat soils and the results also indicate high amounts of silica, alumina and calcium oxide and therefore the soil contains high amounts of clay in it. The clays in the soil accompanied by the high plasticity index which is 30.5% which is above the required which is supposed to be 25% and the high liquid limit that is 50.6% which is also above the required indicate the expansive nature of the soil. The soil swell also indicates that it has the ability to take in water and retain it for a long time and thereby increasing in volume. Also, according to literature, montmorillonite clay has about 49.40% silica, 19.70% alumina and 1.50% calcium oxide

which were the major components of the soil (Alfard, 2019). The soil was therefore containing clayey soils and is therefore expansive in nature.

4.3.5 The swelling action of the soil

The clay mineral with the ability to swell is montmorillonite clay mineral, which easily takes in water and the swelling effect is brought about when a double layer is formed (Norrish, 2019). This explanation was backed up by (Teich-McGoldrick *et al.*, 2021) who explained the structure of montmorillonite clay. It contains an octahedral structure sandwiched between two tetrahedral structures and they are held together by weak forces of attraction. Therefore, due to this they easily allow in water and this water further separates the weak bond and displaces the sheets and hence causing the increase in size or swell. On losing water, these soils tend to reduce in size and hence shrink. This is what brings about the cracks.

4.3.6 Specific gravity test on river sand

The specific gravity of the a given material shows the ratio f the mass of the sample to its unit volume at a given temperature. The specific gravity was carried out at a temperature of about 20 degrees.

4.4 Variation in strength values with different mixes

4.4.1 Effect of river sand and saw dust ash on the Atterberg limits of the soil

Table 6: Summary of Atterberg limit values

Percentage variations	LL (%)	PI (%)	SL (%)
0% river sand and 12% saw dust ash	26.5	9.1	9.1
15% river sand and 9% saw dust ash	24.8	7.0	7
30% river sand and 6% saw dust ash	24.2	6.4	6.45
45% river sand and 3% saw dust ash	23.3	5.3	5.25
60% river sand and 0% saw dust ash	22.8	Non-Plastic	Non-Plastic

4.4.1.1 Liquid limit

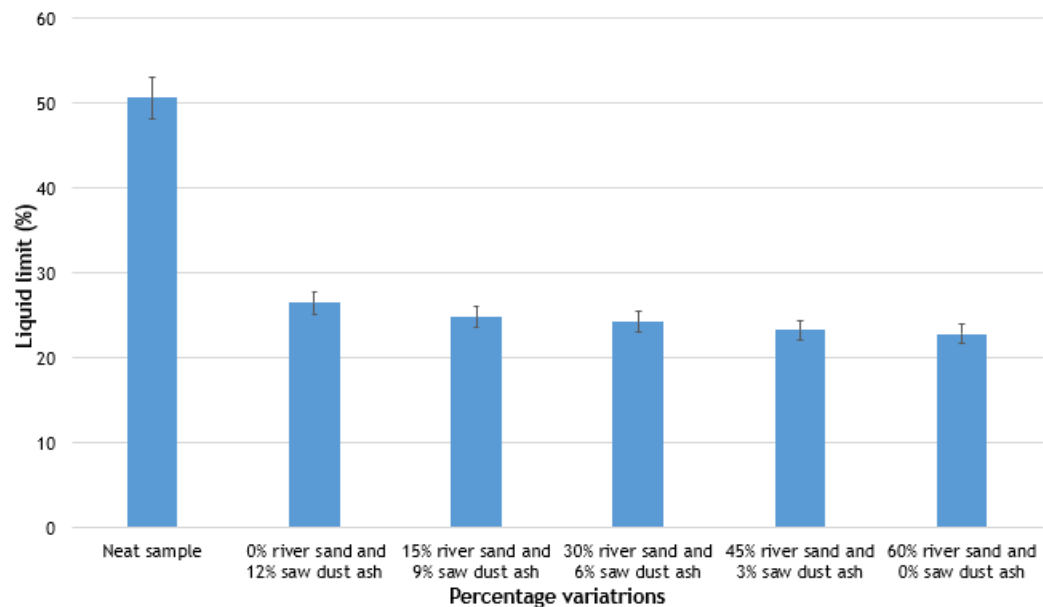


Figure 10: Shows a graph of liquid limit against percentage variations

The above table indicated the results of the Atterberg limit values when different percentages of saw dust ash and river sand are added to the neat sample. There is a notable decrease in liquid limit value from 50.6% to 22.8%. This is attributed to the decrease in the affinity for water when the soil sample contains more river sand which is non plastic in nature and less saw dust ash is added to the soil and therefore reduces the liquid limit of the soil and its plasticity. Due to this reduction in the liquid limit value, this leads to a reduction in the swelling characteristics of the soil.

4.4.1.2 Plasticity index

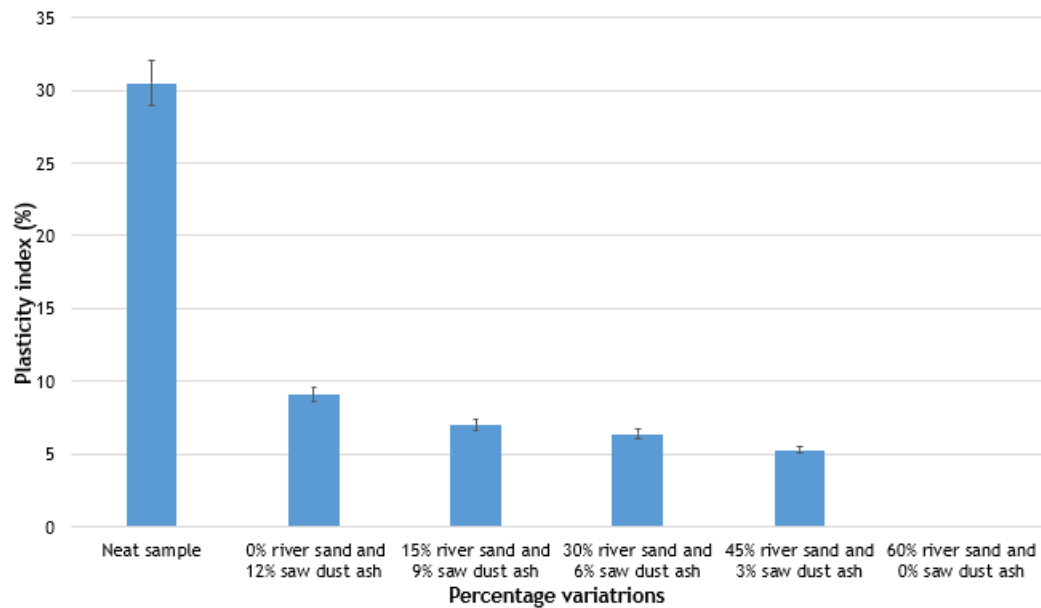


Figure 11: Shows a graph of plasticity against percentage variations

The PI decreased from 30.5% to 5.3% with increasing percentage of the river sand added to the soil and reduction in saw dust ash is attributed to the non-plastic nature of the sand. As the amount of river sand added in the sample increases, the sample becomes harder to roll into the threads of 3mm diameter as the test is carried and therefore the sample with more amounts of river sand and less saw dust ash, that is 60% river sand and 0% saw dust ash, has the lowest plastic limit value as 5.3%.

4.4.1.3 Linear shrinkage

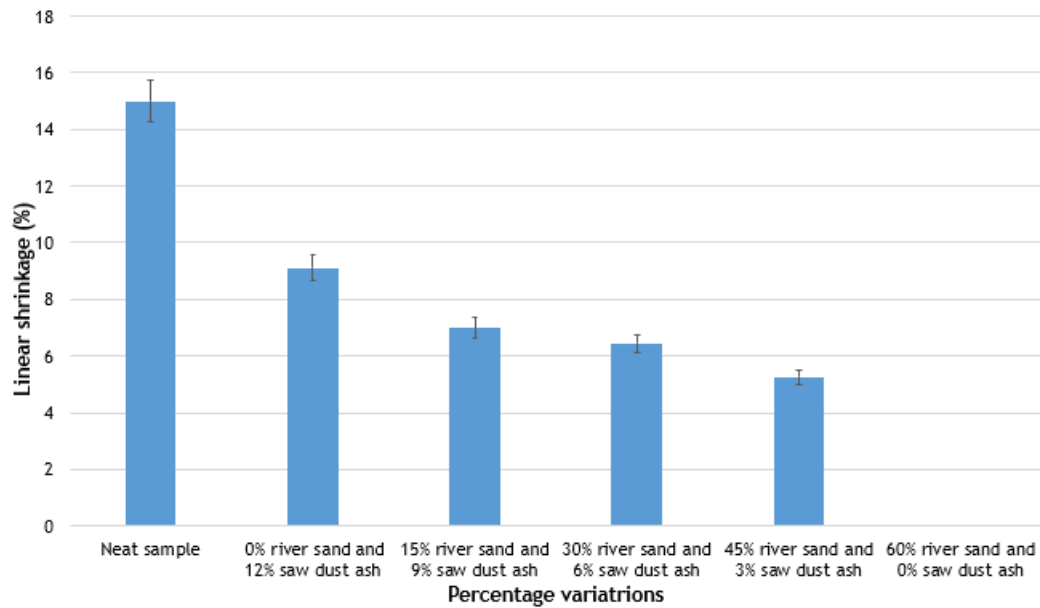


Figure 12: Shows a graph of linear shrinkage against percentage variations

There is a notable decreasing trend in the LS value which increase in the river sand added to the soil which is from 50.6% and on addition of 0% river sand and 12% saw dust ash it reduces significantly until it is non-plastic on addition of 60% river sand and 0% saw dust ash. This is due to the addition of a mechanical stabilizer which is granular in nature. When added to the expansive soil which mainly comprise of the fines, the fines fill the voids and occupy most of the void. Few of these are left, allowing a reduction in the water intake and therefore it is noted that as more sand is added to the soil, there is less shrinkage in the sample since there are less fines which can hold the water.

4.4.2 Effect of river sand and saw dust ash on proctor values of the soil

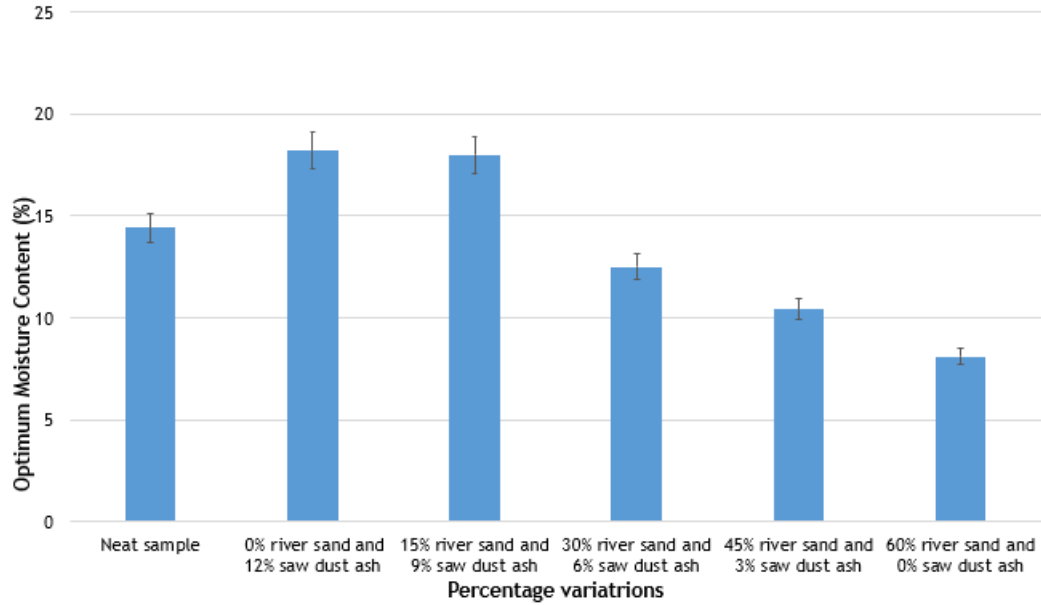


Figure 13: Shows a graph of OMC against percentage variations

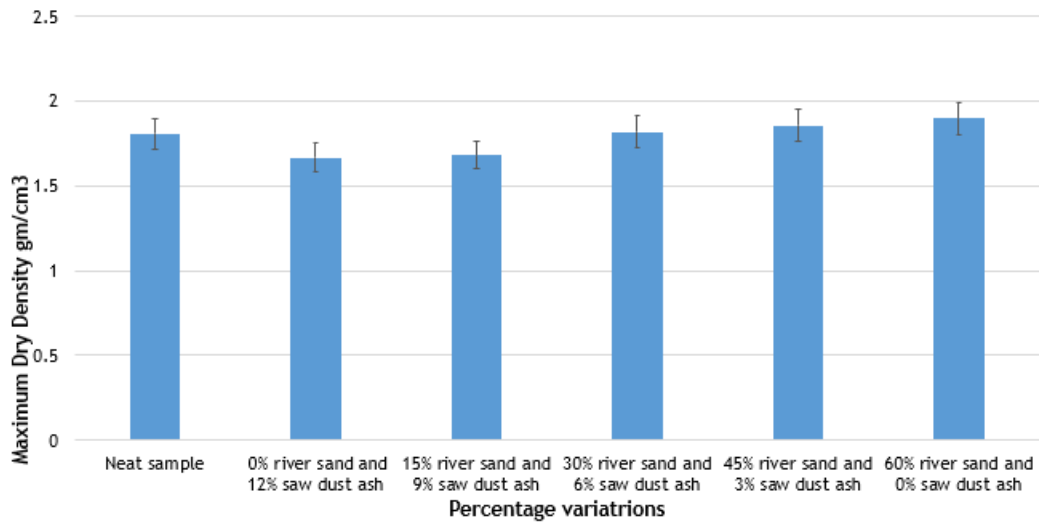


Figure 14: Shows a graph of MDD against percentage variations

From the graph there is a decreasing trend in the OMC but an increasing trend in the MDD for the varying percentages of river sand and saw dust ash added to the soil.

Increasing the river sand used led to an increase in the MDD of the soil from 1.667g/cm³ to 1.898g/cm³ since this increased the coarse fraction of the soil and therefore there was an improved size distribution in the soil which occupies a wider range. The particles of the river sand are angular shaped interlocking with the soil particles which comprise of the fines. These fines fill the voids and hence lead to formation of a densely packed soil sample. Therefore, the more river sand added to the soil, the less the fine particles in the soil hence an increase in the MDD and a reduction in OMC from 18.2% to 8.1% due to the same effect.

4.4.3 Effect of river sand and saw dust ash on CBR values of the soil

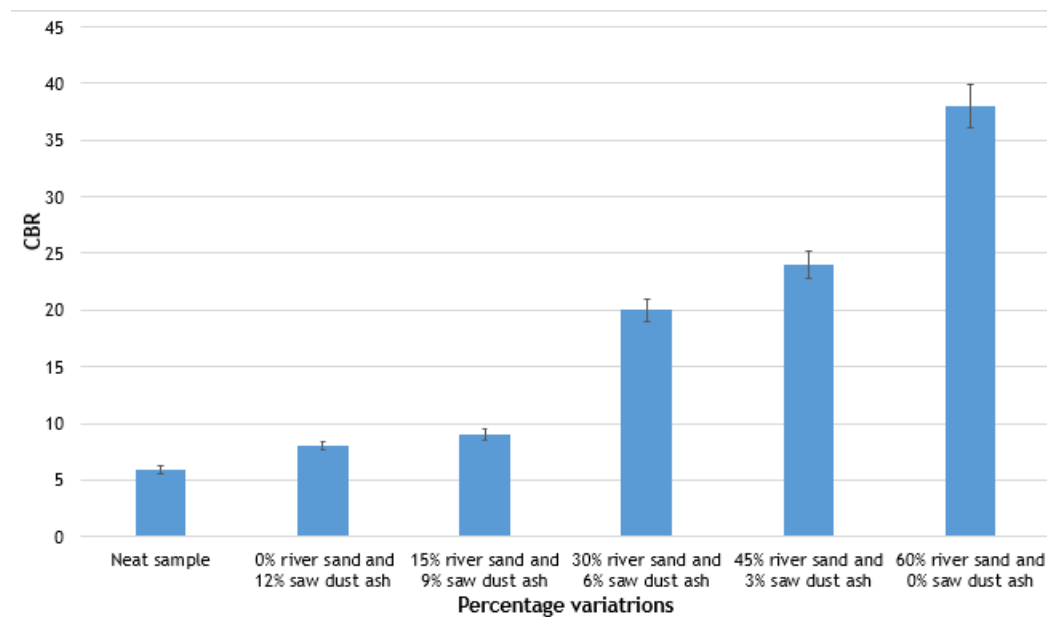


Figure 15: Shows a graph of CBR against percentage variations

From the graphs shown above, the CBR value of the stabilized expansive soil sample with varying percentages of river sand and saw dust ash varied as shown above indicates and increase in the CBR value of the soil from 8% to 38%. CBR is the strength property of the soil. This increase is attributed to the river sand which when added improves the gradation of the soil hence reducing percentage fines and this river sand is bonded to the soil particles strongly by the saw dust ash which is pozzolanic in nature. The amorphous silica and calcium oxide in the saw dust ash give it the pozzolanic properties, whereby the calcium oxide from the saw dust ash reacts in the presence of water with the silicates and aluminates in the soil and saw dust ash to form cementitious materials which is in form of a gel hence binding the particles together. However as seen from the graph above, with addition of 30% river sand and 6% saw dust ash the CBR value is lower because increase in the saw dust ash adds excess fines in the soil and therefore making the soil less strong.

4.4.4 Effect of river sand and saw dust ash on UCS values of the soil

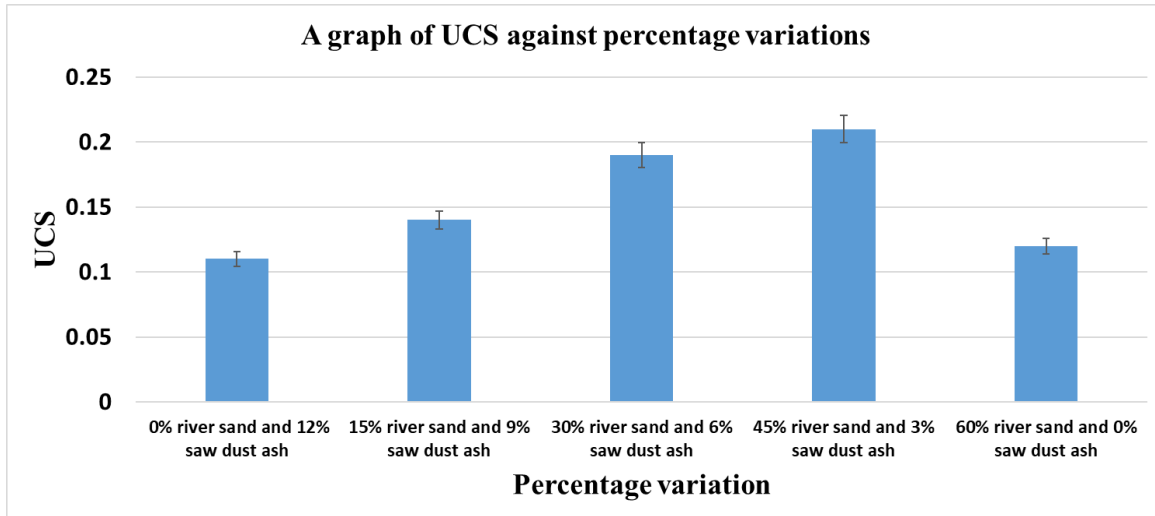


Figure 16: Shows a graph of UCS against percentage variations

The compressive strength of the soil increases with increase in river sand and saw dust ash this is because the addition of the two improves the gradation of the soil. The UCS value is seen to attain the maximum value at 45% river sand and 3% saw dust ash. Here the sample was able to attain an increased compaction the saw dust ash played a very important role in this case in that it helped in proper bonding of the particles together. At 60% river sand and 0% saw dust ash, the UCS value was seen to decrease and this is because the particles of the soil could not remain effectively bonded together. Therefore, causing the decrease in the shear strength.

4.5 DESIGN MATRIX

Table 7: Mix design for stabilized sample

100	0	0	50.6	20.1	30.5	15	1.807	14.4	6	1	-
88	0	12	26.5	17.4	9.1	5	1.667	18.2	8	0.65	0.11
76	15	9	24.8	17.7	7.0	3.6	1.682	18	9	0.6	0.14
64	30	6	24.2	17.8	6.45	3.2	1.819	12.5	20	0.33	0.19
52	45	3	23.3	18	5.3	2.7	1.857	10.4	24	0.46	0.21
40	60	0	23.0	NON-PLASTIC		1.4	1.898	8.1	38	0.16	0.12

4.6 Optimum mix of river sand and saw dust ash added to the soil.

The optimum mix attained was 45% river sand and 3% saw dust ash which gave the best engineering properties of the soil. The river sand added to the soil, improved on the gradation of the soil since it has angular shaped particles that interlock with the weak soils. The saw dust ash acts as a chemical stabilizer to improve on the bonding of the soil.

Table 8: Obtained values and standard values

Soil properties	Value obtained	Standard
Liquid limit	23.3	<41
Plastic index	18	<25
Shrinkage limit	1.4	<8%
CBR	24%	<15%

From the results obtained, the swelling potential of the soil reduced which means the soil swells less, also the Atterberg limits reduces and they therefore do not take in a lot of water. Therefore, the stabilized soil with 45% river sand and 3% saw dust ash is an optimum mix design to use since it gives the values that fit within the standard to be used as a G15 subgrade material.

4.6.1 Particle size distribution of the optimum soil sample attained.

For 45% river sand and 3% saw dust ash.

Table 9: PSD for optimum mix design ratio

Sieve size	63	37.5	20	5	2	0.425	0.075
Percentage passing	100	100	100	98.8	96.8	76.3	26.4

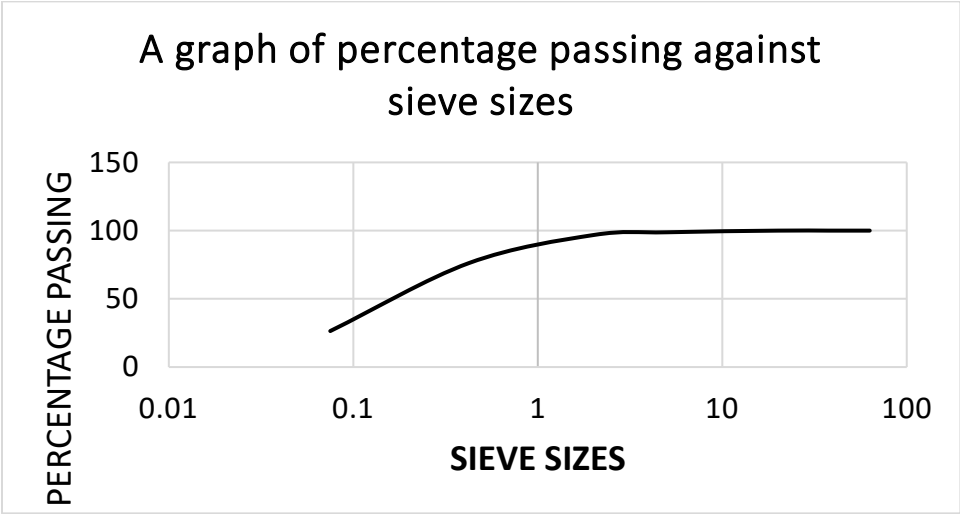


Figure 17: Shows a graph of percentage passing against sieve sizes

Having analyzed these results, the sample comprises of 26.4% fines and 73.6% coarse grained particles, hence resulting in a coarse-grained soil as evidenced by more particles in the coarse fraction being present in the soil sample. The numerous coarse particles in the soil are a reason for the reduction in the swell properties of the stabilized soil sample since the samples are no longer sensitive to water and are more cohesionless. Also, the distribution of these particles in the soil indicates a lot about the strength properties of the soil.

From the graph, it can be observed that the particles occupy a wide distribution range, between 0.075mm and 10mm and hence the soil is well graded.

Grading modulus

Also, based on the collected results, the soil's grading modulus was determined to be 1.006. The grading modulus shows whether the particles are uniformly distributed or not. With the addition of saw dust ash and river sand as stabilizers, the GM is seen to increase from 0.678 to 1.006 and this is because with the addition of more granular particles, there is an increase in the percentage retained on the last sieves that is 2mm, 0.425mm and 0.075mm sieve sizes. A high GM indicates presence of more particles in the coarse fraction. Also, the GM meets the requirements as per Ministry of Works and Transport General Specifications which require that a subgrade material must have a minimum of 1.

4.6.2 Atterberg limit results.

The liquid limit of the soil sample that was stabilized with 45% river sand and 3% saw dust ash was obtained as 23.3 after carrying out the cone penetration test. The plastic limit was obtained as 17.8% which gives a plasticity index of 5.5%.

Classifying the soil using AASHTO

Based on the findings from the particle size distribution and the Atterberg tests, the stabilized soils from the study are classified as a coarse-grained soil according to the AASHTO soil classification for highways (1967) since it contains less than 35% passing the 0.075mm sieve and therefore it comprising of mainly large particles. The stabilized soil sample is an excellent to good clayey gravel and sand which falls under the category of A-2-6. It can therefore be used as a good subgrade material. Subgroup A-2-6 includes those materials with low plasticity indexes and are do not undergo high volume changes hence have a high bearing capacity.

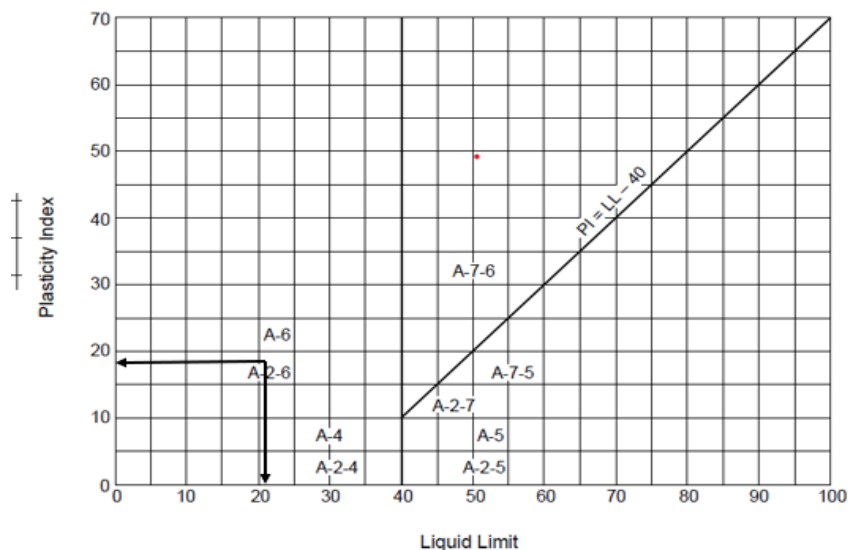


Figure 18: Shows the AASHTO classification chart value

Classifying the soil using USCS

Having classified the soil using USCS with less than 50% passing sieve No. 200, the soil sample is classed as CL soils which are inorganic clays with low plasticity of 5.5%

USCS soil classification system chart

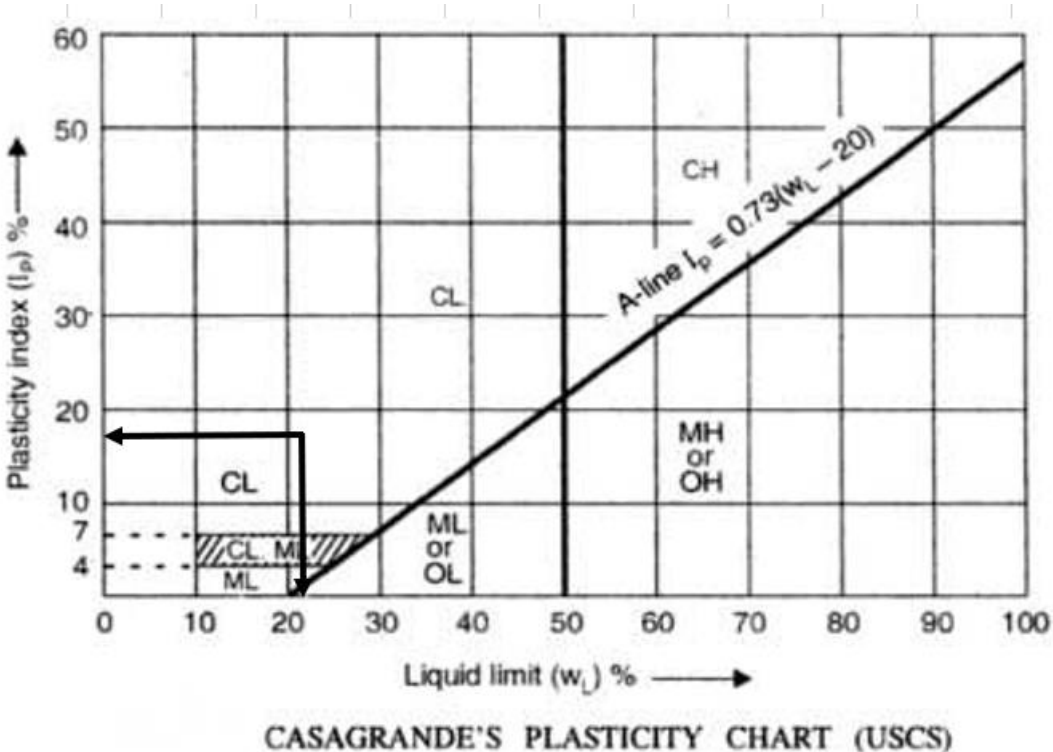


Figure 19: Shows the UCS soil classification chart value

For clayey materials, determination of GI is important to identify the change or the improvement that has occurred after the stabilization of the soil sample. From the equation below, the GI was obtained where F is the percentage fines that pass sieve No. 200

$$GI = (F - 35)[0.2 + 0.005(LL - 40)] + 0.01(F - 15)(PI - 10)$$

$$GI = (23.7 - 35)[0.2 + 0.005(23.3 - 40)] + 0.01(23.7 - 15)(5.2 - 10)$$

$$GI = 3$$

However, according to the standards, the group index of the soil standards indicates the soil type as the follows to be used as a subgrade material.

Table 10: GI categories

Type of subgrade soil	Group index
Good	0-1
Fair	2-4
Poor	5-9
Very poor	10-20

Since the $GI = 3$ therefore the soil is fair and can therefore be used as a subgrade material since it meets the requirements for construction of a subgrade layer on the road according to the Ministry of Works, Housing and Communication, General Specifications for National Roads of 2004.

Expansive soils that have been stabilized with 45% river sand and 3% saw dust ash with a CBR value of 24% qualify to be G15 materials which can be used as subgrade materials in road construction.

Therefore, according to General Specifications of Roads and Bridges by MoWT, clause 38, G 15 material can be used as an improved subgrade material of the road with the upper layers stronger to ensure that they protect the lower road pavement layers.

4.6 3 Shear box test

This test was carried out on the optimum mix which was 45% river sand and 3% saw dust ash and it was done in triplicates. For the normal stresses applied which were 50, 100, 200 kPa the shear values were obtained as 38, 78 and 150 kPa respectively. A graph of the shear strengths against the normal stresses was then plotted and the cohesion of the soil was attained as 2kPa and the angle of friction as 36.6 degrees. This is because the percentage of the coarse fraction was increased and therefore this plays an important role in resisting the force that can cause particles to slide over one another when a force is applied in the horizontal direction.

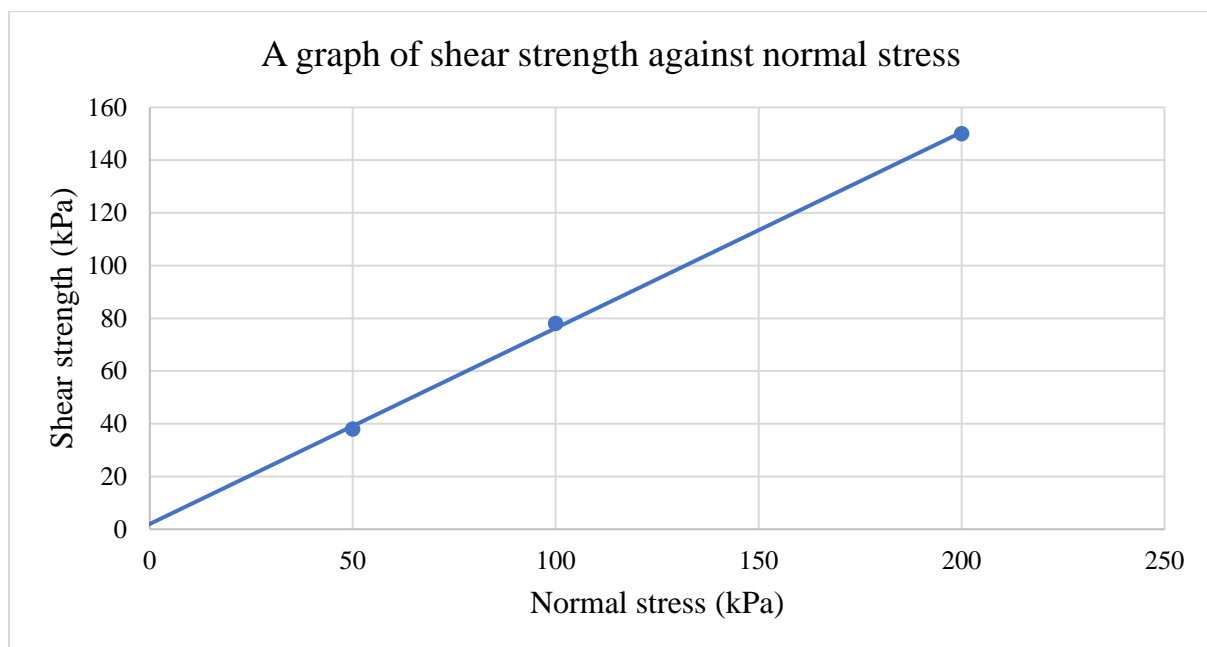


Figure 20: Shows a graph of shear strength against normal stress

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The neat soil did not meet the requirements for G15 subgrade material according to the ministry of works general specifications for road and bridge works 2005 and therefore they needed to be stabilized so this purpose.

The composition of the saw dust ash which was 67.86% silicon dioxide, 10.47% calcium oxide, 8.63% aluminium oxide, 4.54% iron (III) oxide and other trace elements was such that the sum of the percentage of silicon dioxide, Aluminum dioxide and iron (III) oxide was 81.04% which was greater than 50% which implies that this sample of saw dust ash was a class C agro-pozzolan according to the ASTM standard. The river sand also met the standards to be used as a stabilizer since it's grading curve was within the grading envelope and therefore was a suitable stabilizer.

The optimum percentages for stabilization of weak subgrade soils using river sand and saw dust ash were found to be 45% river sand and 3% saw dust ash and 52% soil in order to achieve the properties fit for a soil of material class G15. The CBR value was obtained as 24% conforming to the standards.

5.2 Recommendations

Stabilization of the soil with 45% river sand and 3% saw dust ash gives a UCS value of 0.21 MPA which is still below the standards, therefore further research should be conducted on to ensure optimization of this value to meet the required standards.

In this research conducted, the saw dust ash was used as a mixture of ash from both the soft and hard wood trees, therefore research should be done on the effect of using

only soft or hardwood trees so obtain the effect of each on the engineering properties of the soil.

From the research conducted, since there is an increasing trend in the UCS values of the soil from the mix design used, and at 45% river sand and 3% saw dust ash and all the soil parameters are within the required range except the UCS value, then a range for the amount of river sand and saw dust ash to be added was chosen to be between 45% to 50% river sand and 3% saw dust ash. The UCS value shows the potential to increase to reach the standard which is 0.25 for a G15 subgrade material.

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APPENDIX A



Figure 21: Shows drying sample



Figure 22: Shows moulds soaking



Figure 23: Showing wet sieving



Figure 24: Shows sample being placed in mould




Figure 25: Shows saw dust ash



Figure 26: Shows sample being weighed

APPENDIX B

INSTITUTION		STUDENTS		TESTING LAB														
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32214) & MCARNOLD GARRY (S20B32003)		<div style="border: 1px solid black; padding: 5px; display: inline-block;"> Stirling </div>														
PROJECT: ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS																		
SUMMARY OF TEST RESULTS FOR NEAT MATERIAL AT NEAT SAMPLE																		
LOCATION	BLENDED %	SAMPLING DATE	GRADING					ATTERBERG LIMITS					MDD		CBR		CBR SWELL	AVERAGE
			63	37.5	20	5	2	0.425	0.075	GM	LL	PL	PI	LS	MDD	OMC		
EXPANSIVE SOILS	100	100	100	100	100	99	91	56	50.3	19.9	30.4	15.0	1.807	14.4	5.9	1.00	1.00	
		100	100	100	99	99	92	57	50.8	20.2	30.6	15.0	-	-	-	-	-	
		100	100	100	99.45	99.11	91.58	56.78	0.53	50.6	20.1	30.5	15.0	1.807	14.4	6	1.00	1.00
		12/10/2023																
AVERAGE		100	100	100	99	92	57	0.575	50.6	20.2	30.5	15.0	1.807	14.4	5.9	1.00	1.00	

FOR LAB

FOR STUDENTS

Lab Technician



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UGANDA CHRISTIAN UNIVERSITY
A Centre of Excellence in the Heart of Africa

NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)

Stirling

INSTITUTION

STUDENTS

TESTING LAB

PROJECT:

ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS

SUMMARY OF TEST RESULTS FOR NEAT MATERIAL AT NEAT SAMPLE

LOCATION	BLENDED %	GRADING										ATTERBERG LIMITS					MODD		CBR	CBR SWELL	AVERAGE				
		SAMPLING DATE	63	37.5	20	5	2	0.425	0.075	GM	LL	PL	PI	IS	MDD	OMC									
EXPANSIVE SOILS		100	100	100	100	99	91	56	0.53	50.3	19.9	30.4	15.0	1.807	14.4	5.9	1.00	1.00							
		100	100	100	99	99	92	57	0.52	50.8	20.2	30.6	15.0												
		100	100	100	99.45	99.11	91.58	56.78	0.53	50.6	20.1	30.5	15.0	1.807	14.4				6	1.00	1.00				
NEAT SAMPLE																									
AVERAGE		100	100	100	99	99	92	57	0.525	50.6	20.2	30.5	15.0	1.807	14.4	5.9	1.00	1.00							

FOR LAB


FOR STUDENTS

Lab Technician



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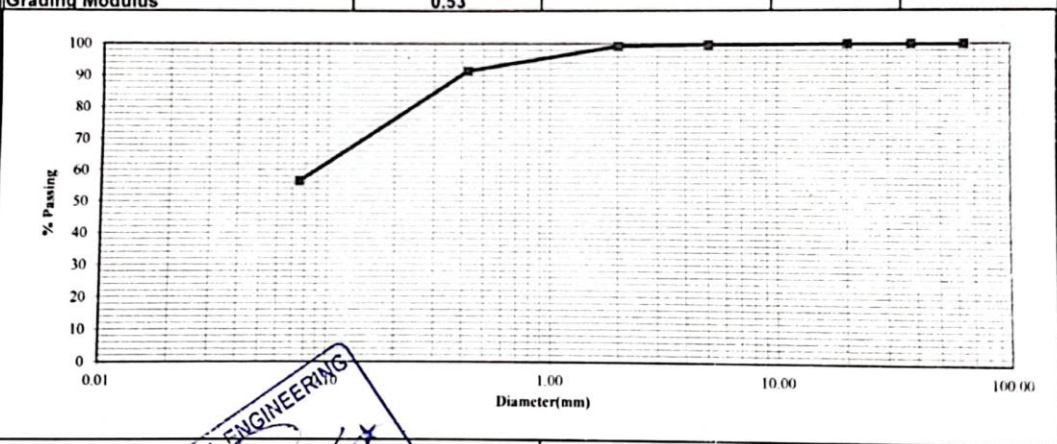
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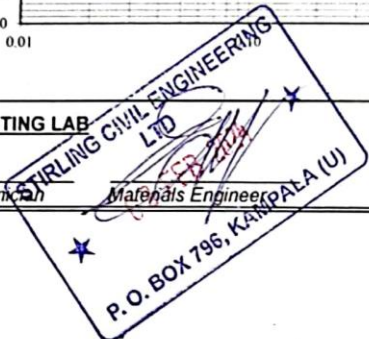


INSTITUTION	STUDENTS NAMES	CONTRACTOR
 UGANDA CHRISTIAN UNIVERSITY <small>A Cause of Excellence in the Heart of Africa</small>	NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)	Stirling


PROJECT : ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS

PARTICLE SIZE DISTRIBUTION (BS 1377 - 2 - 90)

Test Reference No.:			Lab. Reference No.:		
Location : (km)	NEAT SAMPLE		Dry wt. of sample before washing: (g)	5270	
Depth: (m)			Dry wt. of sample after washing: (g)	2322.3	
Material description:	EXPANSIVE SOILS		Date Sampled:	Date Tested:	Technician
			10/Dec/2023	13/Dec/2023	Lab team
Sieve Size (mm)	Weight Retained (g)	Retained (%)	Passing (%)	Grading Limits (G60 & 80)	
63.0	0.0	0	100	100	100
37.5	0.0	0.0	100	80	100
20.0	0.0	0.0	100	60	95
5.0	18.3	0.3	100	30	65
2.00	24.7	0.5	99	20	50
0.425	411.9	7.8	91	10	30
0.075	1839.0	34.9	56	5	15
Total fines	2976.1	56.5			
Bottom Pan	28.4				
Extracted fines	2947.7				
Total sample	5270.0				
Grading Modulus	0.53				



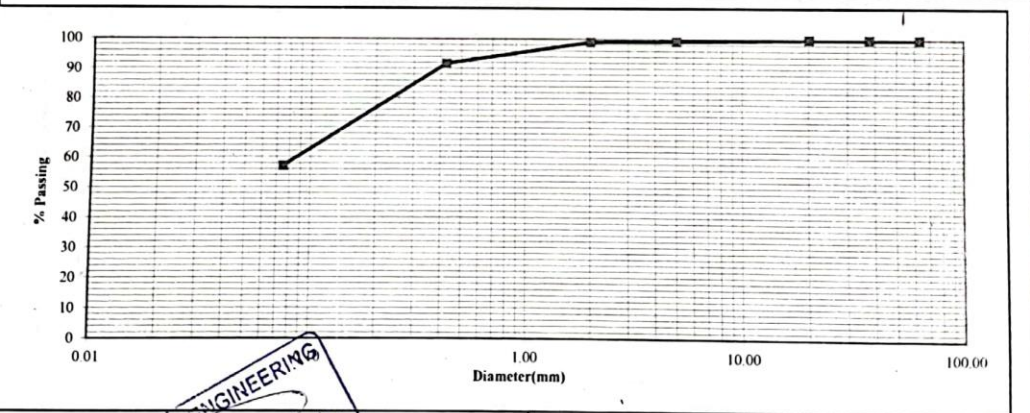
FOR TESTING LAB  Lab Techn (S)	FOR STUDENTS  
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 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>	NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)	Stirling

PROJECT : **ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS**


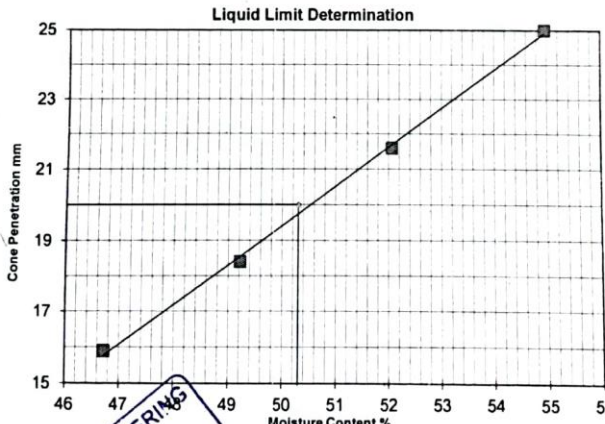


PARTICLE SIZE DISTRIBUTION (BS 1377 - 2 - 90)


Test Reference No.:		Lab. Reference No.:			
Location : (km)	NEAT SAMPLE		Dry wt. of sample before washing: (g)	4583.7	
Depth: (m)			Dry wt. of sample after washing: (g)	1993.7	
Material description:	EXPANSIVE SOILS		Date Sampled:	Date Tested:	Technician
			10/Dec/2023	13/Dec/2023	Lab team
Sieve Size (mm)	Weight Retained (g)	Retained (%)	Passing (%)	Grading Limits (G60 & 80)	
63.0	0.0	0	100	100	100
37.5	0.0	0.0	100	80	100
20.0	0.0	0.0	100	60	95
5.0	34.9	0.8	99	30	65
2.00	9.6	0.2	99	20	50
0.425	331.3	7.2	92	10	30
0.075	1591.1	34.7	57	5	15
Total fines	2616.8	57.1			
Bottom Pan	26.8				
Extracted fines	2590.0				
Total sample	4583.7				
Grading Modulus		0.52			



<p>FOR TESTING LAB</p> <p><i>Stirling Engineering Ltd</i></p> <p>Lab Technician</p>	<p>FOR STUDENTS</p> <p><i>Nambooze Justine Shilla</i></p> <p><i>McArnold Garry</i></p>
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INSTITUTION		STUDENTS		TESTING LAB		
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling		
PROJECT:		ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS				
ATTERBERG LIMITS						
<i>Liquid limit (cone penetrometer) and plastic limit</i>						
Test Reference No.:		Lab. Reference No.:		Technician:	Lab Team	
Location		NEAT SAMPLE		Sample Date	10/Dec/2023	
Test method		BS 1377: Part 2, 1990: 4.3/4.4		Test Date	13/Dec/2023	
LAYER		EXPANSIVE SOILS				
PLASTIC LIMIT		Test No.	Q	TM	Average	
Mass of wet soil + container (g)		37.92	34.79		36.355	
Mass of dry soil + container (g)		35.21	32.73		33.97	
Mass of container (g)		21.69	22.26		21.975	
Mass of moisture (g)		2.71	2.1		2.385	
Mass of dry soil (g)		13.52	10.47		11.995	
Moisture content %		20.0	19.7		19.9	
AVERAGE						
LIQUID LIMIT		Test No.	1	2	3	4
Initial gauge reading (mm)		0	0	0	0	0
Final gauge reading (mm)		15.9	18.4	21.6	25.0	25.0
penetration (mm)		15.9	18.4	21.6	25.0	25.0
AVERAGE		15.9	18.4	21.6	25.0	25.0
Container No		A4	PI46	PP	KO	
Mass of wet soil + container (g)		44.80	45.46	59.68	54.43	
Mass of dry soil + container (g)		32.70	32.84	41.58	37.56	
Mass of container (g)		6.80	7.20	6.81	6.86	
Mass of moisture (g)		12.1	12.62	18.1	16.87	
Mass of dry soil (g)		25.9	25.64	34.77	30.7	
Moisture content (%)		46.7	49.2	52.1	55.0	
AVERAGE		46.7	49.2	52.1	55.0	
		Liquid limit (%)		50.3		
		Plastic limit (%)		19.9		
		Plasticity Index (%)		30.4		
		Linear shrinkage				
		Trough No		Y		
		Trough length (cm)		14.0		
		Specimen length (cm)		11.9		
		L.shrinkage =		2.1		
		% L.shrinkage =		15.0		
Remarks:						
TESTING LAB STIRLING Materials Engineer.		STUDENTS  				
Lab Technician P.O. BOX 33, KAMPALA (U)						

INSTITUTION  UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>	STUDENTS NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)	TESTING LAB Stirling
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PROJECT: ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS

ATTERBERG LIMITS

Liquid limit (cone penetrometer) and plastic limit

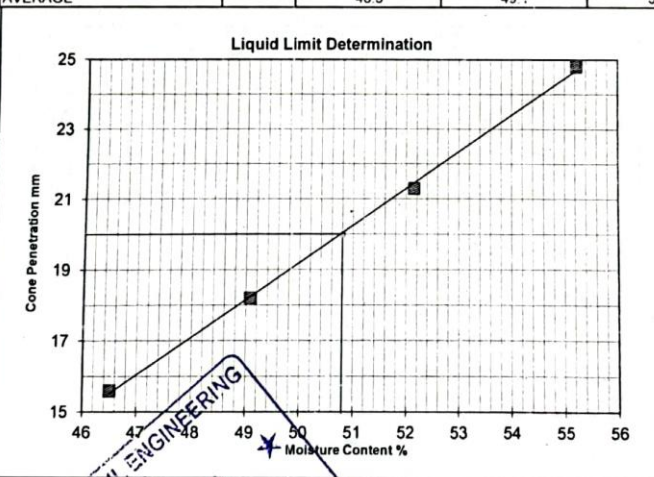
Test Reference No.:	Lab. Reference No.:	Technician:	Lab Team
Location	NEAT SAMPLE		Sample Date
Test method	BS 1377: Part 2, 1990 4.3/4.4	Test Date	13/Dec/2023
LAYER	EXPANSIVE SOILS		

PLASTIC LIMIT	Test No.	LL	13	Average
Mass of wet soil + container (g)		37	36.43	36.715
Mass of dry soil + container (g)		34.47	34.14	34.305
Mass of container (g)		22.35	22.46	22.405
Mass of moisture (g)		2.53	2.3	2.41
Mass of dry soil (g)		12.12	11.68	11.9
Moisture content %		20.9	19.6	20.2

AVERAGE

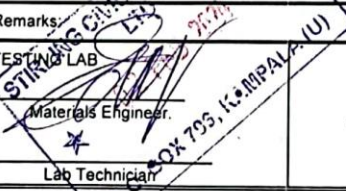
LIQUID LIMIT	Test No	1	2	3	4
Initial gauge reading (mm)		0	0	0	0
Final gauge reading (mm)		15.6	18.2	21.3	24.8
penetration (mm)		15.6	18.2	21.3	24.8
AVERAGE		15.6	18.2	21.3	24.8

	28PI	PI2H	PI66	AX
Container No				
Mass of wet soil + container (g)	46.96	51.02	49.60	41.19
Mass of dry soil + container (g)	34.26	37.99	35.01	29.02
Mass of container (g)	6.95	11.44	7.03	6.98
Mass of moisture (g)	12.7	13.03	14.59	12.17
Mass of dry soil (g)	27.31	26.55	27.98	22.04
Moisture content (%)	46.5	49.1	52.1	55.2
AVERAGE	46.5	49.1	52.1	55.2




Liquid limit (%)	50.8
Plastic limit (%)	20.2
Plasticity Index (%)	30.6
Linear shrinkage	
Trough No.	Y
Trough length (cm)	14.0
Specimen length (cm)	11.9
L.shrinkage =	2.1
% L.shrinkage =	15.0

Remarks: _____

TESTING LAB:  STIRLING CIVIL ENGINEERING
P.O. BOX 795, KAMPALA (U)

Materials Engineer: _____
Lab Technician: _____

STUDENTS: Justine Shilla
McArnold Garry

INSTITUTION	STUDENTS NAMES	TESTING LAB
 UGANDA CHRISTIAN UNIVERSITY A Centre of Excellence in the Heart of Africa	NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)	Stirling

PROJECT: ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS

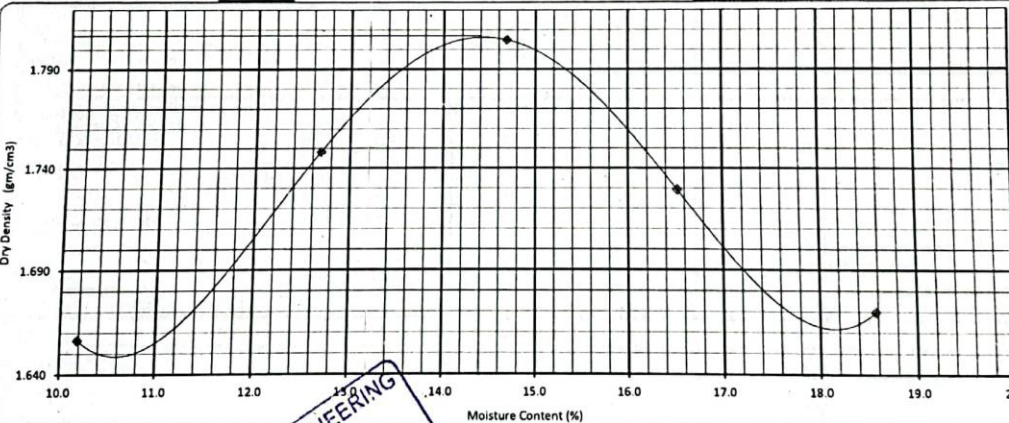
Test Reference No.	Lab. Reference No.	Date Sampled	Date Tested	Technician
Mix	NEAT SAMPLE	10/Dec/23	13/Dec/23	Lab team
Material description:	EXPANSIVE SOILS	Natural moisture (%) :	11.0	

TEST DATA					
Weight of rammer (Kg)	No. of blows per layer	No of layers	Height of drop (mm)	Diameter of mould(mm)	Volume of mould (cm ³)
4.5	62	5	457	152	2,305

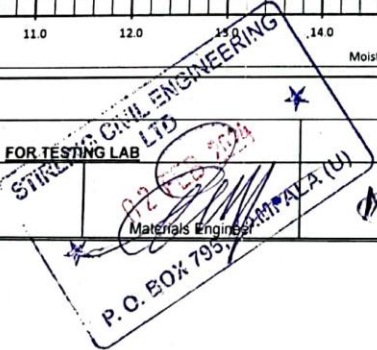



MOISTURE CONTENT DATA					
Test No.	1	2	3	4	5
Tin No.	A	A	A	A	A
Water Added	cm ³ 160	260	360	460	560
Mass of Compacted soil + mould	gm 6,100	6,245	6,345	6,290	6,255
Mass of Mould	gm 4,275	4,275	4,275	4,275	4,275
Mass of Compacted soil	gm 1825	1970	2070	2015	1980
Volume of mould	cm ³ 1,000	1,000	1,000	1,000	1,000
Wet density of soil	g/cm ³ 1.825	1.970	2.070	2.015	1.980



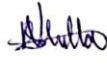
DATA FOR PROCTOR CURVE					
Container No.	KT	MJR	BOJ	BBC	FDC
Mass of wet soil + Container	gm 2,315.0	2,300.0	2,245.0	2,145.0	2,310.0
Mass of dry soil + container	gm 2,175.0	2,130.0	2,060.0	1,955.0	2,075.0
Mass of container	gm 800.0	790.0	800.0	805.0	810.0
Mass of water added	gm 140	170	185	190	235
Mass of dry soil	gm 1375	1340	1260	1150	1265
Moisture content	% 10.2	12.7	14.7	16.5	18.6
Dry density	g/cm ³ 1.655	1.748	1.805	1.729	1.670

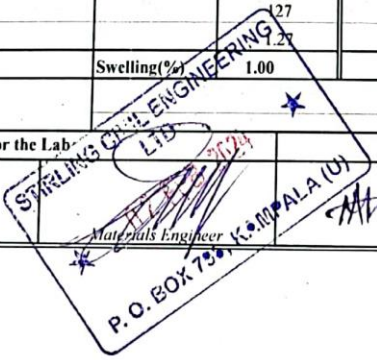
Maximum dry density (gm/cm³) 1.807 Optimum moisture content (%) 14.4



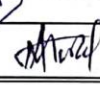


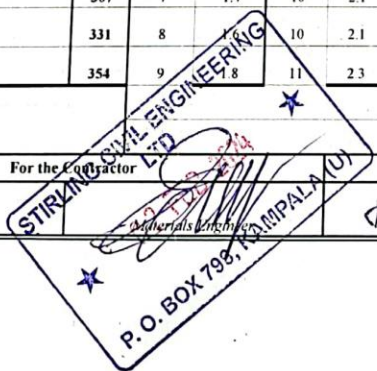
Remarks:

FOR TESTING LAB 	FOR STUDENTS 
Lab Technician 	

Institution  UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>		Students Names NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Testing Lab <div style="border: 2px solid black; padding: 5px; display: inline-block;"> Stirling </div>	
ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS					
CALIFORNIA BEARING RATIO TEST (BS 1377 Part 4)					
Test sample reference :		Laboratory Reference No.:		Sampling Date : 10/Dec/23	
Location:		NEAT SAMPLE		Casting date : 14/Dec/23	
Sample Description:		EXPANSIVE SOILS		Testing Date : 18/Dec/23	
				Technician : Lab team	
				Volume of Mould used (m ³) 2305	
Natural moisture of air dried sample			Volume of water added		
Tin No.	ACB		Mass of air dried soil (g)		6000
Tin + air dried soil sample (g)	2500		MDD (Mg/m ³)		1.807
Tin + oven dry soil sample (g)	2420		N.M.C (%)		4.9
Tin (g)	780		OMC (%)		14.4
Dry soil sample	1640		Added OMC (%)		9.5
Water (g)	80		Calculated dry wt of soil (g)		5707.3
N.M.C (%)	4.9		Water added (g)		545
Average (%)		4.9	Water added (mL)		545
Number of blows	62				
Number of layer	5				
Water Content Determination			Before Soaking	After Soaking	
Tare No	CML	-	FT	-	
Mass of wet sample + Tare	g	2090	-	2255	-
Mass of dry sample + Tare	g	1923	-	2000	-
Mass of Tare	g	760	-	755	-
Mass of water	g	167	-	255	-
Mass of dry sample	g	1163	-	1245	-
Water content	%	14.4	-	20.5	-
Average water Content	%	14.4	-	20.5	-
Density determination					
Mould No	N				
Mass of mould + soil	g	11435		11724	
Mass of mould	g	6720		6720	
Mass of soil	g	4715		5004	
Volume of the mould	cm ³	2305		2305	
Moist density	g/cm ³	2.046		2.171	
Dry density	g/cm ³	1.789		1.802	
Swell Determination					
Date	Hour	D.Gauge Reding			
Initial reading	96 hrs	20.15			
Final reading		21.42			
Height of the specimen		127			
Height of swell		127			
	Swelling(%)	1.00			
Observations					
For the Lab			For Students		
Lab. Technician 					


STIRLING ENGINEERING LTD
 Materials Engineer
 P.O. BOX 750, K. NDAALA (U)

Institution  UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>		Students Names NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Testing Lab <div style="border: 2px solid black; padding: 5px; display: inline-block;"> Stirling </div>	
ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS					
CALIFORNIA BEARING RATIO TEST (BS1377 Part 4)					
Test sample reference :		Laboratory Reference No.:		Sampling Date 10/Dec/23	
Location:				Penetration Date 18/Dec/23	
Depth :				Technician :: Lab team	
Sample Description : EXPANSIVE SOILS					
Number of blows per layer		62			
Number of layers		5		5	
Mould No		N			
Capacity of the Proving Ring (KN)		50		50	
Proving Ring Constant (KN/div.)		0.2052		0.2052	
Speed : mm min.		Top		Bottom	
Penetration of the plunger (mm)		Time (s)	Reading *10 ³ mm	Force (KN)	Reading *10 ³ mm (KN)
0		0	0	0.0	0
0.25		12	0	0.0	0
0.5		24	0	0.0	1
0.75		35	0	0.0	1
1		47	1	0.2	2
1.5		71	1	0.2	2
2		94	2	0.4	3
2.5		118	2	0.4	3
3		142	3	0.6	4
3.5		165	3	0.6	5
4		189	4	0.8	6
4.5		213	4	0.8	7
5		236	5	1.0	7
5.5		260	6	1.2	8
6		283	7	1.4	9
6.5		307	7	1.4	10
7		331	8	1.4	10
7.5		354	9	1.8	11
Observations					
For the Contractor			For Students		
Lab. Technician 					



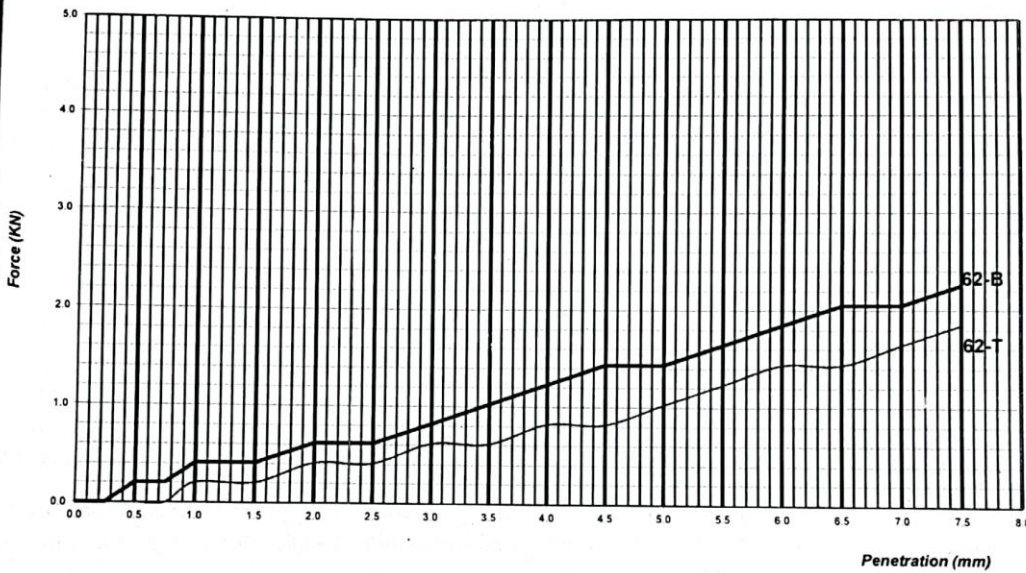
Institution UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>	Students Names NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)	Testing Lab Stirling
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ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS

CALIFORNIA BEARING RATIO TEST (BS1377 Part 4)

Test sample reference:	Laboratory Reference No.:	Sampling Date: 10/Dec/23
Location:		Testing Date: 18/Dec/23
Depth:		Technician: Lab team
Sample Description: EXPANSIVE SOILS		

PENETRATION vs FORCE CURVE



	62 blows			
	Force		CBR	
	Bottom	Top	Bottom	Top
2.5 mm Penetration	0.6	0.4	5	3
5.0 mm Penetration	1.4	1.0	7	5
Average	1.0	0.7	5.9	4.1
Retained CBR	5.9			
Observations	CBR = 6			
Lab. Technician	For the Lab		For Students	
	Material Engineer			



Telephone
+256 (0) 414 250 464 (Gen)
+256 (0) 414 250 474
Email: dgal@mia.go.ug
Website: www.mia.go.ug

In any Correspondence on
this subject please

quote No.....**GE 038/2024**

02nd February 2024

MS. NAMBOOZE JUSTINE SHILLAH AND MR Mc ARNOLD GARRY
REG NO. S20B32/214 & S20B32/033
UGANDA CHRISTIAN UNIVERSITY
P.O BOX 4,
MUKONO-UGANDA
Tel: 256-778-051449



MINISTRY OF INTERNAL AFFAIRS
DIRECTORATE OF GOVERNMENT
ANALYTICAL LABORATORY
Plot No. 2 Lourdel Road
Wandegeya,
P.O. BOX 105639
Kampala - Uganda

REPORT OF ANALYSIS

Description of the Samples

One sample in a black polythene bag containing saw dust ash sample was submitted by Ms. Nambooze Justine, on 25th January 2024, and analysed on 31st January 2024. A summary of the sample received is shown in table below

S/N	Description	Quantity	Assigned Lab ID
1	Saw dust Ash sample packed in a black polythene bag.	01	Sample "A" GE 038/2024

Analysis Requested

Elemental analysis

Method of Analysis

Elemental analysis was done using the XRF Method.

Results of Analysis

The above sample has been analyzed with the following results as below.


Parameter	Units	Results
		Saw dust Ash sample GE 038/2024
Silicon dioxide	% m/m	67.87
Calcium Oxide	% m/m	10.47
Aluminum Oxide	% m/m	8.63
Iron (III) Oxide	% m/m	4.54
Manganese (II) Oxide	% m/m	4.53
Potassium Oxide	% m/m	2.80
Phosphorous pent oxide	% m/m	0.19
Titanium di oxide	% m/m	0.07

Remarks

1. Results relate to sample analyzed and are reported as on received basis.

Semalago Fredrick 02/02/2024

Semalago Fredrick
Government Analyst


INSTITUTION	STUDENTS	TESTING LAB	
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>	NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)	Stirling	
SAMPLE DIScription:	SAND	Sampling Date:	14-Jan-24
SAMPLE SOURCE:	FROM LWERA	Testing Date:	15-Jan-24
TEST	DETERMINATION OF SILT CONTEt		
TEST METHOD	ASTM C40		
S.no	Description	Sample 1	Sample 1
1	Volume of sample Sand (V2)	78	93
2	Volume of silt layer + Sand sample(V1)	80	95.3
3	Volume of silt layer (V3)	2	2.3
4	Percentage of silt % $(V3/V1) \times 100$	2.6	2.5

FOR TESTING LAB

STIRLING CIVIL ENGINEERING LTD

(Signature)

P.O. BOX 796, KAMPALA (U)

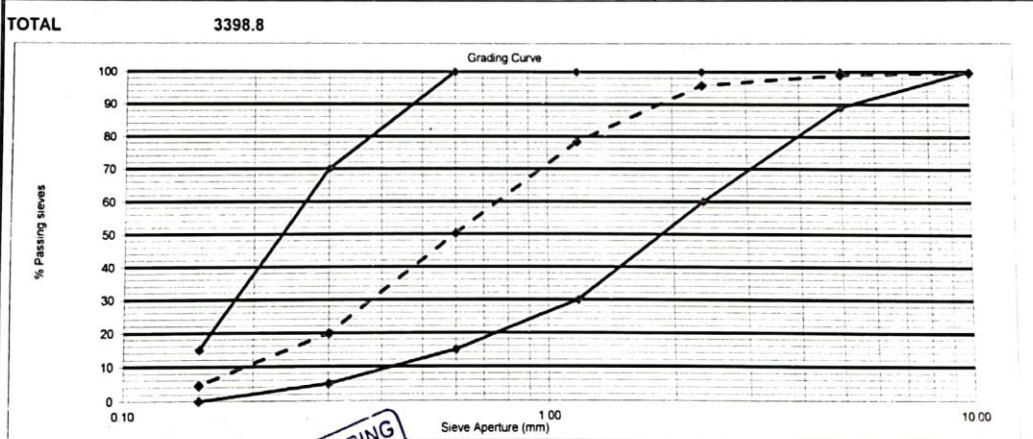
INSTITUTION	STUDENTS	TESTING LAB
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>	NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)	Stirling


PROJECT: ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS


TEST: GRADING FOR SAND
(BS 882 - 1992)

MATERIAL :	NATURAL SAND	OPERATORS:	LAB TEAM
MATERIAL SOURCE:	STOCKPILED AT YARD FROM LWERA IN MASAKA	TOTAL DRY WT. OF SAMPLE:	3423.2
SAMPLE No:	SAMPLE A	TOTAL WT AFTER WASHING	3398.8
MATERIAL DESCRIPTION:	NATURAL SAND	MOISTURE CONTENT:	
		WET OR DRY SIEVING:	WET
		DATE SAMPLED:	14-Jan-24
		DATE TESTED:	15-Jan-24

MAXIMUM SIEVE SIZE (mm)	WEIGHT RETAINED (gm)	PERCENTAGE RETAINED (%)	PERCENTAGE PASSING (%)	BS 882:1992 Table 4. (%)
10.00	9.7	0.28	100	100
5	22.9	0.67	99	89-100
2.36	111.0	3.24	96	60 - 100
1.18	597.2	17.45	78	30 - 100
0.600	960.8	28.07	50	15 - 100
0.300	1042.8	30.46	20	5 - 70
0.150	522.3	15.26	5	0 - 15
PAN	132.1			
TOTAL	3398.8			



FOR TESTING LAB

STIRLING CIVIL ENGINEERING LTD
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INSTITUTION	STUDENTS	TESTING LAB
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>	NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)	Stirling

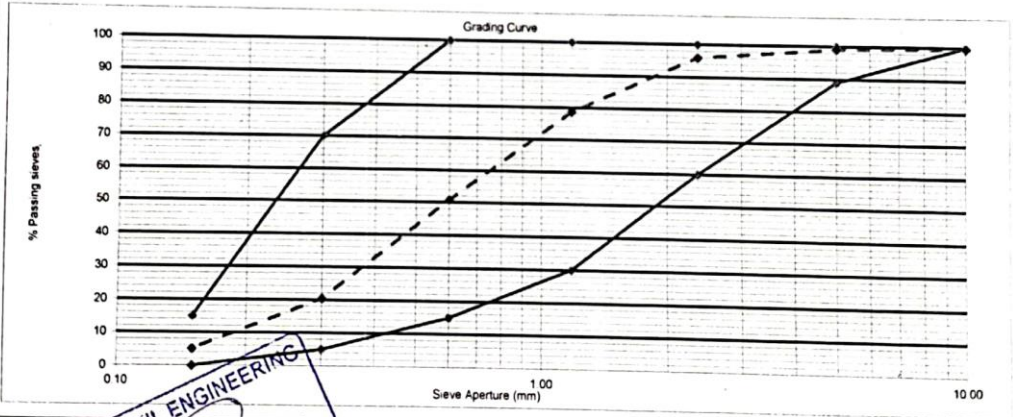
PROJECT: ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS

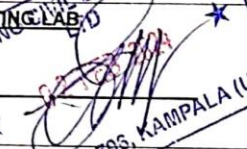
TEST: GRADING FOR SAND
(BS 882 - 1992)


MATERIAL :	NATURAL SAND	OPERATORS:	LAB TEAM
MATERIAL SOURCE:	STOCKPILED AT YARD FROM LWERA IN MASAKA	TOTAL DRY WT. OF SAMPLE:	3923.5
SUPPLIER :	STIRLING	TOTAL WT AFTER WASHING	3854.9
SAMPLE No:	SAMPLE B	MOISTURE CONTENT:	
MATERIAL DESCRIPTION:	NATURAL SAND	WET OR DRY SIEVING:	WET
		DATE SAMPLED:	14-Jan-24
		DATE TESTED:	15-Jan-24

MAXIMUM SIEVE SIZE (mm)	WEIGHT RETAINED (gm)	PERCENTAGE RETAINED (%)	PERCENTAGE PASSING (%)	BS 882:1992 Table 4. (%)
10.00	13.9	0.35	100	100
5	20.9	0.53	99	89-100
2.36	123.7	3.15	96	60 - 100
1.18	678.5	17.29	79	30 - 100
0.600	1093.3	27.87	51	15 - 100
0.300	1193.2	30.41	20	5 - 70
0.150	601.6	15.33	5	0 - 15
PAN	129.8			

TOTAL 3854.9



FOR TESTING LAB

STIRLING ENGINEERING
 P.O. BOX 796, KAMPALA (U)


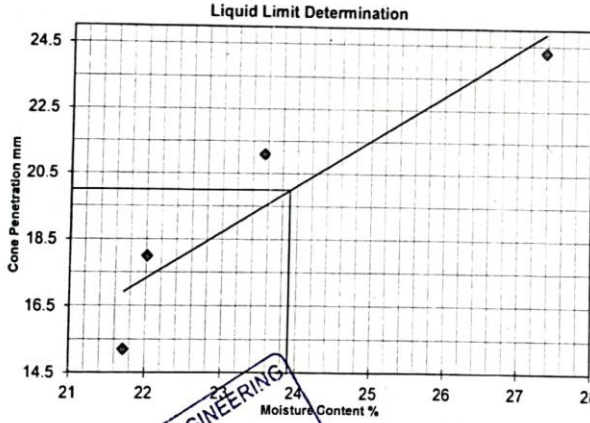

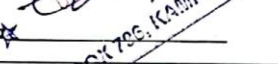


INSTITUTION	STUDENTS		TESTING LAB
 UGANDA CHRISTIAN UNIVERSITY <small>A Member of Universities in the Heart of Africa</small>	NAMBOOZE JUSTINE SHILLA (S20B332/214) & MCARNOLD GARRY (S20B32/033)		<div style="border: 1px solid black; padding: 2px; display: inline-block;"> Stirling </div>
PROJECT	ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS		
	TESTING DATE	14-Jan-24	
	SAND SAMPLE 1		
TEST NO	1	2	3
WEIGHT OF SAND	5383	5380	5390
VOLUME OF CONTAINER	0.27	0.27	0.27
BULK DENSITY (g/cm³)	1.994	1.993	1.996
AVERAGE BULK DENSITY(g/cm³)	1.994		


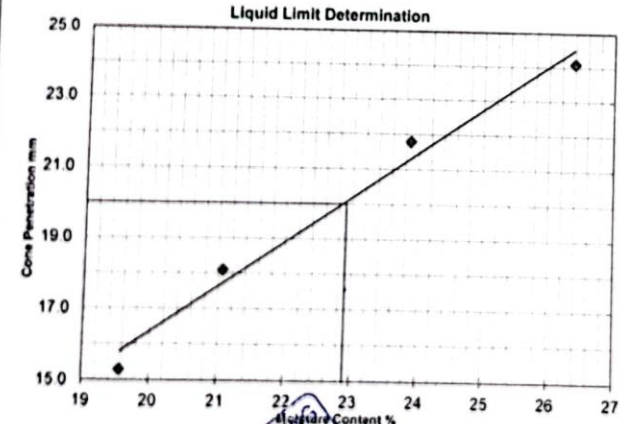
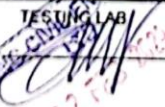

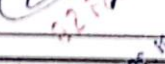

TESTING LAB

STIRLING CIVIL ENGINEERING


14 FEB 2024

P.O. BOX 796, KAMPALA (U)

INSTITUTION		STUDENTS		TESTING LAB	
 UGANDA CHRISTIAN UNIVERSITY <small>A Beacon of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling	
PROJECT:		ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS			
ATTERBERG LIMITS					
<i>Liquid limit (cone penetrometer) and plastic limit</i>					
Test Reference No.:		Lab. Reference No.:		Technician:	
Location				Lab Team	
Test method		BS 1377: Part 2, 1990.4.3/4.4		Sample Date	
Soil description		SAND		Test Date	
				14/Jan/2024	
				15/Jan/2024	
PLASTIC LIMIT					
Test No.				Average	
Mass of wet soil + container (g)		NON PLASTIC			
Mass of dry soil + container (g)					
Mass of container (g)					
Mass of moisture (g)					
Mass of dry soil (g)					
Moisture content %					
LIQUID LIMIT					
Test No.		1	2	3	4
Initial gauge reading (mm)		0	0	0	0
Final gauge reading (mm)		15.2	18	21.1	24.3
Average penetration (mm)		15.2	18.0	21.1	24.3
Container No.		P188	P157	A3	MB
Mass of wet soil + container (g)		42.15	47.49	48.18	47.20
Mass of dry soil + container (g)		35.89	40.18	40.37	38.60
Mass of container (g)		7.06	6.97	7.21	7.18
Mass of moisture (g)		6.26	7.31	7.8	8.6
Mass of dry soil (g)		28.83	33.21	33.16	31.42
Moisture content (%)		21.7	22.0	23.6	27.4
Liquid Limit Determination					
					
				Liquid limit (%)	
				23.9	
				Plastic limit (%)	
				NON PLASTIC	
				Plasticity Index (%)	
Linear shrinkage					
				Trough No.	
				K	
				Trough length (cm)	
				14	
				Specimen length (cm)	
				13.73	
				L. shrinkage =	
				0	
				% L. shrinkage =	
				1.9	
Remarks:					
Materials Engineer: 			STUDENTS		
Lab Technician: 			 		

INSTITUTION  UGANDA CHRISTIAN UNIVERSITY <small>A member of the Christian Council of Africa</small>		STUDENTS NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		TESTING LAB <div style="border: 1px solid black; padding: 5px; display: inline-block;"> Stirling </div>																			
PROJECT:		ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS																					
ATTERBERG LIMITS																							
<i>Liquid limit (cone penetrometer) and plastic limit</i>																							
Test Reference No.		Lab. Reference No.:		Technician:	Lab Team																		
Location		0		Sample Date	14/Jan/2024																		
Test method		BS 1377 Part 2, 1990 4.3/4.4		Test Date	15/Jan/2024																		
Soil description		SAND																					
PLASTIC LIMIT																							
Test No.					Average																		
Mass of wet soil + container (g)		NON PLASTIC																					
Mass of dry soil + container (g)																							
Mass of container (g)																							
Mass of moisture (g)																							
Mass of dry soil (g)																							
Moisture content %																							
LIQUID LIMIT																							
Test No.		1	2	3	4																		
Initial gauge reading (mm)		0	0	0	0																		
Final gauge reading (mm)		15.3	18.1	21.8	24.1																		
Average penetration (mm)		15.3	18.1	21.8	24.1																		
Container No.		P182	P146	P1V6	P18																		
Mass of wet soil + container (g)		49.79	41.95	42.99	53.78																		
Mass of dry soil + container (g)		42.82	36.01	36.05	43.99																		
Mass of container (g)		7.18	7.80	6.97	6.88																		
Mass of moisture (g)		6.97	5.94	6.9	9.79																		
Mass of dry soil (g)		35.64	28.21	29.08	37.11																		
Moisture content (%)		19.6	21.1	23.9	26.4																		
<div style="text-align: center;"> Liquid Limit Determination </div> 		<table border="1"> <tr> <td>Liquid limit (%)</td> <td>22.9</td> </tr> <tr> <td>Plastic limit (%)</td> <td>NONPLASTIC</td> </tr> <tr> <td>Plasticity Index (%)</td> <td></td> </tr> <tr> <td colspan="2" style="text-align: center;">Linear shrinkage</td> </tr> <tr> <td>Trough No.</td> <td>K</td> </tr> <tr> <td>Trough length (cm)</td> <td>14</td> </tr> <tr> <td>Specimen length (cm)</td> <td>13.7</td> </tr> <tr> <td>L shrinkage =</td> <td>0</td> </tr> <tr> <td>% L shrinkage =</td> <td>1.9</td> </tr> </table>				Liquid limit (%)	22.9	Plastic limit (%)	NONPLASTIC	Plasticity Index (%)		Linear shrinkage		Trough No.	K	Trough length (cm)	14	Specimen length (cm)	13.7	L shrinkage =	0	% L shrinkage =	1.9
		Liquid limit (%)	22.9																				
		Plastic limit (%)	NONPLASTIC																				
		Plasticity Index (%)																					
		Linear shrinkage																					
		Trough No.	K																				
Trough length (cm)	14																						
Specimen length (cm)	13.7																						
L shrinkage =	0																						
% L shrinkage =	1.9																						
Remarks																							
Materials Engineer: 		STUDENTS: 																					
Lab Technician: 																							



INSTITUTION	STUDENTS		TESTING LAB	
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>	NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling	
PROJECT	ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS			
SPECIFIC GRAVITY & WATER ABSORPTION FINE AGGREGATES (AASHTO : T84—00) ASTM DESIGNATION ; C128—97				
SOURCE:			OPERATOR:	
SAMPLE No			SAMPLING DATE 14-Jan-24	
SAMPLE DESCRIPTION:	Natural sand		TESTING DATE: 15-Jan-24	
TEST NO				
		A	B	C
[A] wt. of oven dry sample in air (gm)		496.96		485.54
[B] wt. of pycnometer filled with water (gm)		1804.87		1767.7
[C] wt. of pycnometer with specimen and water (gm)		2123.6		2080.3
[S] wt of saturated surface dry sample (gm)		510.04		496.34
Bulk Specific Gravity on oven dry basis	A	2.598		2.643
	(B+S-C)			
Bulk Specific Gravity on saturated surface dry basis	S	2.666		2.701
	(B+S-C)			
Apparent Specific Gravity	A	2.788		2.808
	(B+A-C)			
Water Absorption(%)=	100(S-A)	2.6		2.2
	A			
AVERAGE RESULTS				
BULK SPECIFIC GRAVITY		2.620		
BULK SPECIFIC GRAVITY ON SATURATED SURFACE DRY BASIS		2.684		
APPARENT SPECIFIC GRAVITY		2.798		
WATER ABSORPTION		2.4		
FOR TESTING LAB				



 STIRLING CIVIL ENGINEERING
 P. O. BOX 795, KAMPALA (U)



UGANDA CHRISTIAN UNIVERSITY
A UNIVERSITY OF EXCELLENCE & INTEGRITY

NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)

Stirling

INSTITUTION

STUDENTS

TESTING LAB

PROJECT:

ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS

SUMMARY OF ALL THE TEST RESULTS FOR WEAK SUBGRADE SOILS STABILISED WITH RIVER SAND & SAWDUST


LOCATION	BLENDED %	SAMPLING DATE	GRADING					ATTEMBERG LIMITS					MDD		UCS	CBR	CBR	
			1	2	0.425	0.075	GM	LL	PL	PI	LS	MDD	OMC	62Blows	SWELL			
0	EXPANSIVE SOILS STABILISED WITH 0% RIVER SAND & 12% SAWDUST	100	100	99	98	90	42	0.693	26.6	17.4	9.2	5.0	1.667	18.2	8	-	0.65	
		100	100	99	98	91	41	0.693	26.4	17.4	9.0	5.0	-	-	0.11	-	-	
		100	100	98	97	81	34	0.872	24.5	17.4	7.0	3.6	1.682	18.0	9	-	0.6	
		100	100	98	97	82	38	0.826	25.0	18.0	7.0	3.6	-	-	0.14	-	-	
		12/9/2023	100.0	100.0	99.6	98.0	75.0	31.3	0.957	24.2	17.9	6.3	3.2	1.819	12.5	20	-	0.33
		100.0	100.0	99.4	97.7	73.8	33.5	0.950	24.2	17.6	6.6	3.2	-	-	0.19	-	-	
		100.0	100.0	99.3	96.3	72.3	29.0	1.024	23.3	18.0	5.3	2.7	1.857	10.4	24	-	0.46	
		100.0	100.0	98.3	97.2	80.3	23.7	0.988	23.3	18.0	5.2	2.7	-	-	0.21	-	-	
		100.0	100.0	99.6	96.8	58.8	17.6	1.268	23.0	NON-PLASTIC	1.4	1.898	8.1	-	-	-	-	0.16
		100.0	100.0	99.2	96.4	57.7	11.9	1.339	22.6	-	1.4	-	-	-	-	-	-	-

FOR LAB

STIRLING CIVIL ENGINEERING
Materials Engineer (U)

P.O. BOX 793, KAMPALA (U)

Shanta
Attard

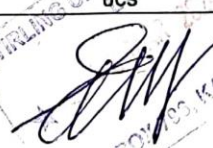
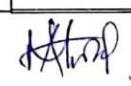
INSTITUTION	STUDENTS NAMES		TESTING LAB	
 UGANDA CHRISTIAN UNIVERSITY <small>A member of Universities in the West of Africa</small>	NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		<h1 style="margin:0;">Stirling</h1>	
PROJECT	ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS			
STABILISED CBR (BS 1924 PART 2 1)				
WEAK SUBGRADE SOILS STABILISED WITH 0% RIVER SAND & 12% SAWDUST				
M/c of air dried sample			M/c After Mixing	
Tin No.	CMD		Stabiliser	0% RIVER SAND & 12% SAWDUST
Tin + Wet soil gm	2022		Content	5.0
Tin + Dry Soil gm	1978		Tin No.	YY
Tin gm	763		Tin + Wet Soil	2167
Water gm	44.0		Tin + Dry Soil	1951
Dry Soil gm	1,215.0		Tin	785
M/c %	3.6		Water	216.0
Av. M/c %	3.6		Dry Soil	1,166.0
			M/c	18.5


(a)MDD	<u>1.667</u>	kg/m3	(b)Air Dry M/c	<u>3.6</u>	%
(c)WD	<u>3.033</u>	kg/m3	(e)M/c to add	<u>14.6</u>	%
(d)OMC	<u>18.2</u>	%	(F) volume	2.305	

Date prepared	<u>2/Mar/24</u>	Date immerse	<u>9/Mar/24</u>	Date tested	<u>16/Mar/24</u>
---------------	-----------------	--------------	-----------------	-------------	------------------

Mould No.			
Factor(f)	2.305		
(h)Wet Soil to fill mould c x f x %comp	6,991.1		
(j) Wt of air dried soil	6,000		
Air dry M/c	3.6		
(k) soil dry wt (100j/100+b)	5,790.3		
Stabiliser	0% RIVER SAND & 12% SAWDUST		
(m)Stabilisers content %	5.0		
(n) Stabiliser to add k x(m/100)	289.5		
Water Addition((j+n)x(d-b))/(100+b)	884.9		
Wt. per layer CBR Only h/3			

SPECIMEN WEIGHT CHECK			
No. of blows	62.0	62.0	AVERAGE
Mould No.	7 DAYS AIR TIGHT, 7 DAYS SOAKED	7 DAYS AIR TIGHT, 7 DAYS SOAKED	
Stabiliser	0% RIVER SAND & 12% SAWDUST	0% RIVER SAND & 12% SAWDUST	
Content %	5.0	5.0	
Mould g	A	B	
Wet Soil g	4,767.0	4,695.0	
Compaction M/c %	18.5	18.5	
Dry density kg/m3	1.745	1.719	
%Compaction	104.7	103.1	
FORCE	1.8	2.3	
UCS	0.101	0.124	0.11



 STIRLING CIVIL ENGINEERING
 P.O. BOX 400, KAMPALA (U)

INSTITUTION	STUDENTS	TESTING LAB
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>	NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)	<div style="border: 1px solid black; padding: 5px; text-align: center;"> Stirling </div>

PROJECT: ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS

SUMMARY OF TEST RESULTS FOR NEAT MATERIAL AT WEAK SUBGRADE SOILS STABILISED WITH 0% RIVER SAND & 12%

LOCATION	BLENDED %	SAMPLING DATE	GRADING					ATTERBERG LIMITS					MDD		CBR	CBR SWELL	AVERAGE		
			37.5	20	5	2	0.425	0.075	GM	LL	PL	PI	LS	MDD				OMC	
WEAK SUBGRAD		63	37.5	20	5	2	0.425	0.075	GM	LL	PL	PI	LS	MDD	OMC	/	8	0.65	0.65
		100	100	100	99	98	90	42	0.69	26.6	17.4	9.2	5.0	1.667	18.2				
		100	100	100	99	98	91	41	0.69	26.4	17.4	9.0	5.0						
EXPANSIVE SOILS		100	100	100	99.12	98.21	90.67	41.8	0.69	26.5	17.4	9.1	5.0	1.667	18.2		8	0.65	0.65
		12/10/2023																	
	AVERAGE	100	100	100	99	98	91	42	0.693	26.5	17.4	9.1	5.0	1.667	18.2		7.7	0.65	0.65

FOR LAB


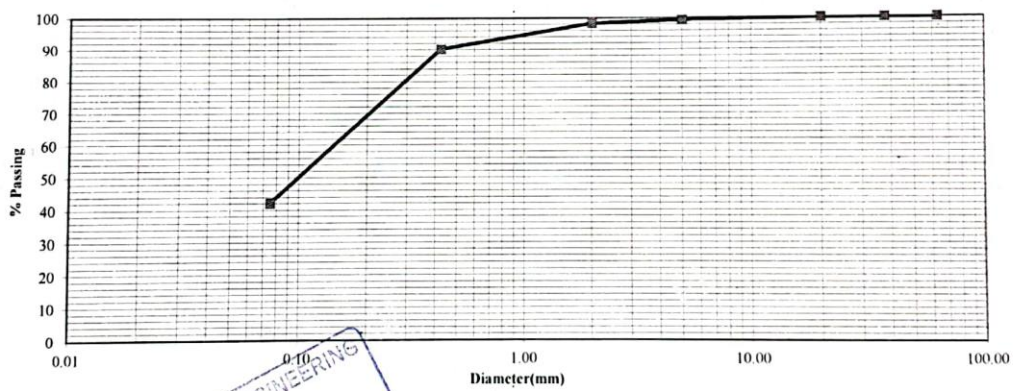
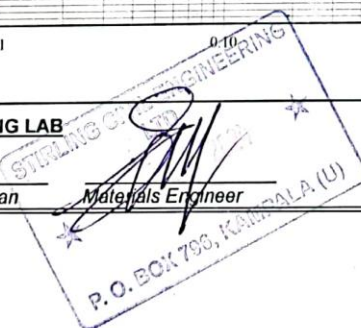

Lab Technician


FOR STUDENTS

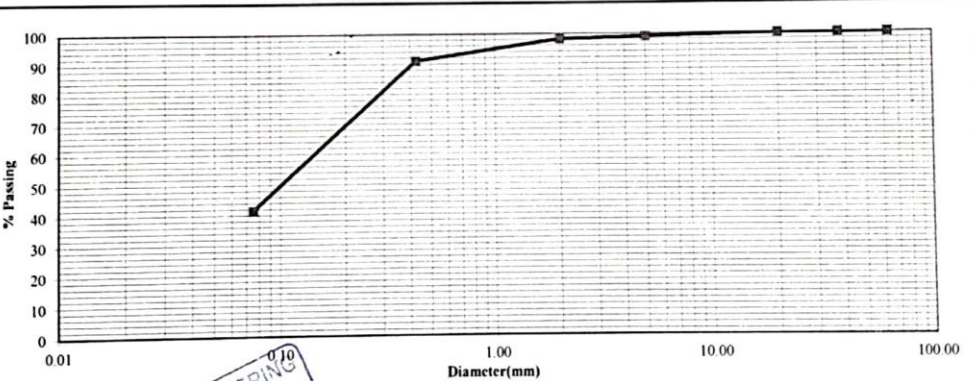





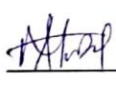
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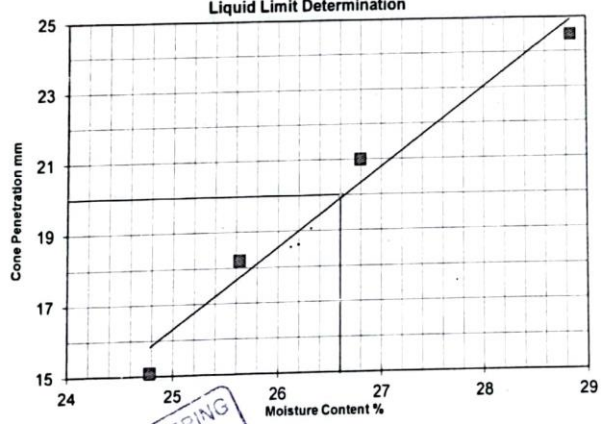
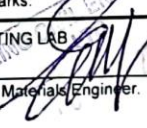
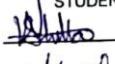
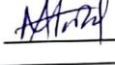
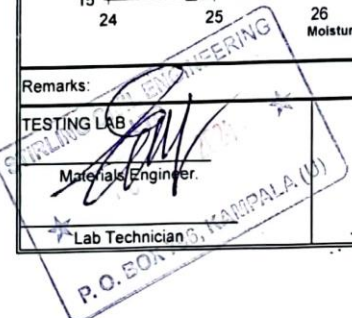
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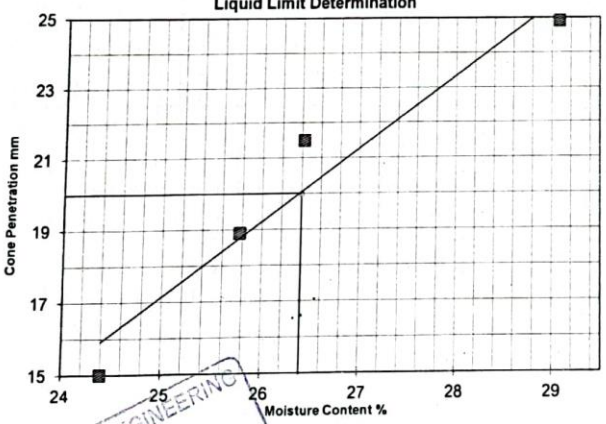

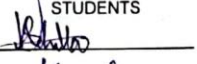
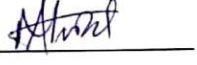
INSTITUTION		STUDENTS NAMES		CONTRACTOR	
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling	
PROJECT : ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS					
PARTICLE SIZE DISTRIBUTION (BS 1377 - 2 - 90)					
Test Reference No.:			Lab. Reference No.:		
Location : (km)	WEAK SUBGRADE SOILS STABILISED WITH 0% RIVER SAND & 12% SAWDUST		Dry wt. of sample before washing: (g)	3138.9	
Depth: (m)			Dry wt. of sample after washing: (g)	1917.7	
Material description:	WEAK SUBGRDE SOILS		Date Sampled:	Date Tested:	Technician
			10/Dec/2023	28/Feb/2024	Lab team
Sieve Size (mm)	Weight Retained (g)	Retained (%)	Passing (%)	Grading Limits (G60 & 80)	
63.0	0.0	0	100	100	100
37.5	0.0	0.0	100	80	100
20.0	0.0	0.0	100	60	95
5.0	21.2	0.7	99	30	65
2.00	32.8	1.0	98	20	50
0.425	253.8	8.1	90	10	30
0.075	1506.4	48.0	42	5	15
Total fines	1324.7	42.2			
Bottom Pan	103.5				
Extracted fines	1221.2				
Total sample	3138.9				
Grading Modulus		0.69			
					
FOR TESTING LAB			FOR STUDENTS		
					
Lab Technician		Materials Engineer			


INSTITUTION		STUDENTS NAMES		CONTRACTOR	
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling	
PROJECT : ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS					
PARTICLE SIZE DISTRIBUTION (BS 1377 - 2 - 90)					
Test Reference No.:			Lab. Reference No.:		
Location : (km)	WEAK SUBGRADE SOILS STABILISED WITH 0% RIVER SAND & 12% SAWDUST		Dry wt. of sample before washing: (g)	3092.3	
Depth: (m)			Dry wt. of sample after washing: (g)	1917.4	
Material description:	WEAK SUBGRDE SOILS		Date Sampled:	Date Tested:	Technician
			10/Dec/2023	28/Feb/2024	Lab team
Sieve Size (mm)	Weight Retained (g)	Retained (%)	Passing (%)	Grading Limits (G60 & 80)	
63.0	0.0	0	100	100	100
37.5	0.0	0.0	100	80	100
20.0	0.0	0.0	100	60	95
5.0	33.7	1.1	99	30	65
2.00	23.8	0.8	98	20	50
0.425	216.6	7.0	91	10	30
0.075	1537.9	49.7	41	5	15
Total fines	1280.3	41.4			
Bottom Pan	105.4				
Extracted fines	1174.9				
Total sample	3092.3				
Grading Modulus		0.69			



FOR TESTING LAB  Lab Technician:  Materials Engineer (U)	FOR STUDENTS  
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INSTITUTION		STUDENTS		TESTING LAB																			
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling																			
PROJECT:		ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS																					
ATTERBERG LIMITS																							
<i>Liquid limit (cone penetrometer) and plastic limit</i>																							
Test Reference No.:		Lab. Reference No.:		Technician:	Lab Team																		
Location		RADE SOILS STABILISED WITH 0% RIVER SAND & 12		Sample Date	10/Dec/2023																		
Test method		BS 1377 Part 2, 1990 4.3/4.4		Test Date	13/Dec/2023																		
LAYER		WEAK SUBGRDE SOILS																					
PLASTIC LIMIT																							
Test No.		A4	Q	Average																			
Mass of wet soil + container (g)		49.63	33.85	41.74																			
Mass of dry soil + container (g)		45.25	31.93	38.59																			
Mass of container (g)		20.58	20.67	20.625																			
Mass of moisture (g)		4.38	1.9	3.15																			
Mass of dry soil (g)		24.67	11.26	17.965																			
Moisture content %		17.8	17.1	17.4																			
AVERAGE																							
LIQUID LIMIT																							
Test No.		1	2	3	4																		
Initial gauge reading (mm)		0	0	0	0																		
Final gauge reading (mm)		15.1	18.2	21	24.5																		
penetration (mm)		15.1	18.2	21.0	24.5																		
AVERAGE		15.1	18.2	21.0	24.5																		
Container No.		DF	PI43	PI2H	PI38																		
Mass of wet soil + container (g)		62.65	78.98	75.26	75.28																		
Mass of dry soil + container (g)		51.56	64.30	61.80	60.00																		
Mass of container (g)		6.81	7.02	11.56	7.03																		
Mass of moisture (g)		11.09	14.68	13.46	15.28																		
Mass of dry soil (g)		44.75	57.28	50.24	52.97																		
Moisture content (%)		24.8	25.6	26.8	28.8																		
AVERAGE		24.8	25.6	26.8	28.8																		
Liquid Limit Determination																							
				<table border="1"> <tr> <td>Liquid limit (%)</td> <td>26.6</td> </tr> <tr> <td>Plastic limit (%)</td> <td>17.4</td> </tr> <tr> <td>Plasticity Index (%)</td> <td>9.2</td> </tr> <tr> <td colspan="2" style="text-align: center;">Linear shrinkage</td> </tr> <tr> <td>Trough No.</td> <td>R</td> </tr> <tr> <td>Trough length (cm)</td> <td>14.0</td> </tr> <tr> <td>Specimen length (cm)</td> <td>13.3</td> </tr> <tr> <td>L. shrinkage =</td> <td>0.7</td> </tr> <tr> <td>% L. shrinkage =</td> <td>5.0</td> </tr> </table>		Liquid limit (%)	26.6	Plastic limit (%)	17.4	Plasticity Index (%)	9.2	Linear shrinkage		Trough No.	R	Trough length (cm)	14.0	Specimen length (cm)	13.3	L. shrinkage =	0.7	% L. shrinkage =	5.0
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Linear shrinkage																							
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Remarks:																							
TESTING LAB  Materials Engineer.			STUDENTS  																				
																							

INSTITUTION		STUDENTS		TESTING LAB																			
 UGANDA CHRISTIAN UNIVERSITY <small>A Beacon of Light in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling																			
PROJECT:		ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS																					
ATTERBERG LIMITS																							
<i>Liquid limit (cone penetrometer) and plastic limit</i>																							
Test Reference No.:		Lab. Reference No.:		Technician:																			
Location		RADE SOILS STABILISED WITH 0% RIVER SAND & 12		Sample Date																			
Test method		BS 1377: Part 2, 1990.4.3/4.4		Test Date																			
LAYER		WEAK SUBGRDE SOILS																					
PLASTIC LIMIT																							
	Test No.	VP	2F	Average																			
Mass of wet soil + container (g)		47.06	50.12	48.59																			
Mass of dry soil + container (g)		43.3	45.97	44.635																			
Mass of container (g)		21.63	22.28	21.955																			
Mass of moisture (g)		3.76	4.2	3.955																			
Mass of dry soil (g)		21.67	23.69	22.68																			
Moisture content %		17.4	17.5	17.4																			
AVERAGE																							
LIQUID LIMIT																							
	Test No.	1	2	3	4																		
Initial gauge reading (mm)		0	0	0	0																		
Final gauge reading (mm)		15.0	18.9	21.5	24.9																		
penetration (mm)		15.0	18.9	21.5	24.9																		
AVERAGE																							
		15.0	18.9	21.5	24.9																		
Container No.		P133	28PI	P143	P153																		
Mass of wet soil + container (g)		73.45	75.78	65.77	65.88																		
Mass of dry soil + container (g)		60.45	61.70	53.53	53.06																		
Mass of container (g)		7.16	7.07	7.20	8.97																		
Mass of moisture (g)		13	14.08	12.24	12.82																		
Mass of dry soil (g)		53.29	54.63	46.33	44.09																		
Moisture content (%)		24.4	25.8	26.4	29.1																		
AVERAGE																							
		24.4	25.8	26.4	29.1																		
Liquid Limit Determination																							
				<table border="1"> <tr> <td>Liquid limit (%)</td> <td>26.4</td> </tr> <tr> <td>Plastic limit (%)</td> <td>17.4</td> </tr> <tr> <td>Plasticity Index (%)</td> <td>9.0</td> </tr> <tr> <td colspan="2" style="text-align: center;">Linear shrinkage</td> </tr> <tr> <td>Trough No.</td> <td>R</td> </tr> <tr> <td>Trough length (cm)</td> <td>14.0</td> </tr> <tr> <td>Specimen length (cm)</td> <td>13.3</td> </tr> <tr> <td>L.shrinkage =</td> <td>0.7</td> </tr> <tr> <td>% L.shrinkage =</td> <td>5.0</td> </tr> </table>		Liquid limit (%)	26.4	Plastic limit (%)	17.4	Plasticity Index (%)	9.0	Linear shrinkage		Trough No.	R	Trough length (cm)	14.0	Specimen length (cm)	13.3	L.shrinkage =	0.7	% L.shrinkage =	5.0
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Remarks:																							
TESTING LAB Materials Engineer Lab Technician 			STUDENTS  																				

INSTITUTION	STUDENTS NAMES	TESTING LAB
 UGANDA CHRISTIAN UNIVERSITY <small>A University of Excellence in the Heart of Africa</small>	NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)	Stirling

PROJECT: **ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS**

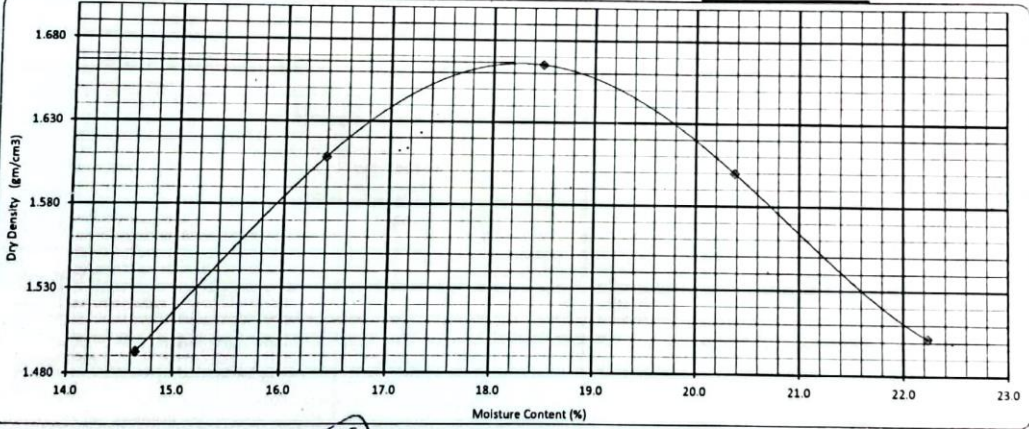
Test Reference No.	Lab. Reference No.	Date Sampled	Date Tested	Technician
Mix	WEAK SUBGRADE SOILS STABILISED WITH 0% RIVER SAND & 12% SAWDUST	10/Dec/23	28/Feb/24	Lab team
Material description:	WEAK SUBGRDE SOILS	Natural moisture (%) :	11.0	

TEST DATA					
Weight of rammer (Kg)	No. of blows per layer	No of layers	Height of drop (mm)	Diameter of mould(mm)	Volume of mould (cm ³)
4.5	62	5	457	152	2,305

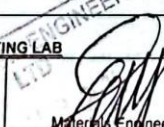

MOISTURE CONTENT DATA					
Test No	1	2	3	4	5
Tin No	A	A	A	A	A
Water Added	cm ³ 320	380	440	500	560
Mass of Compacted soil + mould	gm 4,928	5,089	5,190	5,143	5,053
Mass of Mould	gm 3,217	3,217	3,217	3,217	3,217
Mass of Compacted soil	gm 1711	1872	1973	1926	1836
Volume of mould	cm ³ 1,000	1,000	1,000	1,000	1,000
Wet density of soil	g/cm ³ 1.711	1.872	1.973	1.926	1.836

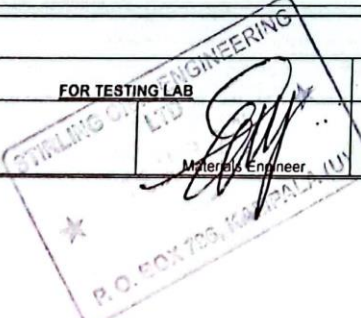
DATA FOR PROCTOR CURVE					
Container No	NBM	FDC	Y6Y	KT	ACB
Mass of wet soil + Container	gm 2,402.0	2,284.0	2,576.0	2,383.0	2,248.0
Mass of dry soil + container	gm 2,197.0	2,076.0	2,302.0	1,993.0	1,981.0
Mass of container	gm 797.0	807.0	820.0	79.0	780.0
Mass of water added	gm 205	208	274	390	267
Mass of dry soil	gm 1400	1269	1482	1914	1201
Moisture content	% 14.6	16.4	18.5	20.4	22.2
Dry density	g/cm ³ 1.492	1.608	1.665	1.600	1.502



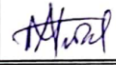
Maximum dry density (gm/cm³) **1.667** Optimum moisture content (%) **18.2**

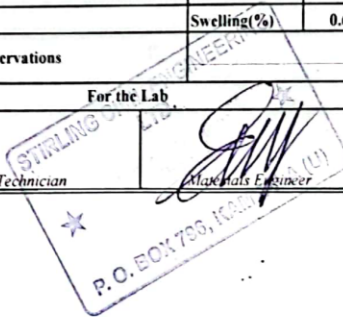



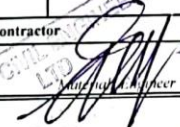


Remarks:

FOR TESTING LAB	FOR STUDENTS
Lab Technician 	Materials Engineer 



Institution	Students Names		Testing Lab	
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>	NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling	
ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS				
CALIFORNIA BEARING RATIO TEST (BS 1377 Part 4)				
Test sample reference :	Laboratory Reference No.:		Sampling Date :	10/Dec/23
Location:	WEAK SUBGRADE SOILS STABILISED WITH 0% RIVER SAND & 12% SAWDUST		Casting date :	2/Mar/24
			Testing Date :	16/Mar/24
Sample Description:	WEAK SUBGRDE SOILS		Technician :	Lab team
			Volume of Mould used (m ³)	2305
Natural moisture of air dried sample			Volume of water added	
Tin No.	CMD		Mass of air dried soil (g)	6000
Tin + air dried soil sample (g)	2022		MDD (Mg/m ³)	1.667
Tin + oven dry soil sample (g)	1978		N.M.C (%)	3.6
Tin (g)	763		OMC (%)	18.2
Dry soil sample	1215		Added OMC (%)	14.6
Water (g)	44		Calculated dry wt of soil (g)	5782.7
N.M.C (%)	3.6		Water added (g)	844
Average (%)	3.6		Water added (mL)	844
Number of blows	62			
Number of layer	5			
Water Content Determination		Before Soaking	After Soaking	
Tare No	YY -	UPC -		
Mass of wet sample + Tare	g 2167 -	2048 -		
Mass of dry sample + Tare	g 1951 -	1847 -		
Mass of Tare	g 785 -	808 -		
Mass of water	g 216 -	201 -		
Mass of dry sample	g 1166 -	1039 -		
Water content	% 18.5 -	19.3 -		
Average water Content	% 18.5	19.3		
Density determination		AS		
Mould No				
Mass of mould + soil	g 9998	10034		
Mass of mould	g 5598	5598		
Mass of soil	g 4400	4436		
Volume of the mould	cm ³ 2305	2305		
Moist density	g/cm ³ 1.909	1.925		
Dry density	g/cm ³ 1.611	1.613		
Swell Determination		Hour	D.Gauge Reding	
Date		96 hrs	9.6	
Initial reading			10.42	
Final reading			127	
Height of the specimen			0.82	
Height of swell			0.65	
		Swelling(%)		
Observations				
For the Lab			For Students	
 Lab Technician			 Student	



Institution		Students Names				Testing Lab	
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)				Stirling	
ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS							
CALIFORNIA BEARING RATIO TEST (BS1377 Part 4)							
Test sample reference :		Laboratory Reference No.:		Sampling Date		10/Dec/23	
Location:				Penetration Date		16/Mar/24	
Depth :				Technician		:: Lab team	
Sample Description :		WEAK SUBGRDE SOILS					
Number of blows per layer		62					
Number of layers		5		5		5	
Mould No		AS					
Capacity of the Proving Ring (KN)		50		50		50	
Proving Ring Constant (KN/div.)		0.2052		0.2052		0.2052	
Speed : mm/min		Top		Bottom			
Penetration of the plunger (mm)		Time (s)	Reading *10 ³ mm	Force (KN)	Reading *10 ³ mm	Force (KN)	
0		0	0	0.0	0	0.0	
0.25		12	1	0.2	1	0.2	
0.5		24	1	0.2	1	0.2	
0.75		35	2	0.4	2	0.4	
1		47	2	0.4	2	0.4	
1.5		71	2	0.4	3	0.6	
2		94	3	0.6	3	0.6	
2.5		118	3	0.6	4	0.8	
3		142	3	0.6	5	1.0	
3.5		165	3	0.6	6	1.2	
4		189	4	0.8	7	1.4	
4.5		213	4	0.8	8	1.6	
5		236	4	0.8	9	1.8	
5.5		260	4	0.8	10	2.1	
6		283	5	1.0	10	2.1	
6.5		307	5	1.0	11	2.3	
7		331	5	1.0	11	2.3	
7.5		354	5	1.0	11	2.3	
Observations							
For the Contractor				For Students			
Lab. Technician		 <small>Authoriser</small>		 <small>Auth</small>		 <small>Auth</small>	

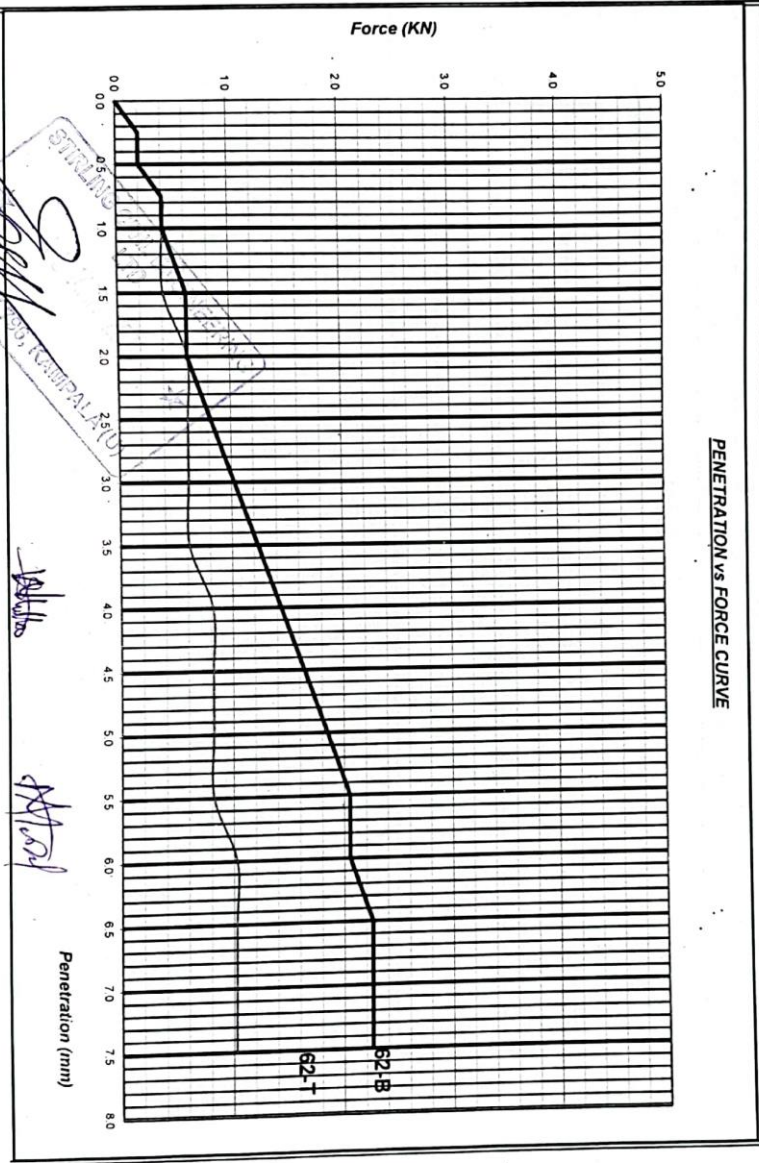


Institution  UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>	Students Names NAMBOOZE JUSTINE SHILLA (S20B32719) & MCARNOLD GARRY (S20B32033)	Testing Lab <div style="border: 2px solid black; padding: 5px; display: inline-block;">Stirling</div>
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ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS

CALIFORNIA BEARING RATIO TEST (BS1377 Part 4)

Test sample reference :	Laboratory Reference No.:	Sampling Date :	10/Dec/23
Location:		Testing Date :	16/Mar/24
Depth:		Technician :	Lab team
Sample Description:	WEAK SUBGRADE SOILS		








	62 blows			
	Force		CBR	
	Bottom	Top	Bottom	Top
2.5 mm Penetration	0.8	0.6	6	5
5.0 mm Penetration	1.8	0.8	9	4
Average	1.3	0.7	7.7	4.4
Retained CBR	27			
Observations	CBR = 8			
For the Lab		For Students		
Lab Technician	Materials Engineer			

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 MATERIALS ENGINEERING

[Handwritten Signature]

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INSTITUTION	STUDENTS NAMES	TESTING LAB
 UGANDA CHRISTIAN UNIVERSITY <small>A University of Excellence in the Heart of Africa</small>	NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)	<h1 style="margin: 0;">Stirling</h1>
PROJECT	ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS	

STABILISED CBR
(BS 1924 PART 2 1)

WEAK SUBGRADE SOILS STABILISED WITH 15% RIVER SAND & 9% SAWDUST

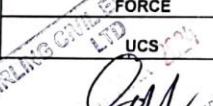
M/c of air dried sample			M/c After Mixing		
Tin No.	BKN		Stabiliser	15% RIVER SAND & 9% SAWDUST	
Tin + Wet soil gm	2088		Content	5.0	
Tin + Dry Soil gm	2050		Tin No.	UPC	
Tin gm	801		Tin + Wet Soil	2344	
Water gm	38.0		Tin + Dry Soil	2104	
Dry Soil gm	1,249.0		Tin	807	
M/c %	3.0		Water	240.0	
Av. M/c %	3.0		Dry Soil	1,297.0	
			M/c	18.5	

(a)MDD	<u>1.682</u>	kg/m ³	(b)Air Dry M/c	<u>3.0</u>	%
(c)WD	<u>3.028</u>	kg/m ³	(e)M/c to add	<u>15.0</u>	%
(d)OMC	<u>18.0</u>	%	(F) volume	2.305	

Date prepared 2/Mar/24 Date immerse 9/Mar/24 Date tested 16/Mar/24

Mould No.			
Factor(f)	2.305		
(h)Wet Soil to fill mould c x f x %comp	6,979.4		
(j) Wt of air dried soil	6,000		
Air dry M/c	3.0		
(k) soil dry wt (100j/100+b)	5,822.8		
Stabiliser	15% RIVER SAND & 9% SAWDUST		
(m)Stabilisers content %	5.0		
(n) Stabiliser to add k x(m/100)	291.1		
Water Addition((j+n)x(d-b))/(100+b)	913.2		
Wt. per layer CBR Only h/3			

SPECIMEN WEIGHT CHECK			
No. of blows	62.0	62.0	AVERAGE
Mould No.	7 DAYS AIR TIGHT, 7 DAYS SOAKED	7 DAYS AIR TIGHT, 7 DAYS SOAKED	
Stabiliser	15% RIVER SAND & 9% SAWDUST	15% RIVER SAND & 9% SAWDUST	
Content %	5.0	5.0	
Mould g	A	B	
Wet Soil g	5,280.0	5,142.0	
Compaction M/c %	18.5	18.5	
Dry density kg/m ³	1.933	1.882	
%Compaction	114.9	111.9	
FORCE	2.5	2.7	
UCS	0.135	0.146	0.14


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UGANDA CHRISTIAN UNIVERSITY
A Centre of Excellence in the Heart of Africa.

NAMBOOZE JUSTINE SHILLA (S20B32/214) &
MCARNOLD GARRY (S20B32/033)

Stirling

INSTITUTION

STUDENTS

TESTING LAB

PROJECT:

ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS

SUMMARY OF TEST RESULTS FOR WEAK SUBGRADE SOILS STABILISED WITH 15% RIVER SAND & 5


LOCATION	BLENDED %	SAMPLING DATE	GRADING										ATTERBERG LIMITS					MDD		CBR	CBR SWELL	AVERAGE
			63	37.5	20	5	2	0.425	0.075	GM	LL	PL	PI	LS	MDD	OMC	CBR	CBR SWELL				
WEAK SUBGRADE SOILS	100	100	100	100	98	97	81	34	0.87	24.45	17.4	7.0	3.6	1.682	18.0	9.3	0.59	0.59				
		100	100	100	99	97	82	38	0.83	25.0	18.0	7.0	3.6	-	-	-	-	-				
		100	100	100	98.57	97.03	81.69	36.39	0.85	24.7	17.7	7.0	3.6	1.682	18.0	9	0.59	0.59				
D WITH 15% RIVER SAND & 9% SAWDUST																						
AVERAGE			100	100	100	99	97	82	36	0.849	24.7	18.0	7.0	3.6	1.682	18.0	9.3	0.59	0.59			

FOR LAB

Lab Technician

FOR STUDENTS

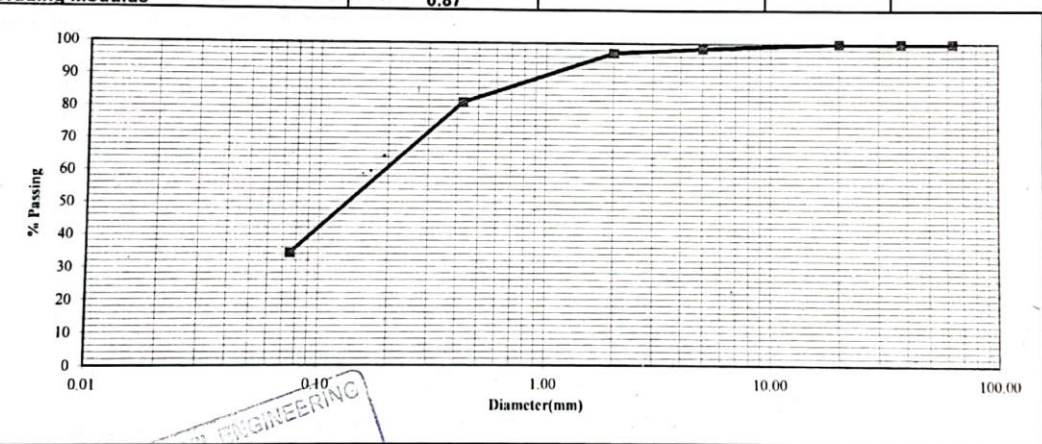


INSTITUTION	STUDENTS NAMES	CONTRACTOR
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>	NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)	Stirling

PROJECT : ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS


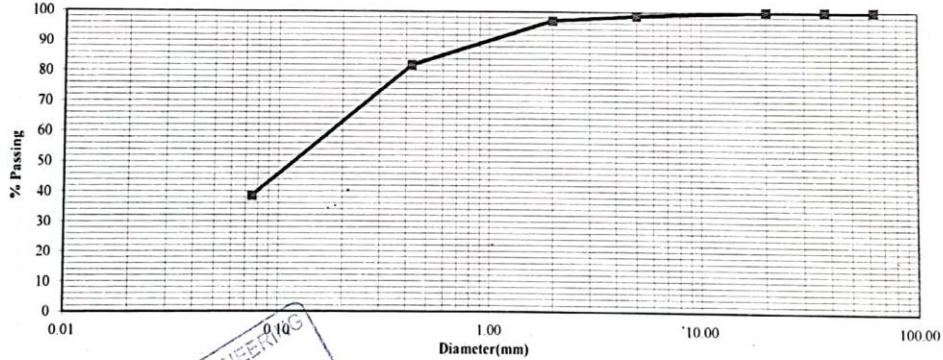
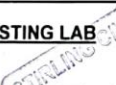


PARTICLE SIZE DISTRIBUTION (BS 1377 - 2 - 90)

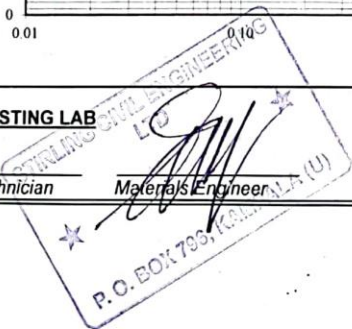
Test Reference No.:		Lab. Reference No.:			
Location : (km)	WEAK SUBGRADE SOILS STABILISED WITH 15% RIVER SAND & 9% SAWDUST		Dry wt. of sample before washing: (g)	3314.6	
Depth: (m)			Dry wt. of sample after washing: (g)	2273.1	
Material description:	WEAK SUBGRADE SOILS		Date Sampled:	Date Tested:	Technician
			10/Dec/2023	28/Feb/2024	Lab team
Sieve Size (mm)	Weight Retained (g)	Retained (%)	Passing (%)	Grading Limits (G60 & 80)	
63.0	0.0	0	100	100	100
37.5	0.0	0.0	100	80	100
20.0	0.0	0.0	100	60	95
5.0	50.2	1.5	98	30	65
2.00	48.1	1.5	97	20	50
0.425	515.0	15.5	81	10	30
0.075	1564.8	47.2	34	5	15
Total fines	1136.5	34.3			
Bottom Pan	95.0				
Extracted fines	1041.5				
Total sample	3314.6				
Grading Modulus	0.87				


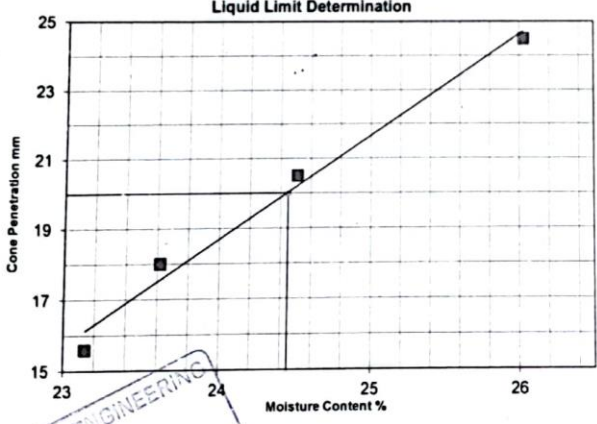
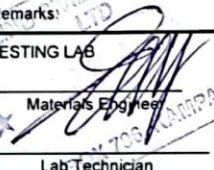




<p>FOR TESTING LAB</p> <p>Lab Technician: <i>[Signature]</i></p> <p>Material Engineer: <i>[Signature]</i></p>	<p>FOR STUDENTS</p> <p><i>[Signature]</i> <i>[Signature]</i></p>
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INSTITUTION		STUDENTS NAMES		CONTRACTOR	
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling	
PROJECT : ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS					
PARTICLE SIZE DISTRIBUTION (BS 1377 - 2 - 90)					
Test Reference No.:			Lab. Reference No.:		
Location : (km)	WEAK SUBGRADE SOILS STABILISED WITH 15% RIVER SAND & 9% SAWDUST		Dry wt. of sample before washing: (g)	2913.7	
Depth: (m)			Dry wt. of sample after washing: (g)	1874.1	
Material description:	WEAK SUBGRADE SOILS		Date Sampled:	Date Tested:	Technician
			10/Dec/2023	28/Feb/2024	Lab team
Sieve Size (mm)	Weight Retained (g)	Retained (%)	Passing (%)	Grading Limits (G60 & 80)	
63.0	0.0	0	100	100	100
37.5	0.0	0.0	100	80	100
20.0	0.0	0.0	100	60	95
5.0	39.2	1.3	99	30	65
2.00	47.3	1.6	97	20	50
0.425	441.2	15.1	82	10	30
0.075	1264.7	43.4	38	5	15
Total fines	1121.3	38.5			
Bottom Pan	81.7				
Extracted fines	1039.6				
Total sample	2913.7				
Grading Modulus		0.83			
					
FOR TESTING LAB			FOR STUDENTS		
 Lab Technician		 Materials Engineer		 Student	



INSTITUTION		STUDENTS		TESTING LAB																			
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling																			
PROJECT:		ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS																					
ATTERBERG LIMITS																							
<i>Liquid limit (cone penetrometer) and plastic limit</i>																							
Test Reference No.:	Lab. Reference No.:		Technician:	Lab Team																			
Location	RADE SOILS STABILISED WITH 15% RIVER SAND & 9		Sample Date	10/Dec/2023																			
Test method	BS 1377: Part 2, 1990 4.3/4.4		Test Date	13/Dec/2023																			
LAYER	WEAK SUBGRADE SOILS																						
PLASTIC LIMIT																							
	Test No	KK	KJ		Average																		
Mass of wet soil + container (g)		37.22	39.6		38.41																		
Mass of dry soil + container (g)		34.94	36.85		35.895																		
Mass of container (g)		22.25	20.58		21.415																		
Mass of moisture (g)		2.28	2.8		2.515																		
Mass of dry soil (g)		12.69	16.27		14.48																		
Moisture content %		18.0	16.9		17.4																		
AVERAGE																							
LIQUID LIMIT																							
	Test No	1	2	3	4																		
Initial gauge reading (mm)		0	0	0	0																		
Final gauge reading (mm)		15.6	18	20.5	24.5																		
penetration (mm)		15.6	18.0	20.5	24.5																		
AVERAGE																							
		15.6	18.0	20.5	24.5																		
Container No	PI4	PP	PI35	PIV6																			
Mass of wet soil + container (g)	70.92	73.54	83.75	71.56																			
Mass of dry soil + container (g)	58.87	60.81	69.09	58.19																			
Mass of container (g)	6.79	6.91	9.28	6.82																			
Mass of moisture (g)	12.05	12.73	14.66	13.37																			
Mass of dry soil (g)	52.08	53.9	59.81	51.37																			
Moisture content (%)	23.1	23.6	24.5	26.0																			
AVERAGE																							
		23.1	23.6	24.5	26.0																		
Liquid Limit Determination																							
				<table border="1"> <tr> <td>Liquid limit (%)</td> <td>24.5</td> </tr> <tr> <td>Plastic limit (%)</td> <td>17.4</td> </tr> <tr> <td>Plasticity Index (%)</td> <td>7.0</td> </tr> <tr> <td colspan="2" style="text-align: center;">Linear shrinkage</td> </tr> <tr> <td>Trough No.</td> <td>1</td> </tr> <tr> <td>Trough length (cm)</td> <td>14.0</td> </tr> <tr> <td>Specimen length (cm)</td> <td>13.5</td> </tr> <tr> <td>L.shringage =</td> <td>0.5</td> </tr> <tr> <td>% L.shrinkage =</td> <td>3.6</td> </tr> </table>		Liquid limit (%)	24.5	Plastic limit (%)	17.4	Plasticity Index (%)	7.0	Linear shrinkage		Trough No.	1	Trough length (cm)	14.0	Specimen length (cm)	13.5	L.shringage =	0.5	% L.shrinkage =	3.6
Liquid limit (%)	24.5																						
Plastic limit (%)	17.4																						
Plasticity Index (%)	7.0																						
Linear shrinkage																							
Trough No.	1																						
Trough length (cm)	14.0																						
Specimen length (cm)	13.5																						
L.shringage =	0.5																						
% L.shrinkage =	3.6																						
Remarks:																							
TESTING LAB  Materials Engineer Lab Technician			STUDENTS  																				

P.O.

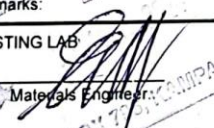
INSTITUTION  UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>	STUDENTS NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)	TESTING LAB <div style="border: 2px solid black; padding: 5px; display: inline-block;">Stirling</div>			
PROJECT: ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS					
ATTERBERG LIMITS					
<i>Liquid limit (cone penetrometer) and plastic limit</i>					
Test Reference No.:	Lab. Reference No.:	Technician:	Lab Team		
Location	RADE SOILS STABILISED WITH 15% RIVER SAND & 9	Sample Date	10/Dec/2023		
Test method	BS 1377: Part 2, 1990 4 3/4 4	Test Date	13/Dec/2023		
LAYER	WEAK SUBGRADE SOILS				
PLASTIC LIMIT					
	Test No	JL	OG	Average	
Mass of wet soil + container (g)		52.45	52.04	52.245	
Mass of dry soil + container (g)		47.88	47.39	47.635	
Mass of container (g)		22.54	21.41	21.975	
Mass of moisture (g)		4.57	4.7	4.61	
Mass of dry soil (g)		25.34	25.98	25.66	
Moisture content %		18.0	17.9	18.0	
AVERAGE					
LIQUID LIMIT					
	Test No	1	2	3	4
Initial gauge reading (mm)		0	0	0	0
Final gauge reading (mm)		15.2	18	21.3	24.9
penetration (mm)		15.2	18.0	21.3	24.9
AVERAGE		15.2	18.0	21.3	24.9
Container No.	P133	IA	FORD	A7	
Mass of wet soil + container (g)	66.18	65.63	62.33	66.59	
Mass of dry soil + container (g)	54.96	54.22	50.94	54.64	
Mass of container (g)	6.98	7.22	6.91	9.27	
Mass of moisture (g)	11.22	11.41	11.39	11.95	
Mass of dry soil (g)	47.98	47	44.03	45.37	
Moisture content (%)	23.4	24.3	25.9	26.3	
AVERAGE					
		23.4	24.3	25.9	26.3

Liquid Limit Determination

Liquid limit (%)	25.0
Plastic limit (%)	18.0
Plasticity Index (%)	7.0
Linear shrinkage	
Trough No	1
Trough length (cm)	14.0
Specimen length (cm)	13.5
L.shrinkage =	0.5
% L.shrinkage =	3.6

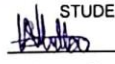
Remarks:


TESTING LAB


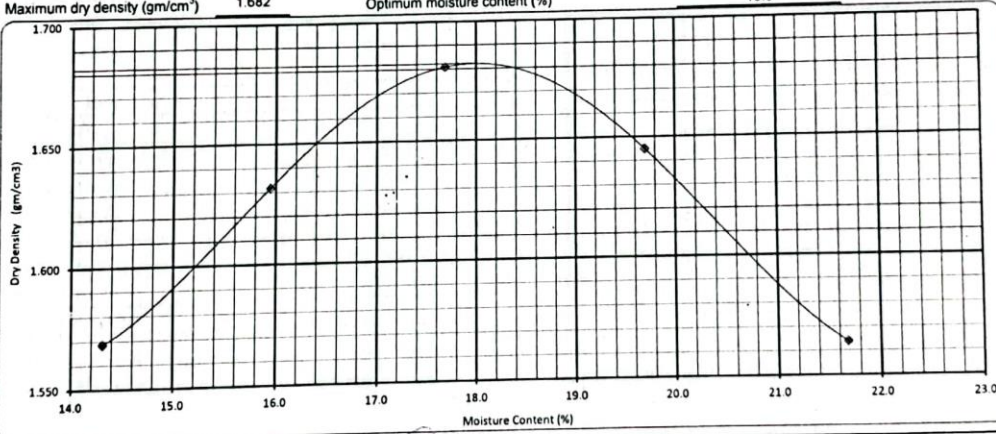
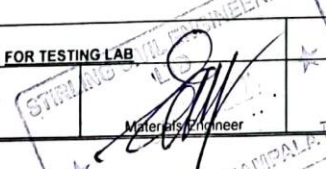
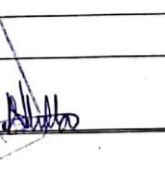
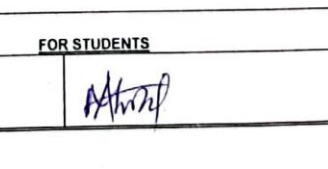
Materials Engineer: 

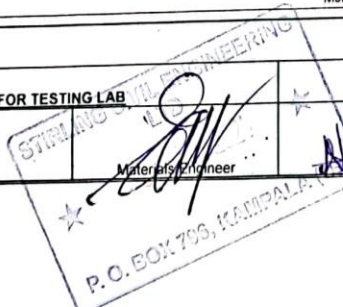
Lab Technician


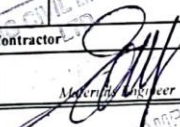

STUDENTS






INSTITUTION	STUDENTS NAMES		TESTING LAB		
 UGANDA CHRISTIAN UNIVERSITY	NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling		
PROJECT: ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS					
Test Reference No.	Lab Reference No		Date Sampled	Date Tested	Technician
Mix	WEAK SUBGRADE SOILS STABILISED WITH 15% RIVER SAND & 9% SAWDUST		10/Dec/23	28/Feb/24	Lab team
Material description:	WEAK SUBGRADE SOILS		Natural moisture (%):	11.0	
TEST DATA					
Weight of rammer (Kg)	No. of blows per layer	No of layers	Height of drop (mm)	Diameter of mould(mm)	Volume of mould (cm ³)
4.5	62	5	457	152	2.305
MOISTURE CONTENT DATA					
Test No.	1	2	3	4	5
Tin No.	A	A	A	A	A
Water Added	cm ³	320	380	440	500
Mass of Compacted soil + mould	gm	5,010	5,109	5,195	5,186
Mass of Mould	gm	3,217	3,217	3,217	3,217
Mass of Compacted soil	gm	1,793	1,892	1,978	1,969
Volume of mould	cm ³	1,000	1,000	1,000	1,000
Wet density of soil	g/cm ³	1.793	1.892	1.978	1.969
DATA FOR PROCTOR CURVE					
Container No.	Z6T	BAK	MJR	2I	CR7
Mass of wet soil + Container	gm	2,191.0	2,303.0	2,162.0	2,303.0
Mass of dry soil + container	gm	2,018.0	2,097.0	1,956.0	2,056.0
Mass of container	gm	809.0	805.0	791.0	802.0
Mass of water added	gm	173	206	206	247
Mass of dry soil	gm	1209	1292	1165	1254
Moisture content	%	14.3	15.9	17.7	19.7
Dry density	g/cm ³	1.569	1.632	1.681	1.645
Maximum dry density (gm/cm ³)	1.682				Optimum moisture content (%)
					18.0
					
Remarks:					
FOR TESTING LAB			FOR STUDENTS		
 Lab Technician		 Materials Engineer		 Student	



Institution		Students Names				Testing Lab	
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)				Stirling	
ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS							
CALIFORNIA BEARING RATIO TEST (BS1377 Part 4)							
Test sample reference :		Laboratory Reference No.:		Sampling Date		10/Dec/23	
Location:				Penetration Date		16/Mar/24	
Depth :				Technician		Lab team	
Sample Description :		WEAK SUBGRADE SOILS					
Number of blows per layer		62					
Number of layers		5		5		5	
Mould No		1A					
Capacity of the Proving Ring (KN)		50		50		50	
Proving Ring Constant (KN/div.)		0.2052		0.2052		0.2052	
Speed : mm/mm.		Top		Bottom			
Penetration of the plunger (mm)		Time (s)	Reading *10 ⁻³ mm	Force (KN)	Reading *10 ⁻³ mm	Force (KN)	
0		0	0	0.0	0	0.0	
0.25		12	1	0.2	1	0.2	
0.5		24	1	0.2	1	0.2	
0.75		35	1	0.2	2	0.4	
1		47	2	0.4	3	0.6	
1.5		71	2	0.4	3	0.6	
2		94	2	0.4	5	1.0	
2.5		118	3	0.6	6	1.2	
3		142	3	0.6	6	1.2	
3.5		165	4	0.8	7	1.4	
4		189	4	0.8	8	1.6	
4.5		213	4	0.8	8	1.6	
5		236	5	1.0	9	1.8	
5.5		260	5	1.0	9	1.8	
6		283	6	1.2	10	2.1	
6.5		307	7	1.4	11	2.3	
7		331	8	1.6	12	2.5	
7.5		354	9	1.8	13	2.7	
Observations							
For the Contractor				For Students			
Lab. Technician		 <small>Material Engineer</small>					



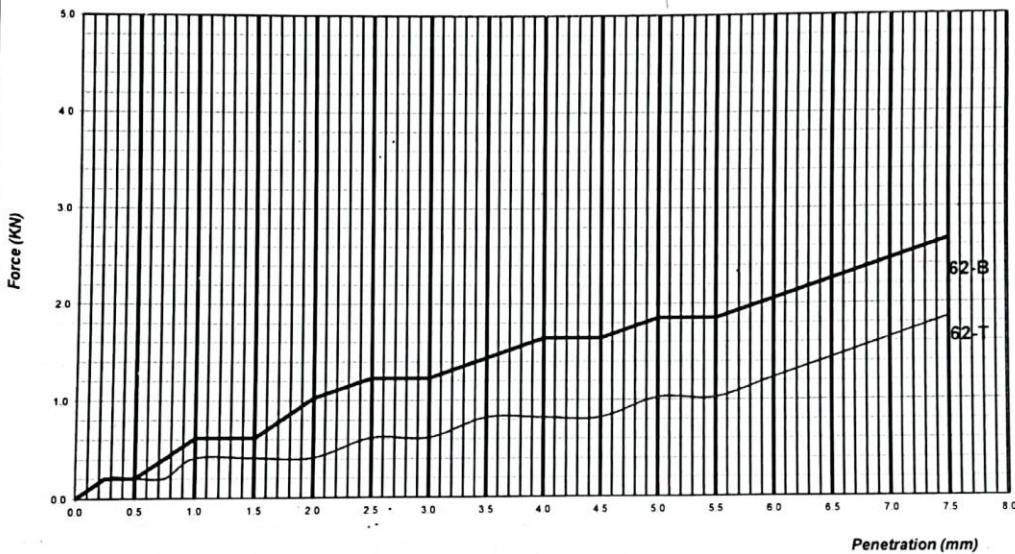
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>	Students Names NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)	Testing Lab <div style="border: 2px solid black; padding: 5px; display: inline-block;"> Stirling </div>
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ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS

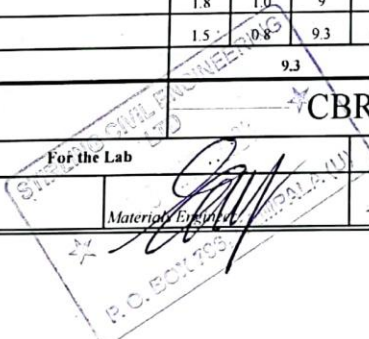
CALIFORNIA BEARING RATIO TEST (BSI377 Part 4)


Test sample reference :	Laboratory Reference No.:	Sampling Date : 10/Dec/23
Location:		Testing Date : 16/Mar/24
Depth:		Technician : Lab team
Sample Description: WEAK SUBGRADE SOILS		

PENETRATION vs FORCE CURVE



	62 blows									
	Force		CBR							
	Bottom	Top	Bottom	Top						
2.5 mm Penetration	1.2	0.6	9	5						
5.0 mm Penetration	1.8	1.0	9	5						
Average	1.5	0.8	9.3	4.9						
Retained CBR	9.3									
Observations	CBR = 9									
For the Lab					For Students					
Lab. Technician	<i>[Signature]</i>				<i>[Signature]</i>		<i>[Signature]</i>			



INSTITUTION	STUDENTS NAMES	TESTING LAB
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>	NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)	Stirling
PROJECT	ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS	

STABILISED CBR
(BS 1924 PART 2 1)

WEAK SUBGRADE SOILS STABILISED WITH 30% RIVER SAND & 6% SAWDUST

M/c of air dried sample			M/c After Mixing		
Tin No.	NMT		Stabiliser	30% RIVER SAND & 6% SAWDUST	
Tin + Wet soil gm	1951		Content	5.0	
Tin + Dry Soil gm	1922		Tin No.	CML	
Tin gm	768		Tin + Wet Soil	2147	
Water gm	29.0		Tin + Dry Soil	2012	
Dry Soil gm	1,154.0		Tin	877	
M/c %	2.5		Water	135.0	
Av. M/c %	2.5		Dry Soil	1,135.0	
			M/c	11.9	

(a)MDD	<u>1.819</u>	kg/m ³	(b)Air Dry M/c	<u>2.5</u>	%
(c)WD	<u>2.274</u>	kg/m ³	(e)M/c to add	<u>10.0</u>	%
(d)OMC	<u>12.5</u>	%	(F) volume	2.305	

Date prepared 2/Mar/24 Date immerse 9/Mar/24 Date tested 16/Mar/24


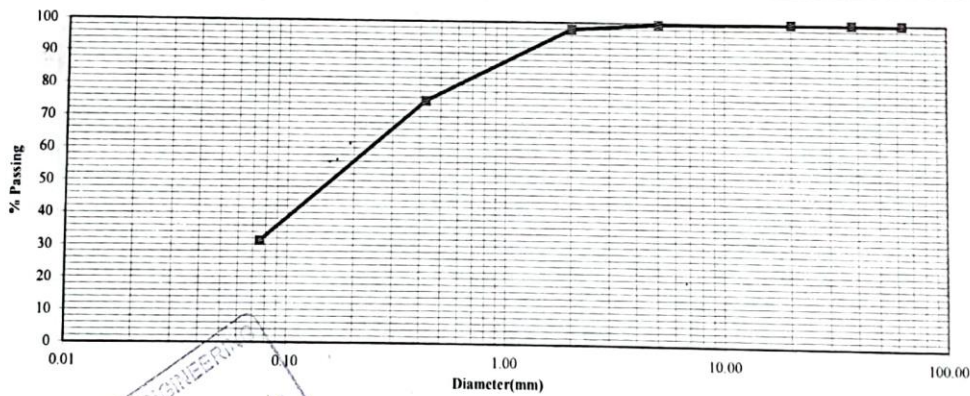


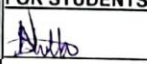

Mould No.			
Factor(f)	2.305		
(h)Wet Soil to fill mould c x f x %comp	5,240.7		
(j) Wt of air dried soil	6,000		
Air dry M/c	2.5		
(k) soil dry wt (100j/100+b)	5,852.9		
Stabiliser	30% RIVER SAND & 6% SAWDUST		
(m)Stabilisers content %	5.0		
(n) Stabiliser to add k x(m/100)	292.6		
Water Addition((j+n)x(d-b))/(100+b)	613.0		
Wt. per layer CBR Only h/3			

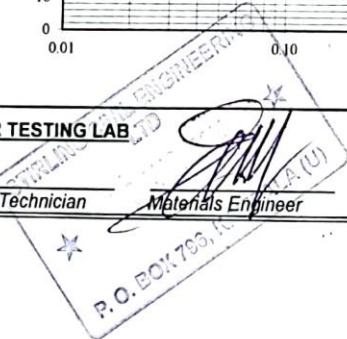
SPECIMEN WEIGHT CHECK			
No. of blows	62.0	62.0	AVERAGE
Mould No.	7 DAYS AIR TIGHT, 7 DAYS SOAKED	7 DAYS AIR TIGHT, 7 DAYS SOAKED	
Stabiliser	30% RIVER SAND & 6% SAWDUST	30% RIVER SAND & 6% SAWDUST	
Content %	5.0	5.0	
Mould g	A	B	
Wet Soil g	5,111.0	4,985.0	
Compaction M/c %	11.9	11.9	
Dry density kg/m ³	1.982	1.933	
%Compaction	108.9	106.3	
FORCE	3.3	3.5	
UCS	0.180	0.191	0.19


 STIRLING CIVIL ENGINEERING LTD
P.O. BOX 796, KAMPALA (U)

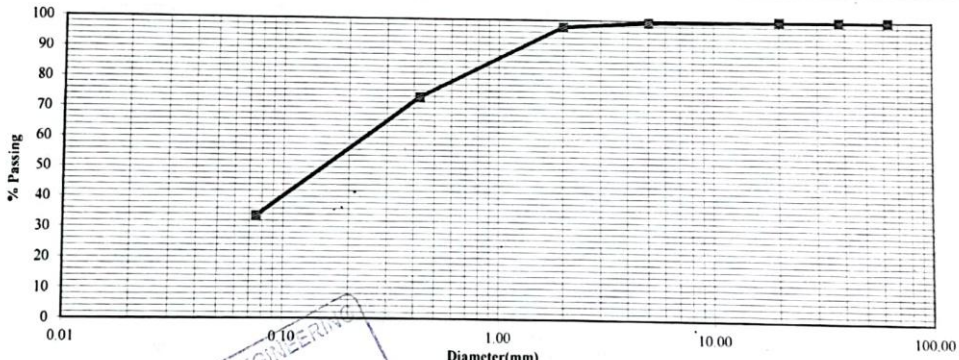
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
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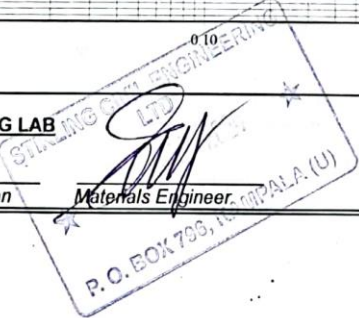
INSTITUTION		STUDENTS NAMES		CONTRACTOR	
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling	
PROJECT : ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS					
PARTICLE SIZE DISTRIBUTION (BS 1377 - 2 - 90)					
Test Reference No.:			Lab. Reference No.:		
Location : (km)	WEAK SUBGRADE SOILS STABILISED WITH 30% RIVER SAND & 6% SAWDUST		Dry wt. of sample before washing: (g)	2814.1	
Depth: (m)			Dry wt. of sample after washing: (g)	1959.5	
Material description:	WEAK SUBGRADE		Date Sampled:	Date Tested:	Technician
			10/Dec/2023	1/Mar/2024	Lab team
Sieve Size (mm)	Weight Retained (g)	Retained (%)	Passing (%)	Grading Limits (G60 & 80)	
63.0	0.0	0	100	100	100
37.5	0.0	0.0	100	80	100
20.0	0.0	0.0	100	60	95
5.0	11.5	0.4	100	30	65
2.00	45.8	1.6	98	20	50
0.425	646.1	23.0	75	10	30
0.075	1228.5	43.7	31	5	15
Total fines	882.2	31.3			
Bottom Pan	27.6				
Extracted fines	854.6				
Total sample	2814.1				
Grading Modulus		0.96			
					
FOR TESTING LAB			FOR STUDENTS		
 Lab Technician		 Materials Engineer		 	


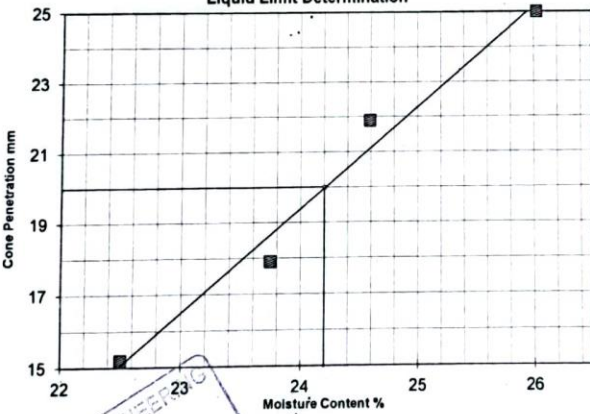
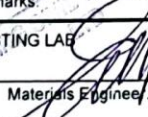


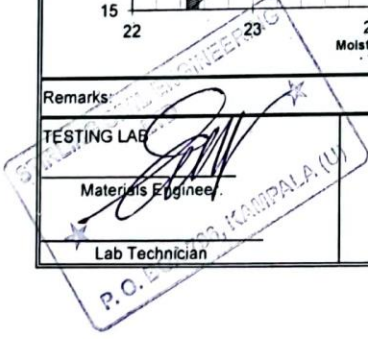



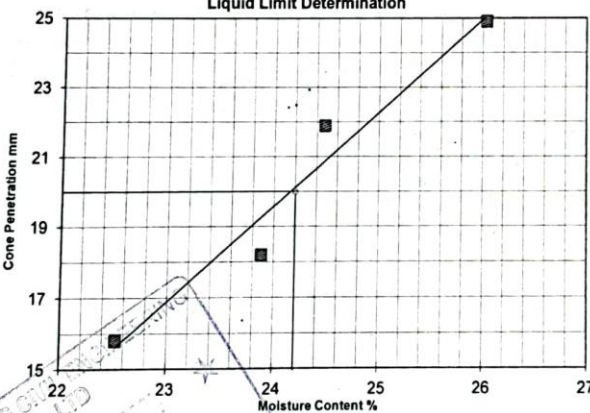
INSTITUTION		STUDENTS NAMES		CONTRACTOR	
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling	
PROJECT : ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS					
PARTICLE SIZE DISTRIBUTION (BS 1377 - 2 - 90)					
Test Reference No.:			Lab. Reference No.:		
Location : (km)		WEAK SUBGRADE SOILS STABILISED WITH 30% RIVER SAND & 6% SAWDUST		Dry wt. of sample before washing: (g)	
Depth: (m)				3519.9	
Material description:		WEAK SUBGRADE		Dry wt. of sample after washing: (g)	
				2354.4	
				Date Sampled:	
				Date Tested:	
				Technician	
				10/Dec/2023	
				1/Mar/2024	
				Lab team	
Sieve Size (mm)	Weight Retained (g)	Retained (%)	Passing (%)	Grading Limits (G60 & 80)	
63.0	0.0	0	100	100	100
37.5	0.0	0.0	100	80	100
20.0	0.0	0.0	100	60	95
5.0	20.0	0.6	99	30	65
2.00	59.7	1.7	98	20	50
0.425	843.5	24.0	74	10	30
0.075	1417.1	40.3	34	5	15
Total fines	1179.6	33.5			
Bottom Pan	14.1				
Extracted fines	1165.5				
Total sample	3519.9				
Grading Modulus		0.95			


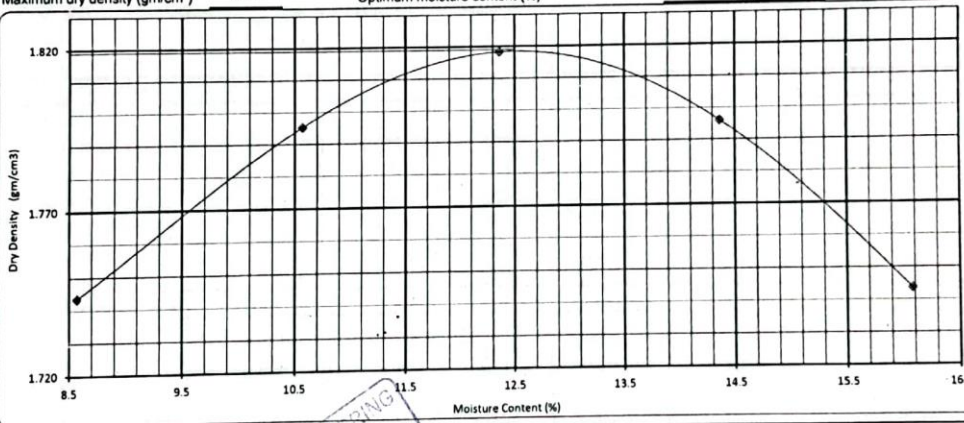





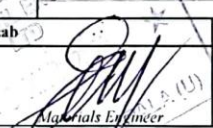
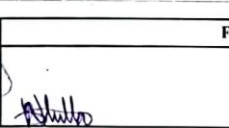
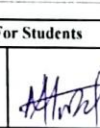
FOR TESTING LAB  Lab Technician	FOR STUDENTS  
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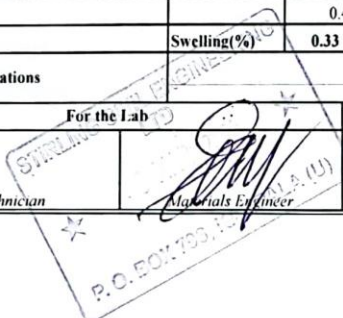



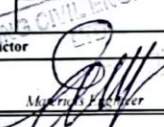


INSTITUTION		STUDENTS		TESTING LAB																			
 UGANDA CHRISTIAN UNIVERSITY <small>A Vision of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling																			
PROJECT:		ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS																					
ATTERBERG LIMITS																							
<i>Liquid limit (cone penetrometer) and plastic limit</i>																							
Test Reference No.:		Lab. Reference No.:		Technician:	Lab Team																		
Location		RADE SOILS STABILISED WITH 30% RIVER SAND & 6		Sample Date	10/Dec/2023																		
Test method		BS 1377: Part 2, 1990 4 3/4 4		Test Date	13/Dec/2023																		
LAYER		WEAK SUBGRADE																					
PLASTIC LIMIT																							
	Test No	DT	J		Average																		
	Mass of wet soil + container (g)	34.85	32.95		33.9																		
	Mass of dry soil + container (g)	33.02	31.58		32.3																		
	Mass of container (g)	22.8	23.9		23.35																		
	Mass of moisture (g)	1.83	1.4		1.6																		
	Mass of dry soil (g)	10.22	7.68		8.95																		
	Moisture content %	17.9	17.8		17.9																		
AVERAGE																							
LIQUID LIMIT																							
	Test No	1	2	3	4																		
	Initial gauge reading (mm)	0	0	0	0																		
	Final gauge reading (mm)	15.2	17.9	21.9	25.0																		
	penetration (mm)	15.2	17.9	21.9	25.0																		
AVERAGE		15.2	17.9	21.9	25.0																		
Container No.		PI42	PA	FOO	A6																		
Mass of wet soil + container (g)		60.38	66.81	71.51	70.80																		
Mass of dry soil + container (g)		53.09	55.29	58.75	57.59																		
Mass of container (g)		20.69	6.77	6.86	6.83																		
Mass of moisture (g)		7.29	11.52	12.76	13.21																		
Mass of dry soil (g)		32.4	48.52	51.89	50.76																		
Moisture content (%)		22.5	23.7	24.6	26.0																		
AVERAGE		22.5	23.7	24.6	26.0																		
Liquid Limit Determination																							
				<table border="1"> <tr> <td>Liquid limit (%)</td> <td>24.2</td> </tr> <tr> <td>Plastic limit (%)</td> <td>17.9</td> </tr> <tr> <td>Plasticity Index (%)</td> <td>6.3</td> </tr> <tr> <td colspan="2" style="text-align: center;">Linear shrinkage</td> </tr> <tr> <td>Trough No</td> <td>Y</td> </tr> <tr> <td>Trough length (cm)</td> <td>14.0</td> </tr> <tr> <td>Specimen length (cm)</td> <td>13.6</td> </tr> <tr> <td>L. shrinkage =</td> <td>0.4</td> </tr> <tr> <td>% L. shrinkage =</td> <td>3.2</td> </tr> </table>		Liquid limit (%)	24.2	Plastic limit (%)	17.9	Plasticity Index (%)	6.3	Linear shrinkage		Trough No	Y	Trough length (cm)	14.0	Specimen length (cm)	13.6	L. shrinkage =	0.4	% L. shrinkage =	3.2
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Remarks:																							
TESTING LAB  Materials Engineer			STUDENTS  																				
 Lab Technician																							


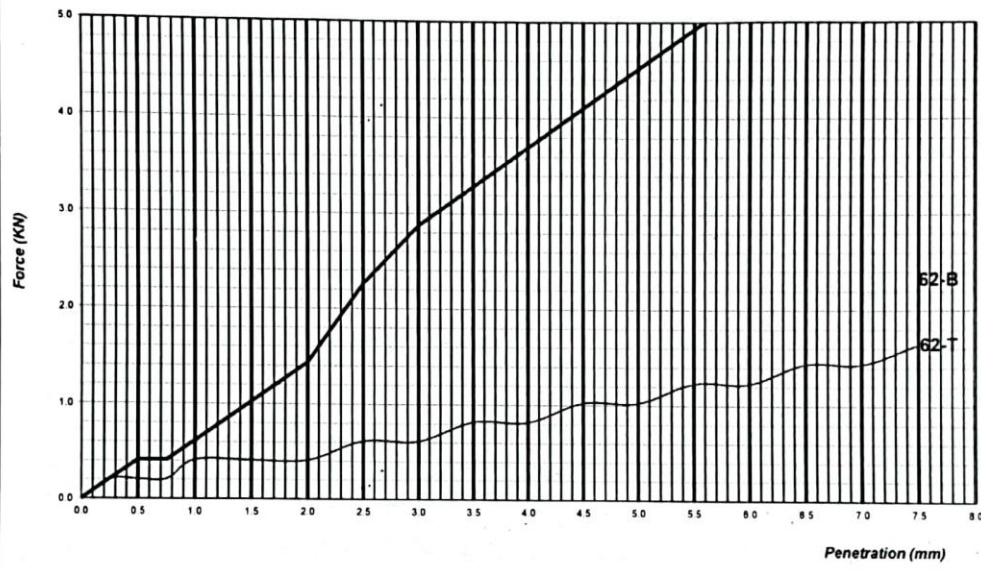
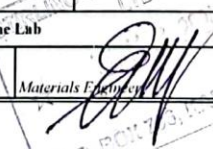

INSTITUTION		STUDENTS		TESTING LAB																			
 UGANDA CHRISTIAN UNIVERSITY <small>A Church of Christ in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling																			
PROJECT:		ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS																					
ATTERBERG LIMITS																							
<i>Liquid limit (cone penetrometer) and plastic limit</i>																							
Test Reference No.:		Lab. Reference No.:		Technician:																			
Location		RADE SOILS STABILISED WITH 30% RIVER SAND & d		Sample Date																			
Test method		BS 1377: Part 2, 1990.4 3/4 4		Test Date																			
LAYER		WEAK SUBGRADE																					
PLASTIC LIMIT																							
	Test No.	OG	LL		Average																		
Mass of wet soil + container (g)		38.31	47.31		42.81																		
Mass of dry soil + container (g)		35.77	43.6		39.685																		
Mass of container (g)		21.43	22.37		21.9																		
Mass of moisture (g)		2.54	3.7		3.125																		
Mass of dry soil (g)		14.34	21.23		17.785																		
Moisture content %		17.7	17.5		17.6																		
AVERAGE																							
LIQUID LIMIT																							
	Test No	1	2	3	4																		
Initial gauge reading (mm)		0	0	0	0																		
Final gauge reading (mm)		15.8	18.2	21.9	24.9																		
penetration (mm)		15.8	18.2	21.9	24.9																		
AVERAGE		15.8	18.2	21.9	24.9																		
Container No.		PIB6	PIMO	P126	AB																		
Mass of wet soil + container (g)		62.45	60.55	58.78	61.70																		
Mass of dry soil + container (g)		52.26	50.25	48.63	50.42																		
Mass of container (g)		7.02	7.12	7.16	7.09																		
Mass of moisture (g)		10.19	10.3	10.15	11.28																		
Mass of dry soil (g)		45.24	43.13	41.47	43.33																		
Moisture content (%)		22.5	23.9	24.5	26.0																		
AVERAGE		22.5	23.9	24.5	26.0																		
Liquid Limit Determination																							
					<table border="1"> <tr> <td>Liquid limit (%)</td> <td>24.2</td> </tr> <tr> <td>Plastic limit (%)</td> <td>17.6</td> </tr> <tr> <td>Plasticity Index (%)</td> <td>6.6</td> </tr> <tr> <td colspan="2" style="text-align: center;">Linear shrinkage</td> </tr> <tr> <td>Trough No.</td> <td>Y</td> </tr> <tr> <td>Trough length (cm)</td> <td>14.0</td> </tr> <tr> <td>Specimen length (cm)</td> <td>13.6</td> </tr> <tr> <td>L.shringage =</td> <td>0.4</td> </tr> <tr> <td>% L.shrinkage =</td> <td>3.2</td> </tr> </table>	Liquid limit (%)	24.2	Plastic limit (%)	17.6	Plasticity Index (%)	6.6	Linear shrinkage		Trough No.	Y	Trough length (cm)	14.0	Specimen length (cm)	13.6	L.shringage =	0.4	% L.shrinkage =	3.2
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Remarks:																							
TESTING LAB		STUDENTS																					
Materials Engineer.																							
Lab Technician																							


INSTITUTION	STUDENTS NAMES		TESTING LAB		
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>	NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling		
PROJECT: ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS					
Test Reference No.	Lab Reference No	Date Sampled	Date Tested	Technician	
Mix	WEAK SUBGRADE SOILS STABILISED WITH 30% RIVER SAND & 8% SAWDUST	10/Dec/23	1/Mar/24	Lab team	
Material description:	WEAK SUBGRADE		Natural moisture (%):	11.0	
TEST DATA					
Weight of rammer (Kg)	No. of blows per layer	No of layers	Height of drop (mm)	Diameter of mould(mm)	Volume of mould (cm ³)
4.5	62	5	457	152	2,305
MOISTURE CONTENT DATA					
Test No.	1	2	3	4	5
Tin No.	A	A	A	A	A
Water Added	cm ³	180	240	300	360
Mass of Compacted soil + mould	gm	5,108	5,200	5,258	5,269
Mass of Mould	gm	3,215	3,215	3,215	3,215
Mass of Compacted soil	gm	1893	1985	2043	2054
Volume of mould	cm ³	1,000	1,000	1,000	1,000
Wet density of soil	g/cm ³	1.893	1.985	2.043	2.054
DATA FOR PROCTOR CURVE					
Container No.	MJR	BAK	BBC	ACB	Z6T
Mass of wet soil + Container	gm	2,172.0	2,050.0	2,081.0	2,031.0
Mass of dry soil + container	gm	2,063.0	1,931.0	1,941.0	1,874.0
Mass of container	gm	791.0	805.0	808.0	781.0
Mass of water added	gm	109	119	140	157
Mass of dry soil	gm	1272	1126	1133	1093
Moisture content	%	8.6	10.6	12.4	14.4
Dry density	g/cm ³	1.744	1.795	1.818	1.796
Maximum dry density (gm/cm ³)	1.819		Optimum moisture content (%)		12.5
					
Remarks:					
FOR TESTING LAB			FOR STUDENTS		
Lab Technician	 Materials Engineer				

Institution		Students Names		Testing Lab	
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling	
ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS					
CALIFORNIA BEARING RATIO TEST (BS 1377 Part 4)					
Test sample reference :		Laboratory Reference No.:		Sampling Date :	
Location:		WEAK SUBGRADE SOILS STABILISED WITH 30% RIVER SAND & 6% SAWDUST		Casting date : 1/Mar/24	
Sample Description:		WEAK SUBGRADE.		Testing Date : 15/Mar/24	
				Technician : Lab team	
				Volume of Mould used (m ³) 2305	
Natural moisture of air dried sample			Volume of water added		
Tin No.	NMT		Mass of air dried soil (g)	6000	
Tin + air dried soil sample (g)	1951		MDD (Mg/m ³)	1.819	
Tin + oven dry soil sample (g)	1922		N.M.C (%)	2.5	
Tin (g)	768		OMC (%)	12.5	
Dry soil sample	1154		Added OMC (%)	10.0	
Water (g)	29		Calculated dry wt of soil (g)	5849.2	
N.M.C (%)	2.5		Water added (g)	585	
Average (%)	2.5		Water added (mL)	585	
Number of blows	62				
Number of layer	5				
Water Content Determination		Before Soaking	After Soaking		
Tare No	CML	-	BA	-	
Mass of wet sample + Tare	g	2147	-	2422	-
Mass of dry sample + Tare	g	2012	-	2214	-
Mass of Tare	g	877	-	768	-
Mass of water	g	135	-	208	-
Mass of dry sample	g	1135	-	1446	-
Water content	%	11.9	-	14.4	-
Average water Content	%	11.9	-	14.4	-
Density determination		DT			
Mould No					
Mass of mould + soil	g	10209		10326	
Mass of mould	g	5501		5501	
Mass of soil	g	4708		4825	
Volume of the mould	cm ³	2305		2305	
Moist density	g/cm ³	2.043		2.093	
Dry density	g/cm ³	1.825		1.830	
Swell Determination		Hour	D.Gauge Reading		
Date		96 hrs	12.1		
Initial reading			12.52		
Final reading			127		
Height of the specimen			0.42		
Height of swell					
		Swelling(%)	0.33		
Observations					
For the Lab			For Students		
Lab. Technician 		Materials Engineer 			



Institution	Students Names		Testing Lab		
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>	NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling		
ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS					
CALIFORNIA BEARING RATIO TEST (BSI377 Part 4)					
Test sample reference	Laboratory Reference No		Sampling Date	10/Dec/23	
Location:			Penetration Date	15/Mar/24	
Depth:			Technician	Lab team	
Sample Description:	WEAK SUBGRADE				
Number of blows per layer	62				
Number of layers	5		5	5	
Mould No	DT				
Capacity of the Proving Ring (KN)	50		50	50	
Proving Ring Constant (KN/div.)	0.2052		0.2052	0.2052	
Speed: mm/min	Top		Bottom		
Penetration of the plunger (mm)	Time (s)	Reading *10 ³ mm	Force (KN)	Reading *10 ³ mm	Force (KN)
0	0	0	0.0	0	0.0
0.25	12	1	0.2	1	0.2
0.5	24	1	0.2	2	0.4
0.75	35	1	0.2	2	0.4
1	47	2	0.4	3	0.6
1.5	71	2	0.4	5	1.0
2	94	2	0.4	7	1.4
2.5	118	3	0.6	11	2.3
3	142	3	0.6	14	2.9
3.5	165	4	0.8	16	3.3
4	189	4	0.8	18	3.7
4.5	213	5	1.0	20	4.1
5	236	5	1.0	22	4.5
5.5	260	6	1.2	24	4.9
6	283	6	1.2	26	5.3
6.5	307	7	1.4	28	5.7
7	331	7	1.4	29	6.0
7.5	354	8	1.6	30	6.2
Observations					
For the Contractor			For Students		
 <small>Madhusri's Engineer</small>					
					

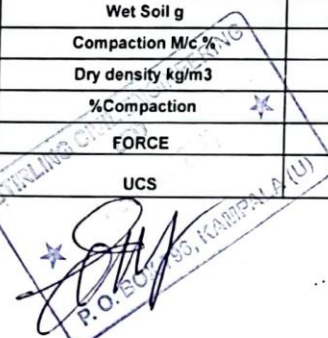
Institution	Students Names		Testing Lab	
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>	NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		<div style="border: 2px solid black; padding: 5px; display: inline-block;">Stirling</div>	
ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS				
CALIFORNIA BEARING RATIO TEST (BS1377 Part 4)				
Test sample reference :	Laboratory Reference No.:	Sampling Date :	10/Dec/23	
Location:		Testing Date :	15/Mar/24	
Depth:		Technician :	Lab team	
Sample Description:	WEAK SUBGRADE			
PENETRATION vs FORCE CURVE				
				
	62 blows			
	Force		CBR	
	Bottom	Top	Bottom	Top
2.5 mm Penetration	2.3	0.6	17	5
5.0 mm Penetration	4.5	1.0	23	5
Average	3.4	0.8	19.8	4.9
Retained CBR	19.8			
Observations	CBR= 20			
	For the Lab		For Students	
Lab. Technician	 Materials Engineer			

INSTITUTION		STUDENTS NAMES		TESTING LAB	
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		<h1 style="margin: 0;">Stirling</h1>	
PROJECT		ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS			
STABILISED CBR (BS 1924 PART 2 1)					
WEAK SUBGRADE SOILS STABILISED WITH 45% RIVER SAND & 3% SAWDUST					
M/c of air dried sample			M/c After Mixing		
Tin No	UBB		Stabiliser	45% RIVER SAND & 3% SAWDUST	
Tin + Wet soil gm	1758		Content	5.0	
Tin + Dry Soil gm	1726		Tin No	AXE	
Tin gm	505		Tin + Wet Soil	2155	
Water gm	32.0		Tin + Dry Soil	2026	
Dry Soil gm	1,221.0		Tin	805	
M/c %	2.6		Water	129.0	
Av. M/c %	2.6		Dry Soil	1,221.0	
			M/c	10.6	

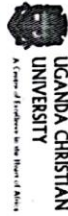
(a)MDD	<u>1.857</u>	kg/m ³	(b)Air Dry M/c	<u>2.6</u>	%
(c)WD	<u>1.931</u>	kg/m ³	(e)M/c to add	<u>7.8</u>	%
(d)OMC	<u>10.4</u>	%	(F) volume	2.305	

Date prepared	2/Mar/24	Date immerse	9/Mar/24	Date tested	16/Mar/24
Mould No.					
Factor(f)		2.305			
(h)Wet Soil to fill mould c x f x %comp		4,451.6			
(j) Wt of air dried soil		6,000			
Air dry M/c		2.6			
(k) soil dry wt (100j/100+b)		5,846.8			
Stabiliser		45% RIVER SAND & 3% SAWDUST			
(m)Stabilisers content %		5.0			
(n) Stabiliser to add k x(m/100)		292.3			
Water Addition((j+n)x(d-b))/(100+b)		477.0			
Wt. per layer CBR Only h/3					

SPECIMEN WEIGHT CHECK			
No. of blows	62.0	62.0	AVERAGE
Mould No.	7 DAYS AIR TIGHT, 7 DAYS SOAKED	7 DAYS AIR TIGHT, 7 DAYS SOAKED	
Stabiliser	45% RIVER SAND & 3% SAWDUST	45% RIVER SAND & 3% SAWDUST	
Content %	5.0	5.0	
Mould g	A	B	
Wet Soil g	4,856.0	4,820.0	
Compaction M/c %	10.6	10.6	
Dry density kg/m ³	1.905	1.891	
%Compaction	102.6	101.8	
FORCE	3.9	3.7	
UCS	0.214	0.203	0.21


 P.O. BOX 99, KAMPALA (U)





UGANDA CHRISTIAN UNIVERSITY
A Centre of Excellence in the Heart of Africa

NAMBOOZE JUSTINE SHILLA (S20832/214) &
MCARNOLD GARRY (S20832/033)

Stirling

INSTITUTION

STUDENTS

TESTING LAB

PROJECT:

ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS

SUMMARY OF TEST RESULTS FOR WEAK SUBGRADE STABILISED WITH 45% RIVER SAND & 3% SAW

LOCATION	BLENDED %	SAMPLING DATE	GRADING										ATTERBERG LIMITS				MDD		CBR	CBR SWELL	AVERAGE
			63	37.5	20	5	2	0.425	0.075	GM	LL	PL	PI	LS	MDD	OMC	62				
WEAK SUBGRADE STABILISE D WITH 45% RIVER SAND & 3% SAWDUST	WEAK SUBGRADE SOILS	12/10/2023	100	100	100	99	96	72	29	1.02	23.3	18.0	5.3	2.7	1.857	10.4	23.7	0.46	0.46		
			100	100	100	98	97	80	24	0.99	23.3	18.0	5.2	2.7	-	-	-	-	-		
			100	100	100	98.83	96.75	76.32	26.34	1.01	23.3	18.0	5.2	2.7	1.857	10.4	24	0.46	0.46		
AVERAGE			100	100	100	99	97	76	26	1.006	23.3	18.0	5.2	2.7	1.857	10.4	23.7	0.46	0.46		

FOR LAB


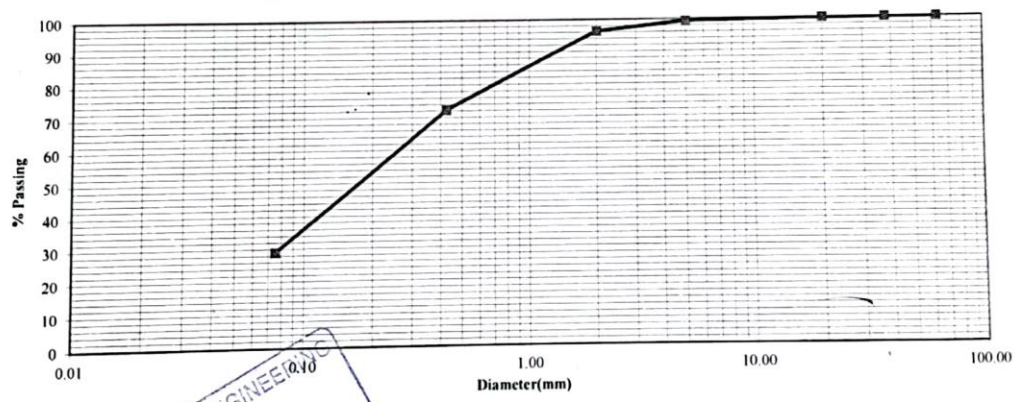
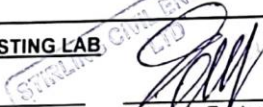

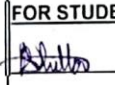
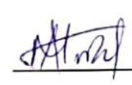
Lab Technician

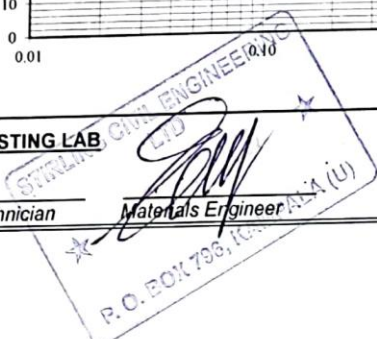
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P.O. BOX 1561, KAMPALA, UGANDA
Master Civil Engineer


FOR STUDENTS

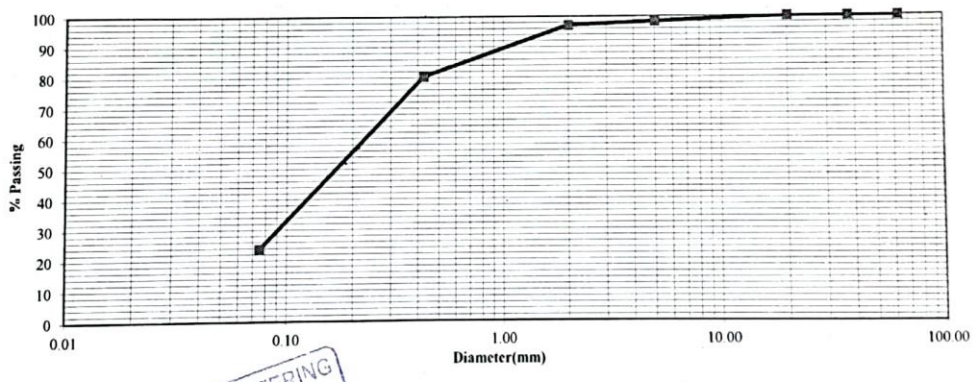
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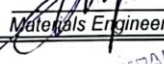


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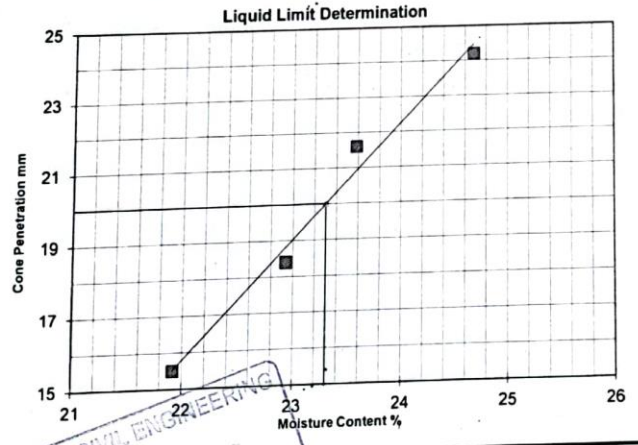
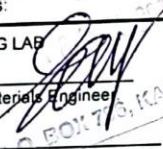
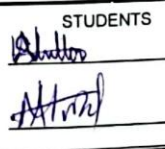

INSTITUTION		STUDENTS NAMES		CONTRACTOR	
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling	
PROJECT : ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS					
PARTICLE SIZE DISTRIBUTION (BS 1377 - 2 - 90)					
Test Reference No.:			Lab. Reference No.:		
Location : (km)	WEAK SUBGRADE STABILISED WITH 45% RIVER SAND & 3% SAWDUST		Dry wt. of sample before washing: (g)	2996.2	
Depth: (m)			Dry wt. of sample after washing: (g)	2155.5	
Material description:	WEAK SUBGRADE SOILS		Date Sampled:	Date Tested:	Technician
			10/Dec/2023	1/Mar/2024	Lab team
Sieve Size (mm)	Weight Retained (g)	Retained (%)	Passing (%)	Grading Limits (G60 & 80)	
63.0	0.0	0	100	100	100
37.5	0.0	0.0	100	80	100
20.0	0.0	0.0	100	60	95
5.0	20.5	0.7	99	30	65
2.00	89.6	3.0	96	20	50
0.425	720.2	24.0	72	10	30
0.075	1296.8	43.3	29	5	15
Total fines	869.1	29.0			
Bottom Pan	28.4				
Extracted fines	840.7				
Total sample	2996.2				
Grading Modulus		1.02			
					
FOR TESTING LAB			FOR STUDENTS		
 Lab Technician		 Materials Engineer		 	


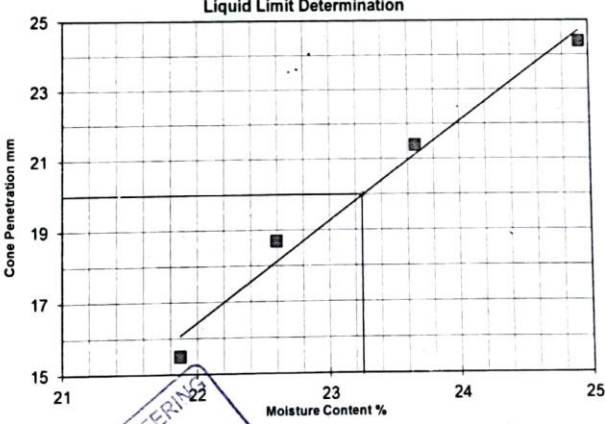
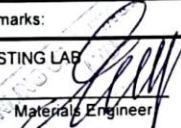
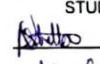




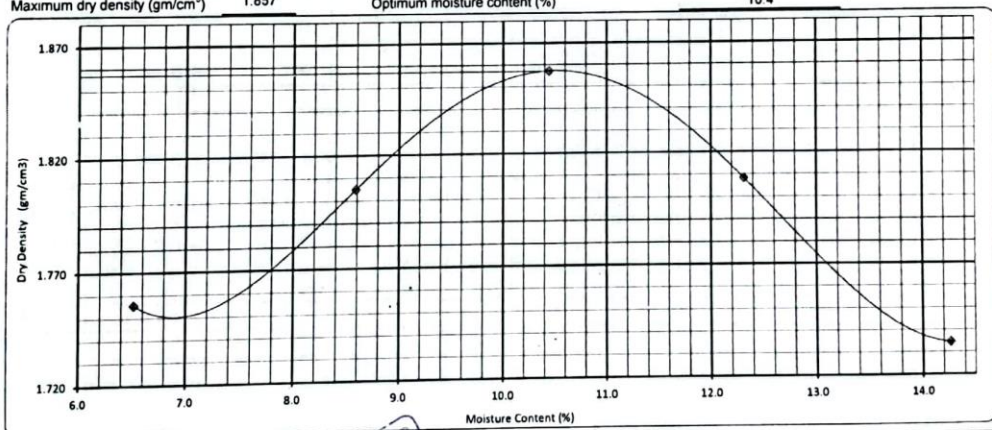


INSTITUTION  UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>		STUDENTS NAMES NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		CONTRACTOR <div style="border: 2px solid black; padding: 5px; display: inline-block;"> Stirling </div>	
PROJECT : ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS					
PARTICLE SIZE DISTRIBUTION (BS 1377 - 2 - 90)					
Test Reference No.:			Lab. Reference No.:		
Location : (km)	WEAK SUBGRADE STABILISED WITH 45% RIVER SAND & 3% SAWDUST		Dry wt. of sample before washing: (g)	2514.7	
Depth: (m)			Dry wt. of sample after washing: (g)	1939.9	
Material description:	WEAK SUBGRADE SOILS		Date Sampled:	Date Tested:	Technician
			10/Dec/2023	1/Mar/2024	Lab team
Sieve Size (mm)	Weight Retained (g)	Retained (%)	Passing (%)	Grading Limits (G60 & 80)	
63.0	0.0	0	100	100	100
37.5	0.0	0.0	100	80	100
20.0	0.0	0.0	100	60	95
5.0	41.5	1.7	98	30	65
2.00	29.3	1.2	97	20	50
0.425	423.5	16.8	80	10	30
0.075	1425.1	56.7	24	5	15
Total fines	595.3	23.7			
Bottom Pan	20.5				
Extracted fines	574.8				
Total sample	2514.7				
Grading Modulus		0.99			







FOR TESTING LAB <div style="border: 1px solid black; padding: 5px; display: inline-block; transform: rotate(-15deg);"> STIRLING CIVIL ENGINEERING LTD </div> Lab Technician:  Materials Engineer: 	FOR STUDENTS  
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INSTITUTION		STUDENTS		TESTING LAB	
 UGANDA CHRISTIAN UNIVERSITY <small>A Course of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling	
PROJECT:		ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS			
ATTERBERG LIMITS					
<i>Liquid limit (cone penetrometer) and plastic limit</i>					
Test Reference No.:		Lab. Reference No.:		Technician:	Lab Team
Location		BGRADE STABILISED WITH 45% RIVER SAND & 3%		Sample Date	10/Dec/2023
Test method		BS 1377: Part 2, 1990 4.3/4.4		Test Date	13/Dec/2023
LAYER		WEAK SUBGRADE SOILS			
PLASTIC LIMIT					
	Test No	DT	PNU		Average
Mass of wet soil + container (g)		39.58	46.84		43.21
Mass of dry soil + container (g)		37	43.2		40.1
Mass of container (g)		22.76	22.85		22.805
Mass of moisture (g)		2.58	3.6		3.11
Mass of dry soil (g)		14.24	20.35		17.295
Moisture content %		18.1	17.9		18.0
AVERAGE					
LIQUID LIMIT					
	Test No	1	2	3	4
Initial gauge reading (mm)		0	0	0	0
Final gauge reading (mm)		15.5	18.4	21.6	24.2
penetration (mm)		15.5	18.4	21.6	24.2
AVERAGE		15.5	18.4	21.6	24.2
Container No.		FORD	PIV/PN	A5	BC
Mass of wet soil + container (g)		44.65	48.18	57.98	59.98
Mass of dry soil + container (g)		37.86	40.52	48.26	49.52
Mass of container (g)		6.88	7.12	7.04	7.14
Mass of moisture (g)		6.79	7.66	9.72	10.46
Mass of dry soil (g)		30.98	33.4	41.22	42.38
Moisture content (%)		21.9	22.9	23.6	24.7
AVERAGE					
					
Liquid limit (%)		23.3			
Plastic limit (%)		18.0			
Plasticity Index (%)		5.3			
Linear shrinkage					
Trough No.		Y			
Trough length (cm)		14.0			
Specimen length (cm)		13.6			
L.shrinkage =		0.4			
% L.shrinkage =		2.7			
Remarks:					
TESTING LAB		STUDENTS			
 Materials Engineer		 Student			
 Lab Technician					


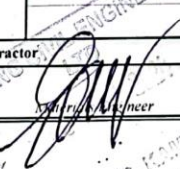


INSTITUTION  UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>		STUDENTS NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		TESTING LAB <div style="border: 2px solid black; padding: 5px; display: inline-block;">Stirling</div>	
PROJECT:		ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS			
ATTERBERG LIMITS					
<i>Liquid limit (cone penetrometer) and plastic limit</i>					
Test Reference No.:		Lab. Reference No.:		Technician:	Lab Team
Location		BGRADE STABILISED WITH 45% RIVER SAND & 3% ASH		Sample Date	10/Dec/2023
Test method		BS 1377: Part 2, 1990.4 3/4 4		Test Date	13/Dec/2023
LAYER		WEAK SUBGRADE SOILS			
PLASTIC LIMIT					
	Test No.	KK	4L		Average
Mass of wet soil + container (g)		44.31	39.00		41.655
Mass of dry soil + container (g)		40.89	36.5		38.695
Mass of container (g)		22.22	22.44		22.33
Mass of moisture (g)		3.42	2.5		2.96
Mass of dry soil (g)		18.67	14.06		16.365
Moisture content %		18.3	17.8		18.0
AVERAGE					
LIQUID LIMIT					
	Test No	1	2	3	4
Initial gauge reading (mm)		0	0	0	0
Final gauge reading (mm)		15.5	18.7	21.4	24.4
penetration (mm)		15.5	18.7	21.4	24.4
AVERAGE		15.5	18.7	21.4	24.4
Container No		P157	BC	P182	A15
Mass of wet soil + container (g)		51.39	51.45	57.88	57.67
Mass of dry soil + container (g)		43.40	43.28	48.15	47.56
Mass of container (g)		6.87	7.12	7.02	7.00
Mass of moisture (g)		7.99	8.17	9.73	10.11
Mass of dry soil (g)		36.53	36.16	41.13	40.56
Moisture content (%)		21.9	22.6	23.7	24.9
AVERAGE		21.9	22.6	23.7	24.9
Liquid Limit Determination					
				Liquid limit (%) 23.3 Plastic limit (%) 18.0 Plasticity Index (%) 5.2 Linear shrinkage	
				Trough No Y Trough length (cm) 14.0 Specimen length (cm) 13.6 L.shrinkage = 0.4 % L.shrinkage = 2.7	
Remarks:					
TESTING LAB  Materials Engineer			STUDENTS  		
Lab Technician					

INSTITUTION		STUDENTS NAMES			TESTING LAB	
 UGANDA CHRISTIAN UNIVERSITY <small>A University of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)			Stirling	
PROJECT: ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS						
Test Reference No.	Lab. Reference No.	Date Sampled	Date Tested	Technician		
Mix	WEAK SUBGRADE STABILISED WITH 45% RIVER SAND & 3% SAWDUST	10/Dec/23	1/Mar/24	Lab team		
Material description:	WEAK SUBGRADE SOILS		Natural moisture (%) :	11.0		
TEST DATA						
Weight of rammer (Kg)	No. of blows per layer	No of layers	Height of drop (mm)	Diameter of mould(mm)	Volume of mould (cm ³)	
4.5	62	5	457	152	2,305	
MOISTURE CONTENT DATA						
Test No.	1	2	3	4	5	
Tin No.	A	A	A	A	A	
Water Added	cm ³	180	240	300	360	420
Mass of Compacted soil + mould	gm	5,085	5,175	5,266	5,246	5,197
Mass of Mould	gm	3,215	3,215	3,215	3,215	3,215
Mass of Compacted soil	gm	1870	1960	2051	2031	1982
Volume of mould	cm ³	1,000	1,000	1,000	1,000	1,000
Wet density of soil	g/cm ³	1.870	1.960	2.051	2.031	1.982
DATA FOR PROCTOR CURVE						
Container No		JKL	FOR	AXE	JK	ROD
Mass of wet soil + Container	gm	2,355.0	2,104.0	2,159.0	1,856.0	2,175.0
Mass of dry soil + container	gm	2,260.0	2,000.0	2,031.0	1,708.0	2,004.0
Mass of container	gm	802.0	789.0	805.0	506.0	805.0
Mass of water added	gm	95	104	128	148	171
Mass of dry soil	gm	1458	1211	1226	1202	1199
Moisture content	%	6.5	8.6	10.4	12.3	14.3
Dry density	g/cm ³	1.756	1.805	1.857	1.808	1.735
Maximum dry density (g/cm ³)	1.857		Optimum moisture content (%)		10.4	
						
Remarks:						
FOR TESTING LAB			FOR STUDENTS			
Lab Technician	 Materials Engineer					


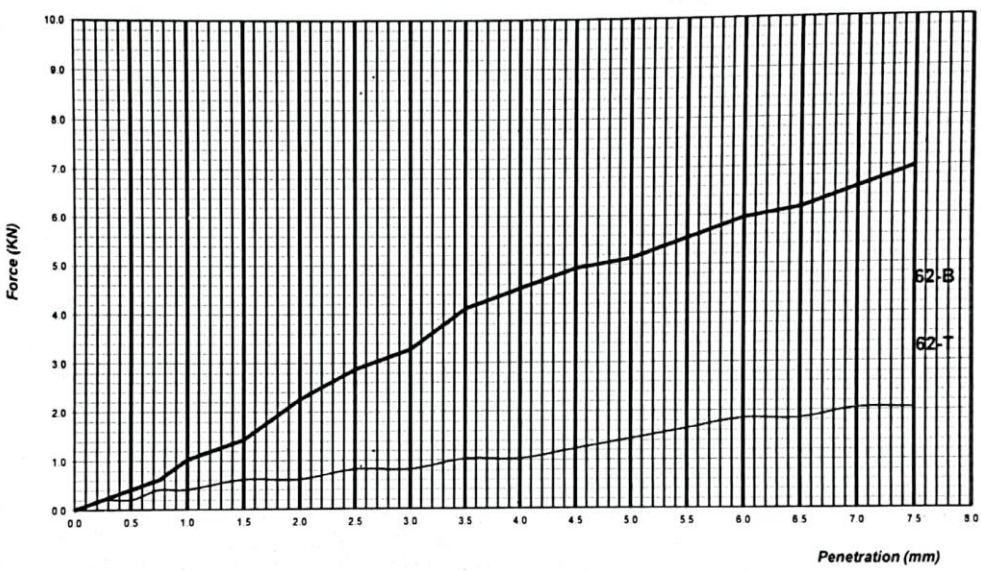



Institution		Students Names		Testing Lab	
 UGANDA CHRISTIAN UNIVERSITY <small>A School of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling	
ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS					
CALIFORNIA BEARING RATIO TEST (BS 1377 Part 4)					
Test sample reference :		Laboratory Reference No.:		Sampling Date :	
		WEAK SUBGRADE STABILISED WITH 45%		10/Dec/23	
Location:		RIVER SAND & 3% SAWDUST		Casting date :	
				3/Mar/24	
				Testing Date :	
				7/Mar/24	
Sample Description:		WEAK SUBGRADE SOILS		Technician :	
				Lab team	
				Volume of Mould used (m ³)	
				2305	
Natural moisture of air dried sample			Volume of water added		
Tin No.	UBB		Mass of air dried soil (g)	6000	
Tin + air dried soil sample (g)	1758		MDD (Mg/m ³)	1.857	
Tin + oven dry soil sample (g)	1726		N.M.C (%)	2.6	
Tin (g)	505		OMC (%)	10.4	
Dry soil sample	1221		Added OMC (%)	7.8	
Water (g)	32		Calculated dry wt of soil (g)	5842.8	
N.M.C (%)	2.6		Water added (g)	455	
Average (%)	2.6		Water added (mL)	455	
Number of blows		62			
Number of layer		5			
Water Content Determination		Before Soaking	After Soaking		
Tare No	AXE	-	SER	-	
Mass of wet sample + Tare	g	2155	-	1752	-
Mass of dry sample + Tare	g	2026	-	1625	-
Mass of Tare	g	805	-	805	-
Mass of water	g	129	-	127	-
Mass of dry sample	g	1221	-	820	-
Water content	%	10.6	-	15.5	-
Average water Content	%	10.6		15.5	
Density determination		BB			
Mould No					
Mass of mould + soil	g	10926		11143	
Mass of mould	g	6509		6509	
Mass of soil	g	4417		4634	
Volume of the mould	cm ³	2305		2305	
Moist density	g/cm ³	1.916		2.011	
Dry density	g/cm ³	1.733		1.741	
Swell Determination		1 Hour	D. Gauge Reding		
Date		96 hrs	17.26		
Initial reading			17.85		
Final reading			127		
Height of the specimen			0.59		
Height of swell					
		Swelling(%)	0.46		
Observations					
For the Lab			For Students		
Lab Technician	 Material Engineer		 Shilla	 Arnold	



Institution		Students Names				Testing Lab	
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)				Stirling	
ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS							
CALIFORNIA BEARING RATIO TEST (BS1377 Part 4)							
Test sample reference :		Laboratory Reference No.:		Sampling Date		10/Dec/23	
Location:				Penetration Date		7/Mar/24	
Depth :				Technician		:: Lab team	
Sample Description :		WEAK SUBGRADE SOILS					
Number of blows per layer		62		5		5	
Number of layers		5		5		5	
Mould No		BB		50		50	
Capacity of the Proving Ring (KN)		50		50		50	
Proving Ring Constant (KN/div.)		0.2052		0.2052		0.2052	
Speed : mm min.		Top		Bottom			
Penetration of the plunger (mm)	Time (s)	Reading *10 ³ mm	Force (KN)	Reading *10 ³ mm	Force (KN)		
0	0	0	0.0	0	0.0		
0.25	12	1	0.2	1	0.2		
0.5	24	1	0.2	2	0.4		
0.75	35	2	0.4	3	0.6		
1	47	2	0.4	5	1.0		
1.5	71	3	0.6	7	1.4		
2	94	3	0.6	11	2.3		
2.5	118	4	0.8	14	2.9		
3	142	4	0.8	16	3.3		
3.5	165	5	1.0	20	4.1		
4	189	5	1.0	22	4.5		
4.5	213	6	1.2	24	4.9		
5	236	7	1.4	25	5.1		
5.5	260	8	1.6	27	5.5		
6	283	9	1.8	29	6.0		
6.5	307	9	1.8	30	6.2		
7	331	10	2.1	32	6.6		
7.5	354	10	2.1	34	7.0		
Observations							
For the Contractor				For Students			
Lab. Technician		 <small>Engineer</small>					



Institution	Students Names	Testing Lab
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>	NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)	Stirling
ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS		
CALIFORNIA BEARING RATIO TEST (BS1377 Part 4)		
Test sample reference :	Laboratory Reference No.:	Sampling Date : 10/Dec/23
Location:		Testing Date : 7/Mar/24
Depth:		Technician : Lab team
Sample Description: WEAK SUBGRADE SOILS		
PENETRATION vs FORCE CURVE		
		
	62 blows	
	Force CBR	
	Bottom	Top
2.5 mm Penetration	2.9	0.8
5.0 mm Penetration	5.1	1.4
Average	4.0	1.1
Retained CBR	23.7	
Observations	CBR = 24	
For the Lab	For Students	
Lab. Technician	Materials Engineer	

INSTITUTION	STUDENTS NAMES	TESTING LAB
 UGANDA CHRISTIAN UNIVERSITY A Centre of Excellence in the Heart of Africa	NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)	<h1 style="margin: 0;">Stirling</h1>

PROJECT	ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS
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STABILISED CBR
(BS 1924 PART 2 1)

WEAK SUBGRADE SOILS STABILISED WITH 60% RIVER SAND ONLY


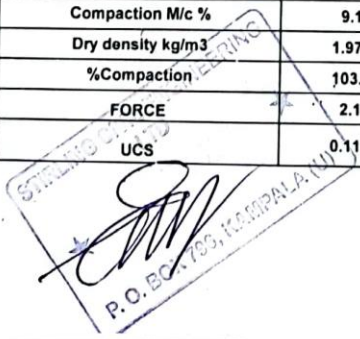
M/c of air dried sample			M/c After Mixing		
Tin No	KAN		Stabiliser	60% RIVER SAND ONLY	
Tin + Wet soil gm	2594		Content	5.0	
Tin + Dry Soil gm	2577		Tin No.	CMD	
Tin gm	799		Tin + Wet Soil	2183	
Water gm	17.0		Tin + Dry Soil	2065	
Dry Soil gm	1,778.0		Tin	765	
M/c %	1.0		Water	118.0	
Av. M/c %	1.0		Dry Soil	1,300.0	
			M/c	9.1	

(a)MDD	1.898	kg/m ³	(b)Air Dry M/c	1.0	%
(c)WD	1.537	kg/m ³	(e)M/c to add	7.1	%
(d)OMC	8.1	%	(F) volume	2.305	

Date prepared 2/Mar/24 Date immerse 9/Mar/24 Date tested 16/Mar/24

Mould No.			
Factor(f)	2.305		
(h)Wet Soil to fill mould c x f x %comp	3,542.7		
(j) Wt of air dried soil	6,000		
Air dry M/c	1.0		
(k) soil dry wt (100j/100+b)	5,943.2		
Stabiliser	60% RIVER SAND ONLY		
(m)Stabilisers content %	5.0		
(n) Stabiliser to add k x(m/100)	297.2		
Water Addition((j+n)x(d-b))/(100+b)	445.6		
Wt. per layer CBR Only h/3			

SPECIMEN WEIGHT CHECK			
No. of blows	62.0	62.0	AVERAGE
Mould No.	7 DAYS AIR TIGHT, 7 DAYS SOAKED	7 DAYS AIR TIGHT, 7 DAYS SOAKED	
Stabiliser	60% RIVER SAND ONLY	60% RIVER SAND ONLY	
Content %	5.0	5.0	
Mould g	A	B	
Wet Soil g	4,955.0	4,796.0	
Compaction M/c %	9.1	9.1	
Dry density kg/m ³	1.971	1.908	
%Compaction	103.9	100.5	
FORCE	2.1	2.5	
UCS	0.113	0.135	0.12



 P.O. BOX 705, KAMPALA, UGANDA






UCANDA CHRISTIAN UNIVERSITY
A College of Excellence in the Heart of Africa.

NAMBOOZE JUSTINE SHILLA (S20B32214) &
MCARNOLD GARRY (S20B32033)

INSTITUTION: UCANDA CHRISTIAN UNIVERSITY
STUDENTS: NAMBOOZE JUSTINE SHILLA (S20B32214) & MCARNOLD GARRY (S20B32033)
TESTING LAB: **Stirling**

PROJECT: ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS

SUMMARY OF TEST RESULTS FOR WEAK SUBGRADE SOILS STABILISED WITH 60% RIVER SAND ON

LOCATION	BLENDED %	SAMPLING DATE	GRADING										ATTERBERG LIMITS					MDD		CBR	CBR SWELL	AVERAGE
			63	37.5	20	5	2	0.425	0.075	GM	LL	PL	PI	LS	MDD	OMC						
WEAK SUBGRAD			100	100	100	100	100	97	59	18	1.27	23	NON PLASTIC	1.4	1.898	8.1	37.8	0.16	0.16			
			100	100	100	99	96	58	12	1.34	22.6	NON PLASTIC	1.4	-	-	-	-	-	-			
	WEAK SUBGRADE	12/10/2023	100	100	100	99.44	96.63	58.27	14.78	1.30	22.8	NON PLASTIC	1.4	1.898	8.1	38	0.16	0.16				
AVERAGE			100	100	100	99	97	58	15	1.303	22.8	NON PLASTIC	0.0	1.4	1.898	8.1	37.8	0.16	0.16			

FOR LAB


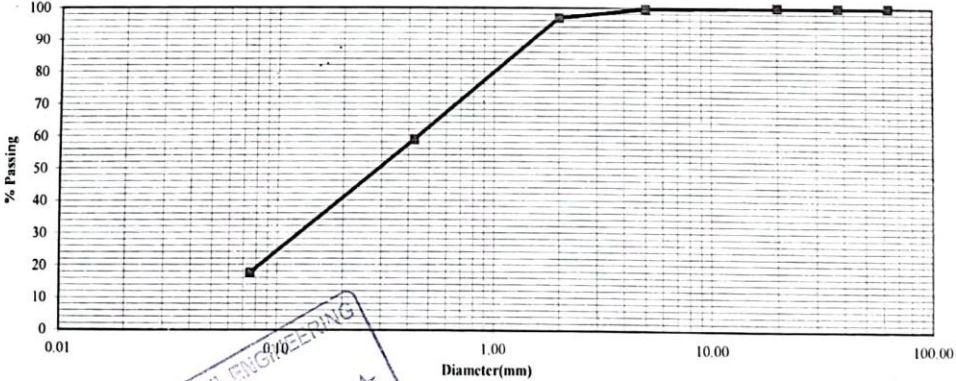
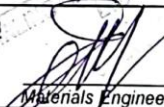
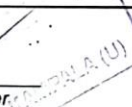


FOR STUDENTS

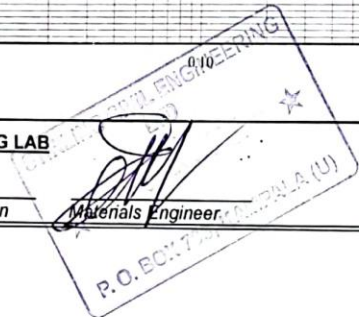
Lab Technician


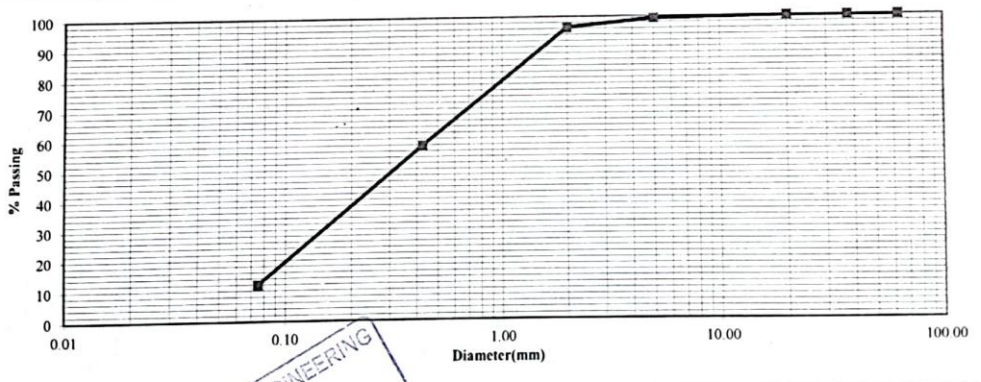

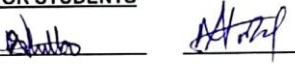
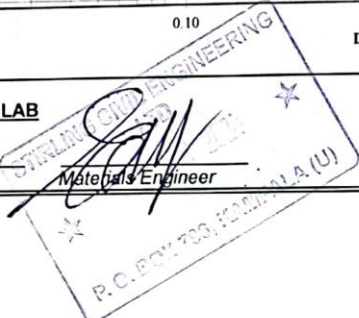
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P. C. P. ...


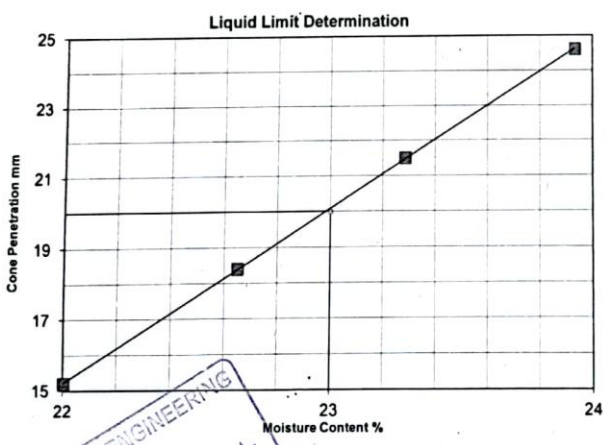



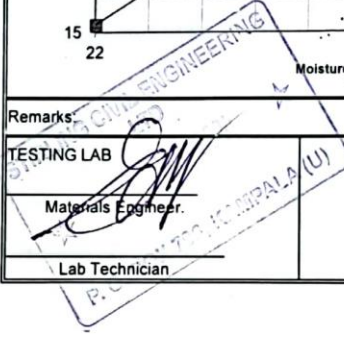
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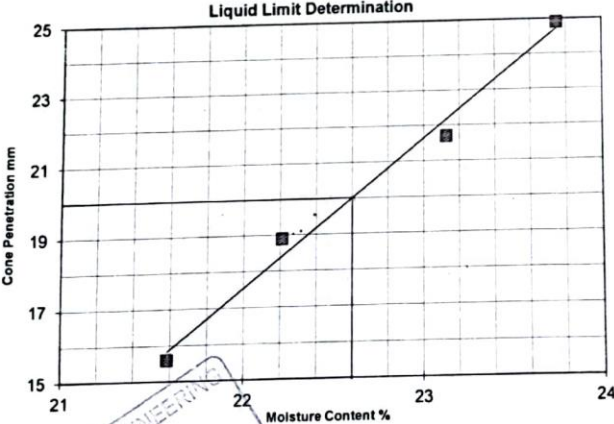
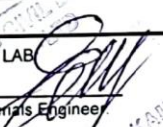

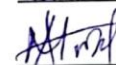
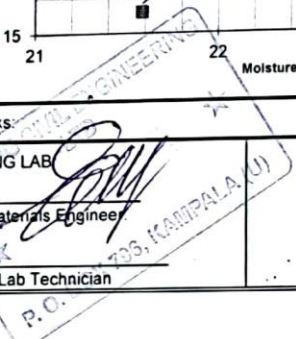
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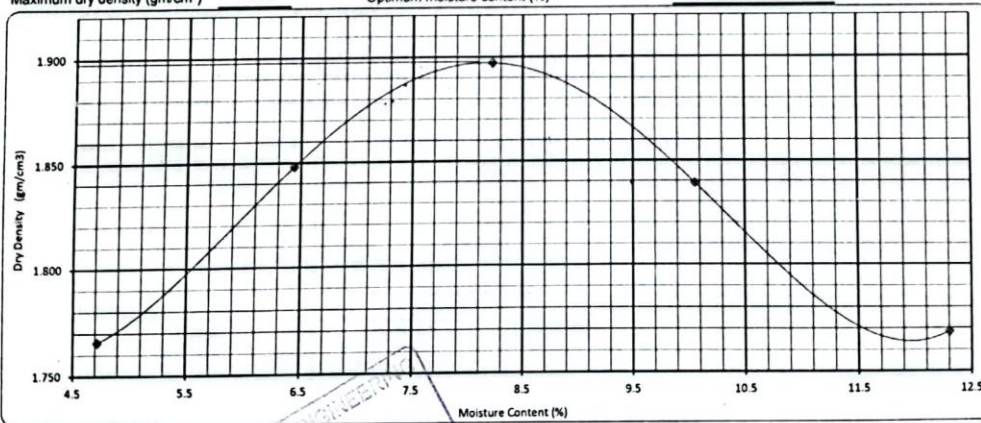
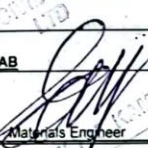
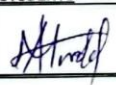
INSTITUTION		STUDENTS NAMES		CONTRACTOR	
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling	
PROJECT : ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS					
PARTICLE SIZE DISTRIBUTION (BS 1377 - 2 - 90)					
Test Reference No.:			Lab. Reference No.:		
Location : (km)	WEAK SUBGRADE SOILS STABILISED WITH 60% RIVER SAND ONLY		Dry wt. of sample before washing: (g)	2631.9	
Depth: (m)			Dry wt. of sample after washing: (g)	2189.6	
Material description:	WEAK SUBGRADE		Date Sampled:	Date Tested:	Technician
			10/Dec/2023	1/Mar/2024	Lab team
Sieve Size (mm)	Weight Retained (g)	Retained (%)	Passing (%)	Grading Limits (G60 & 80)	
63.0	0.0	0	100	100	100
37.5	0.0	0.0	100	80	100
20.0	0.0	0.0	100	60	95
5.0	9.4	0.4	100	30	65
2.00	74.0	2.8	97	20	50
0.425	1001.0	38.0	59	10	30
0.075	1083.8	41.2	18	5	15
Total fines	463.7	17.6			
Bottom Pan	21.4				
Extracted fines	442.3				
Total sample	2631.9				
Grading Modulus		1.27			
					
FOR TESTING LAB			FOR STUDENTS		
Lab Technician:  Materials Engineer: 			 		

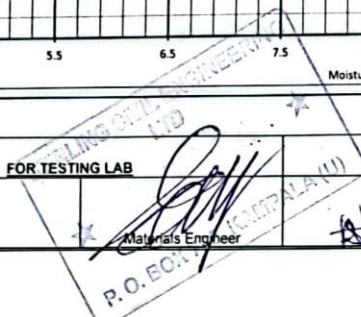



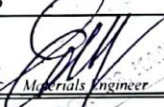

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PROJECT : ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS					
PARTICLE SIZE DISTRIBUTION (BS 1377 - 2 - 90)					
Test Reference No.:			Lab. Reference No.:		
Location : (km)	WEAK SUBGRADE SOILS STABILISED WITH 60% RIVER SAND ONLY		Dry wt. of sample before washing: (g)	2856.8	
Depth: (m)			Dry wt. of sample after washing: (g)	2531.4	
Material description:	WEAK SUBGRADE		Date Sampled:	Date Tested:	Technician
			10/Dec/2023	1/Mar/2024	Lab team
Sieve Size (mm)	Weight Retained (g)	Retained (%)	Passing (%)	Grading Limits (G60 & 80)	
63.0	0.0	0	100	100	100
37.5	0.0	0.0	100	80	100
20.0	0.0	0.0	100	60	95
5.0	21.7	0.8	99	30	65
2.00	80.5	2.8	96	20	50
0.425	1105.1	38.7	58	10	30
0.075	1308.2	45.8	12	5	15
Total fines	341.3	11.9			
Bottom Pan	15.9				
Extracted fines	325.4				
Total sample	2856.8				
Grading Modulus		1.34			
					
FOR TESTING LAB			FOR STUDENTS		
 Lab Technician			 Student		
					





INSTITUTION		STUDENTS		TESTING LAB	
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling	
PROJECT:		ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS			
ATTERBERG LIMITS					
<i>Liquid limit (cone penetrometer) and plastic limit</i>					
Test Reference No.:		Lab. Reference No.:		Technician:	Lab Team
Location		SUBGRADE SOILS STABILISED WITH 60% RIVER SAND		Sample Date	10/Dec/2023
Test method		BS 1377: Part 2, 1990 4.3/4.4		Test Date	13/Dec/2023
LAYER		WEAK SUBGRADE			
PLASTIC LIMIT		Test No.			
Mass of wet soil + container (g)					
Mass of dry soil + container (g)					
Mass of container (g)					
Mass of moisture (g)					
Mass of dry soil (g)					
Moisture content %					
AVERAGE					
LIQUID LIMIT		Test No.	1	2	3
Initial gauge reading (mm)			0	0	0
Final gauge reading (mm)			15.2	18.4	21.5
penetration (mm)			15.2	18.4	21.5
AVERAGE			15.2	18.4	21.5
Container No.		A	P121	AO	GY
Mass of wet soil + container (g)		68.47	80.32	66.06	40.25
Mass of dry soil + container (g)		57.40	66.80	54.89	33.80
Mass of container (g)		7.09	7.11	6.92	6.85
Mass of moisture (g)		11.07	13.52	11.17	6.45
Mass of dry soil (g)		50.31	59.69	47.97	26.95
Moisture content (%)		22.0	22.7	23.3	23.9
AVERAGE		22.0	22.7	23.3	23.9
		Liquid limit (%)	23.0	Plastic limit (%)	NON PLASTIC
		Plasticity Index (%)		Linear shrinkage	
		Trough No.	H	Trough length (cm)	14.0
		Specimen length (cm)	13.8	L.shrinkage =	0.2
		% L.shrinkage =	1.4		
Remarks:					
TESTING LAB  Materials Engineer.		STUDENTS  			
Lab Technician 					

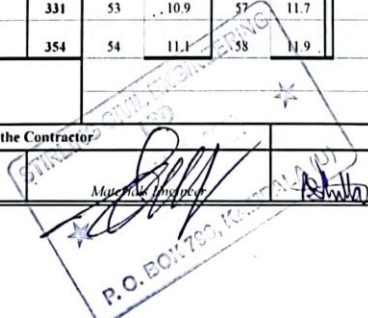
INSTITUTION		STUDENTS		TESTING LAB																			
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling																			
PROJECT:		ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS																					
ATTERBERG LIMITS																							
<i>Liquid limit (cone penetrometer) and plastic limit</i>																							
Test Reference No.:		Lab. Reference No.:		Technician:																			
Location		SUBGRADE SOILS STABILISED WITH 60% RIVER SAND		Sample Date																			
Test method		BS 1377: Part 2, 1990:4 3/4.4		Test Date																			
LAYER		WEAK SUBGRADE																					
PLASTIC LIMIT		Test No.																					
Mass of wet soil + container (g)		NON PLASTIC																					
Mass of dry soil + container (g)																							
Mass of container (g)																							
Mass of moisture (g)																							
Mass of dry soil (g)																							
Moisture content %																							
AVERAGE																							
LIQUID LIMIT		Test No	1	2	3	4																	
Initial gauge reading (mm)			0	0	0	0																	
Final gauge reading (mm)			15.6	18.9	21.7	24.9																	
penetration (mm)			15.6	18.9	21.7	24.9																	
AVERAGE			15.6	18.9	21.7	24.9																	
Container No.		6E	P12H	A5	A6																		
Mass of wet soil + container (g)		68.64	67.24	66.59	64.90																		
Mass of dry soil + container (g)		97.71	57.13	55.41	53.76																		
Mass of container (g)		7.07	11.61	7.07	6.85																		
Mass of moisture (g)		10.93	10.11	11.18	11.14																		
Mass of dry soil (g)		50.64	45.52	48.34	46.91																		
Moisture content (%)		21.6	22.2	23.1	23.7																		
AVERAGE			21.6	22.2	23.1	23.7																	
						<table border="1"> <tr> <td>Liquid limit (%)</td> <td>22.6</td> </tr> <tr> <td>Plastic limit (%)</td> <td rowspan="2">NON PLASTIC</td> </tr> <tr> <td>Plasticity Index (%)</td> </tr> <tr> <td colspan="2" style="text-align: center;">Linear shrinkage</td> </tr> <tr> <td>Trough No.</td> <td>H</td> </tr> <tr> <td>Trough length (cm)</td> <td>14.0</td> </tr> <tr> <td>Specimen length (cm)</td> <td>13.8</td> </tr> <tr> <td>L.shrinkage =</td> <td>0.2</td> </tr> <tr> <td>% L.shrinkage =</td> <td>1.4</td> </tr> </table>	Liquid limit (%)	22.6	Plastic limit (%)	NON PLASTIC	Plasticity Index (%)	Linear shrinkage		Trough No.	H	Trough length (cm)	14.0	Specimen length (cm)	13.8	L.shrinkage =	0.2	% L.shrinkage =	1.4
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Plastic limit (%)	NON PLASTIC																						
Plasticity Index (%)																							
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Trough No.	H																						
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Specimen length (cm)	13.8																						
L.shrinkage =	0.2																						
% L.shrinkage =	1.4																						
Remarks:																							
TESTING LAB  Materials Engineer			STUDENTS  																				
Lab Technician 																							

INSTITUTION		STUDENTS NAMES			TESTING LAB	
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)			Stirling	
PROJECT:		ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS				
Test Reference No.	Lab Reference No.	Date Sampled	Date Tested	Technician		
Mix	WEAK SUBGRADE SOILS STABILISED WITH 60% RIVER SAND ONLY	10/Dec/23	1/Mar/24	Lab team		
Material description:	WEAK SUBGRADE		Natural moisture (%) :	11.0		
TEST DATA						
Weight of rammer (Kg)	No. of blows per layer	No of layers	Height of drop (mm)	Diameter of mould(mm)	Volume of mould (cm ³)	
4.5	62	5	457	152	2,305	
MOISTURE CONTENT DATA						
Test No.	1	2	3	4	5	
Tin No.	A	A	A	A	A	
Water Added	cm ³	120	180	240	300	360
Mass of Compacted soil + mould	gm	6,129	6,247	6,333	6,304	6,266
Mass of Mould	gm	4,280	4,280	4,280	4,280	4,280
Mass of Compacted soil	gm	1849	1967	2053	2024	1986
Volume of mould	cm ³	1,000	1,000	1,000	1,000	1,000
Wet density of soil	g/cm ³	1.849	1.967	2.053	2.024	1.986
DATA FOR PROCTOR CURVE						
Container No.	BKN	CR7	UCU	YCY	NRM	
Mass of wet soil + Container	gm	2,312.0	2,242.0	2,519.0	2,560.0	2,494.0
Mass of dry soil + container	gm	2,244.0	2,153.0	2,389.0	2,401.0	2,308.0
Mass of container	gm	802.0	771.0	808.0	820.0	796.0
Mass of water added	gm	68	89	130	159	186
Mass of dry soil	gm	1442	1382	1581	1581	1512
Moisture content	%	4.7	6.4	8.2	10.1	12.3
Dry density	g/cm ³	1.766	1.848	1.897	1.839	1.768
Maximum dry density (gm/cm ³)	1.898		Optimum moisture content (%)		8.1	
						
Remarks:						
FOR TESTING LAB			FOR STUDENTS			
Lab Technician:  Materials Engineer						



Institution	Students Names		Testing Lab	
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>	NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)		Stirling	
ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS				
CALIFORNIA BEARING RATIO TEST (BS 1377 Part 4)				
Test sample reference :	Laboratory Reference No.:		Sampling Date :	10/Dec/23
Location:	WEAK SUBGRADE SOILS STABILISED WITH 60% RIVER SAND ONLY		Casting date :	2/Mar/24
Sample Description:	WEAK SUBGRADE		Testing Date :	16/Mar/24
			Technician :	Lab team
			Volume of Mould used (m ³)	2305
Natural moisture of air dried sample			Volume of water added	
Tin No.	KAN		Mass of air dried soil (g)	6000
Tin + air dried soil sample (g)	2594		MDD (Mg/m ³)	1.898
Tin + oven dry soil sample (g)	2577		N.M.C (%)	1.0
Tin (g)	799		OMC (%)	8.1
Dry soil sample	1778		Added OMC (%)	7.1
Water (g)	17		Calculated dry wt of soil (g)	5942.6
N.M.C (%)	1.0		Water added (g)	425
Average (%)	1.0		Water added (mL)	425
Number of blows	62			
Number of layer	5			
Water Content Determination				
	Before Soaking	After Soaking		
Tare No	CMD -	BBC -		
Mass of wet sample + Tare	g 2183 -	2303 -		
Mass of dry sample + Tare	g 2065 -	2161 -		
Mass of Tare	g 765 -	808 -		
Mass of water	g 118 -	142 -		
Mass of dry sample	g 1300 -	1353 -		
Water content	% 9.1 -	10.5 -		
Average water Content	% 9.1	10.5		
Density determination				
Mould No	8T			
Mass of mould + soil	g 10196	10264		
Mass of mould	g 5396	5396		
Mass of soil	g 4800	4868		
Volume of the mould	cm ³ 2305	2305		
Moist density	g/cm ³ 2.082	2.112		
Dry density	g/cm ³ 1.909	1.911		
Swell Determination				
Date	Hour	D. Gauge Reading		
Initial reading	96 hrs	20		
Final reading		20.2		
Height of the specimen		127		
Height of swell		0.2		
	Swelling(%)	0.16		
Observations				
For the Lab			For Students	
 Lab. Technician			 For Students	

Institution		Students Names				Testing Lab	
 UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>		NAMBOOZE JUSTINE SHILLA (S20B32/214) & MICARNOLD GARRY (S20B32/033)				Stirling	
ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS							
CALIFORNIA BEARING RATIO TEST (BS1377 Part 4)							
Test sample reference :		Laboratory Reference No.:		Sampling Date		10/Dec/23	
Location:				Penetration Date		16/Mar/24	
Depth :				Technician		Lab team	
Sample Description :		WEAK SUBGRADE					
Number of blows per layer		62					
Number of layers		5		5		5	
Mould No		8T					
Capacity of the Proving Ring (KN)		50		50		50	
Proving Ring Constant (KN/div.)		0.2052		0.2052		0.2052	
Speed : mm/min.							
		Top		Bottom			
Penetration of the plunger (mm)		Time (s)	Reading *10 ¹ mm	Force (KN)	Reading *10 ¹ mm	Force (KN)	
0		0	0	0.0	0	0.0	
0.25		12	1	0.2	1	0.2	
0.5		24	1	0.2	2	0.4	
0.75		35	2	0.4	3	0.6	
1		47	3	0.6	4	0.8	
1.5		71	7	1.4	8	1.6	
2		94	10	2.1	12	2.5	
2.5		118	15	3.1	17	3.5	
3		142	20	4.1	22	4.5	
3.5		165	28	5.7	30	6.2	
4		189	35	7.2	37	7.6	
4.5		213	41	8.4	44	9.0	
5		236	45	9.2	48	9.8	
5.5		260	49	10.1	53	10.9	
6		283	52	10.7	55	11.3	
6.5		307	53	10.9	56	11.5	
7		331	53	10.9	57	11.7	
7.5		354	54	11.1	58	11.9	
Observations							
For the Contractor				For Students			
Lab. Technician		 <small>Municipal Inspector</small>		 <small>Stirling</small>		 <small>Stirling</small>	



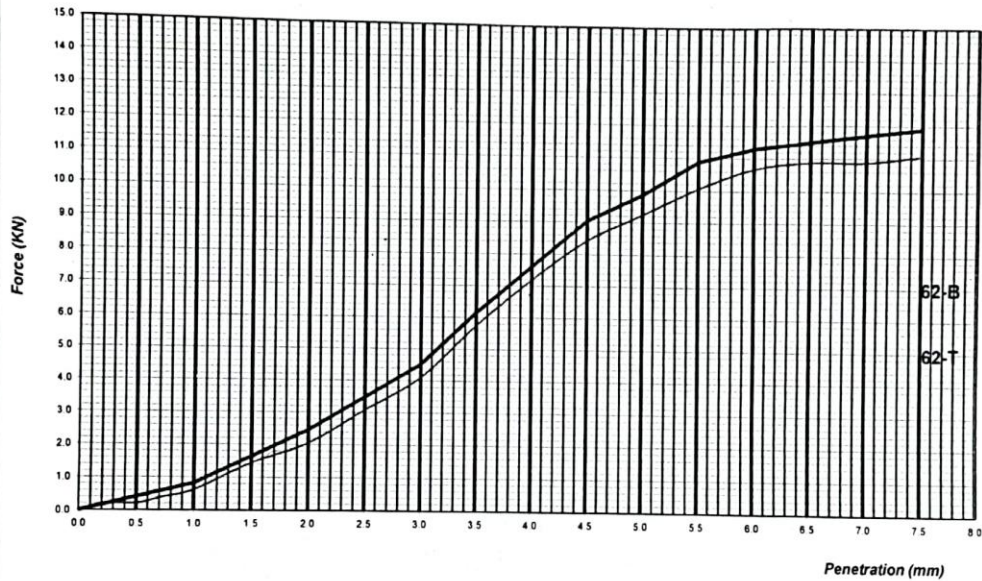
Institution UGANDA CHRISTIAN UNIVERSITY <small>A Centre of Excellence in the Heart of Africa</small>	Students Names NAMBOOZE JUSTINE SHILLA (S20B32/214) & MCARNOLD GARRY (S20B32/033)	Testing Lab Stirling
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ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILISATION OF WEAK SUBGRADE SOILS

CALIFORNIA BEARING RATIO TEST (BS1377 Part 4)

Test sample reference:	Laboratory Reference No.:	Sampling Date : 10/Dec/23
Location:		Testing Date : 16/Mar/24
Depth:		Technician : Lab team
Sample Description: WEAK SUBGRADE		

PENETRATION vs FORCE CURVE



	62 blows							
	Force		CBR					
	Bottom	Top	Bottom	Top				
2.5 mm Penetration	3.5	3.1	26	23				
5.0 mm Penetration	9.8	9.2	49	46				
Average	6.7	6.2	37.8	34.8				
Retained CBR	37.8							
Observations	CBR= 38							
For the Lab	<i>[Signature]</i>				For Students			
Lab. Technician	<i>[Signature]</i>				<i>[Signature]</i>			

P. O. BOX 703
KAMPALA

DIRECT SHEAR BOX TEST OF SOILS (BS EN ISO 178922-9:2017)				
TITLE:	ASSESSING THE USE OF RIVER SAND AND SAW DUST ASH IN THE STABILIZATION OF WEAK SUBGRADE SOILS	Task:	Final Year project	
University:	Uganda CHRISTIAN UNIVERSITY	Students Details:	NAMBOOZE JUSTINE SHILLA S20B32/214	MCARNOLD GARRY S20B32/033
Sample Source:	Busunju			
Sample Type:	sandy CLAYS for subgrade layer modified with 45% River sand and 3% saw dust ash	Depth (m):	1.0 -1.5	
Date Tested:	27-Mar-24			
Material Type:	Moulded Sample.			
Bulk Density	Normal Stress	Shear Strength	Cohesion	Angle of Internal Friction
γ_s	σ_n	τ_s	C	ϕ
Mg/m ³	kPa	kPa	kPa	(Degree)
1.960	50.0	38.0	2.0	36.6
	100.0	78.0		
	200.0	150.0		

Shear Strength vs Normal Stress

Tested by: <i>Nambooze Justine Shilla & McArnold Garry</i> NAMBOOZE JUSTINE SHILLA & MCARNOLD GARRY	Approved by: <i>[Signature]</i> Sen. Laboratory Engineer (O.T)
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Telephone
+256 (0) 414 250 464 (Gen)
+256 (0) 414 250 474
Email: dgal@mia.go.ug
Website: www.mia.go.ug



MINISTRY OF INTERNAL AFFAIRS
DIRECTORATE OF GOVERNMENT
ANALYTICAL LABORATORY
Plot No. 2 Lourdel Road
Wandegeya,
P.O. BOX 105639
Kampala - Uganda

In any Correspondence on
this subject please
quote No.....

GE 038/2024

02nd February 2024

MS. NAMBOOZE JUSTINE SHILLAH AND MR Mc ARNOLD GARRY
REG NO. S20B32/214 & S20B32/033
UGANDA CHRISTIAN UNIVERSITY
P.O BOX 4,
MUKONO-UGANDA
Tel: 256-778-051449

REPORT OF ANALYSIS

Description of the Samples

One sample in a black polythene bag containing saw dust ash sample was submitted by Ms. Nambooze Justine, on 25th January 2024, and analysed on 31st January 2024. A summary of the sample received is shown in table below

S/N	Description	Quantity	Assigned Lab ID
1	Saw dust Ash sample packed in a black polythene bag.	01	Sample "A" GE 038/2024

Analysis Requested

Elemental analysis

Method of Analysis

Elemental analysis was done using the XRF Method.

Results of Analysis

The above sample has been analyzed with the following results as below,

Parameter	Units	Results
		Saw dust Ash sample GE 038/2024
Silicon dioxide	% m/m	67.87
Calcium Oxide	% m/m	10.47
Aluminum Oxide	% m/m	8.63
Iron (III) Oxide	% m/m	4.54
Manganese (II) Oxide	% m/m	4.53
Potassium Oxide	% m/m	2.80
Phosphorous pent oxide	% m/m	0.19
Titanium di oxide	% m/m	0.07

Remarks

1. Results relate to sample analyzed and are reported as on received basis.

Semalago Fredrick 02/02/2024

Semalago Fredrick
Government Analyst