ASSESSING THE USE OF PET FIBRE IN REINFORCEMENT OF LIME STABILISED SOIL

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A FINAL YEAR RESEARCH AND DESIGN PROJECT REPORT SUBMITTED TO THE FACULTY OF ENGINEERING, DESIGN AND TECHNOLOGY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A DEGREE OF BACHELOR OF SCIENCE IN CIVIL AND ENVIRONMENTAL ENGINEERING OF UGANDA CHRISTIAN UNIVERSITY

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Abstract

The presence of poor sub-grade materials, particularly clay soils, poses significant challenges in road construction due to swell and shrink under varying moisture levels. This leads to road cracks and failures requiring methods to enhance soil strength. Chemical and mechanical stabilization methods are commonly employed, with factors like plasticity index and particle size distribution crucial in selecting appropriate stabilizers. Lime and cement are favored for their ability to chemically stabilize such soils, though lime stabilization may exhibit drawbacks such as poor strength characteristics due to factors like carbonation and organic matter presence.

This paper investigated the impact of varying PET fiber content added to lime-stabilized soil, analyzing its influence on soil strength. The study evaluates California Bearing Ratio (CBR) and Unconfined Compression Strength (UCS) of the stabilized soil. Results indicate that soil stabilized with 6% lime alone falls short of minimum standard requirements, with a UCS below the necessary threshold of 0.5 MPa. However, incorporating PET fibers shows promise, with optimum strength improvement observed at 1.5% fiber content, yielding a UCS of 0.59 MPa and a 54% CBR. This indicated an improvement impact on mechanical properties, enhancing the performance of clay soils stabilized with lime.

The study suggested a 6% lime and 1.5% rice husk ash blend enhances strength. It highlights PET fibers' potential in lime stabilization for road construction, addressing weak sub-grade materials and promoting sustainable waste management, particularly plastic waste utilization. This combination offers a promising solution to road construction challenges.

Declaration

I **ASIIMWE CALEB** registration number **S20B32/031** declare that the presented work is my original work which I compiled personally and has never been submitted to any institution or board for any award.

Signature……………………………….

ASIIMWE CALEB

Date …………. /……………………/………………..

Approval

I certify that this report is for **ASIIMWE CALEB** Registration Number **S20B32/031**. This research project was carried out under my supervision and guidance and so submit a final year research and design project report to the Faculty of Engineering, Design, and Technology (FEDT) of Uganda Christian University.

Signature………………………………

MR KENNETH ECONI

DATE………/……………/…………

Project supervisor

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List of Acronyms

AASHTO - American Association of State Highways and Transportation Officials

ASTM – American Society for Testing and Material

BS - British Standards

CBR- California Bearing Ratio

DCP – Dynamic Cone Penetrator

LL - Liquid limit

MDD – Maximum Dry Density

MoWT – Ministry of Works and Transport

OMC – Optimum Moisture Content

PET - Polyethylene Terephthalate fibre

PL- Plastic limit

UCS - Unconfined Compressive Strength

UCU – Uganda Christian University

USCS - Unified Soil Classification System

CHAPTER 1: INTRODUCTION

1.1 Background

The strength and durability of engineering structures depends on the ability of the underlying soils to with stand the stress from to the forces that are subjected on it by the structures. The existence of weak soils like expansive soils has affected the engineering world for a long time. Expansive soils are clays (such bentonite or montmorillonite) that undergo frequent expansions and contractions (shrinkage) as a result of changes in water volume. When expansive soils are exposed to a lot of water, they swell and contract as the water evaporates. These expansions and contractions lead to the movement of the soils that may lead to the cracking, settlement and buckling of the structures that will be constructed on them. These include highways and buildings that may fail. Expanding soils are mostly made up of very finely divided minerals that have very little to no organic matter. As a result, they are very sticky and challenging to drain. The changes in rainfall intensity or extended periods of drought, will also have a major impact on ground shrinkage thus changes in climate affects the quality of the structures built in areas with expansive clay soils (Toll et al., 2012).

Engineers will need to take this into account climate change when designing in the future to reduce the consequences of shrink-swell. The issue of expansive soils affects many parts of the world including Uganda especially the Eastern and Northern regions of the country.

Soil stabilization describes biological, chemical, or mechanical techniques to enhance a soil's engineering qualities and making it more workable. Examples of these qualities are plasticity, permeability, compressibility, durability, and shear strength. The objectives of soil stabilization are mainly; strengthening of the soil along with its bearing capacity, improving permeability characteristics, and even enhance the unfavorable soil properties like excessive swelling or shrinkage (Daily Civil, 2021). In this case, soil stabilization is meant to be implemented in handling the issue of expansive soils which are clayey soils in nature. The study expounds the use of geotextile (Polyethylene Terephthalate fibre) on lime stabilized expansive soils, and improve the tensile strength of such soils. The aim of soil stabilisation is to improve the tensile strength of the soils and make them suitable for engineering works.

1.2 Problem statement

Engineers come across a range of problematic soils, such as expansive soils, during road construction projects that pose significant obstacles. Because highly flexible clay minerals like aluminum and iron, which alternately expand and contract with variable moisture concentrations, are present in expansive soils, the roadways get cracked and collapse (Jones et al., 2012). Expansive soils along the chainages of the Muyembe-Nakapiripirit road were found to have expansive soils which have an issue of experiencing constant volumetric changes due to moisture content variations in the subgrade resulting in pavement damage, and this has led to disruption of normal traffic flow on the road (Augustus, 2023).

Large volumetric changes are a challenge for expansive soils due to seasonal variations in moisture. In arid and semi-arid settings where drying and wetting are frequent occurrences, these types of soils significantly impair civil infrastructure. Expansive soils shrink and swell when they are dried or wet, which can lead to considerable differential movements in building foundations and roadway pavements.

Many problems arise from these movements in lightweight buildings. Variations in water tension and content are explained by these motions, which are particularly noticeable in fine-grained soils with high flexibility. It was discovered that expansive soils are the primary source of known pavement infrastructure cracks and discomfort. Longitudinal cracking indicates volumetric changes in the pavement subgrade. Measured differential movements have a negative impact on pavement performance and shorten its service life. Currently, engineers anticipate a workable and practical resolution to the issue of seasonal pavement surface movements affecting the structural and functional characteristics of the pavement structure(Sarker and Wang, 2022).

The issue of heaving was found to disrupt the normal movement of vehicles along the road section with the expansive soils. An ancient method for managing the expansive soil's swell-shrink properties is lime stabilization. But because sulphate is present in expansive soils, harmful chemicals like ettringite and thaumasite occur, making lime stabilization useless. The experimental research showed that the sulphate contamination had a significant effect on the soil structure, physio-chemical and index properties of lime-stabilized soil (Sriram Karthick Raja and Thyagaraj, 2021).

The solution to the issue is the suggestion to enhance the tensile strength characteristics of expanding soils by utilizing hydrated lime and waste polyethylene terephthalate fiber.

1.3 study Objectives

1.3.1 Main objective

To assess the use of Polyethylene Terephthalate fibre the reinforcement of lime stabilised soils.

1.3.2 Specific Objectives

1. To ascertain the physical properties of the expansive soils.

2. To determine the mechanical properties of the Polyethylene Terephthalate fibre

3. To ascertain the mix ratios of Polyethylene Terephthalate fibre, lime and expansive soils to achieve the desired strength properties.

4. To determine the strength properties of the soil stabilized with varying Polyethylene Terephthalate fibre and lime content and appropriate mix ratios.

1.4 Scope of work

1.3.1 Geographic scope

The study will be carried out along the Muyembe-Nakapiripirit road section, and this is where the expansive soils will be obtained.

1.3.2 Time scope

The study was conducted from September 2023 till April 2024.

1.3.3 Content scope

The study scope will focus on assessing the application of Polyethylene Terephthalate fibre in the reinforcement of lime stabilized soils.

1.5 Justification

The use of the Polyethylene Terephthalate fibre and lime in the stabilisation of expansive soils aims on improvement of the strength properties of soils. Lime has been used widely in the stabilisation though it has been associated to cases of low strength properties exhibited thus failing to carry the loading of the structure in some cases influenced different factors like sulphate attack, carbonation etc. The simultaneous effects of adding lime and employing PET validate that the beneficial impact of stabilizing lime on strength is more significant. In the meantime, the maximal strength for reinforced clayey soil is demonstrated by the restricted 1.5% PET content. Generally, reinforcement with PET leads to higher strength properties based on the point load strength index and more flexibility based on the applied impact loads in comparison with pellet particles (Koohmishi and Palassi, 2022)

Annually, more than 300 million tons of plastic waste are produced, a substantial portion of which is deposited into the environment, exhibiting persistence over decades. On a yearly basis, a minimum of 8 tons of plastic waste infiltrates the ocean, equating to the disposal of a garbage truck into the ocean every minute and without intervention, projections suggest that by 2030, this rate will double to two trucks per minute, and by 2050, it will quadruple to four trucks per minute (Sarker & Wang, 2022). Finding solutions for the elimination or environmentally friendly reuse of these waste materials is necessary (Urian et al., 2023). The Polyethylene Terephthalate waste can be used to get the fibre to be used in the stabilisation of the expansive soils with lime.

1.6 SIGNIFICANCE

The project will expand on the knowledge about soil stabilisation and create an option to blend Polyethylene Terephthalate fibre along with lime in stabilizing expansive soils. This is important as there will be no need of merely excavating and dumping away such soils hence leading to cuts in expenses along with time spent in procurement of labor and machinery to remove the given expansive soils. Additionally, the project will allow for the opportunity to use the good strength properties exhibited by Enhancing the tensile characteristics of expanding soils with Polyethylene Terephthalate fiber.

CHAPTER 2: LITERATURE REVIEW

2.1 Expansive soils

Soil that exhibits volumetric variation in response to variations in water content is essentially expansive. Because these soils include expanding clay elements that absorb water, they inflate and contract. The water content in the near-surface zone controls how much the ground can expand or contract. The processes of swelling and shrinking are not entirely reversible. The process of shrinkage produces fissures that, when the soil is rewetted, do not completely seal, causing the soil to bulk up a little bit and providing the swelling process with more access to water. When debris might get trapped in soil fissures, preventing the soil from moving back, increasing the pressure caused by swelling.

Because of their propensity to expand or contract in response to variations in water content, the clays found in these materials provide a serious risk to engineering construction.

Heaving, or raising, of structures can be caused by swelling pressures, whereas differential settlement might be caused by shrinkage. When the volume changes beneath the foundation are not evenly distributed, failure occurs. For instance, variations in the soil's water content along a building's border may result in pressure buildup beneath the structure's periphery, even when the soil's water content in the center is unchanged. End lift failure is the outcome of this.

The opposite of this is centre lift, where swelling is focused beneath the centre of the structure or where shrinkage takes place under the edges (Jones and Jefferson, 2012).

The molecule composition and arrangement of these clay crystal sheets in an expanding clay have a unique affinity to draw in and retain water molecules in the crystalline layers in a tightly linked "sandwich." Water molecules are attracted to the small clay sheets electrochemically due to their electrical dipole configuration. Adsorption is the process by which these molecules attach themselves to one another.

The clay mineral montmorillonite, part of the sectile family, can adsorb very large amounts of water molecules between its clay sheets, and therefore has a large shrink-swell potential(Jones and Jefferson, 2012).

2.2 Soil stabilisation

Soils stabilisation is the process of modifying an existing soil's properties to meet specific engineering requirements, such as increasing the soil's strength and resistance to water-induced softening. This can be achieved by bonding or water-proofing the particles, or by combining two or more methods of blending and mixing materials.

In most of the world, soils are stabilized for road construction quite frequently for one or more of the following reasons:

i . Strengthening subgrade, subbase, base, and low-cost road surfaces to improve stability and bearing capacity.

ii Enhancing volume stability by addressing issues related to moisture-induced swelling, shrinking, high plasticity, and compaction difficulties.

iii Increasing durability to withstand weathering, erosion, and traffic impacts.

iv Improving characteristics such as high permeability, workability, and reducing dust nuisance

Soil stabilization can be accomplished by several methods and these methods fall into two broad categories namely;

2.2.1 Mechanical stabilization

Soil stabilization can be accomplished through physical means by adding additional physical properties or by causing compaction or induced vibration to change the natural physical characteristics of the soil particles(Makusa, 2013). In order to modify the gradation of the natural soil and enhance its qualities, mechanical stabilization involves combining two or more types of natural soil(Archibong et al., 2020)

Mechanical soil stabilization techniques play a crucial role in geotechnical engineering and construction by providing cost-effective solutions for improving the engineering properties of soil materials. These methods help mitigate the challenges posed by weak or problematic soils, ensuring the safe and sustainable development of infrastructure projects. Here are some common mechanical soil stabilization techniques:

i Soil mixing techniques involve mechanically blending additives like cement, lime, or fly ash into the soil to enhance its engineering properties. Deep soil mixing (DSM), shallow soil mixing (SSM), and cutter soil mixing (CSM) methods are used based on project depth and scale. Soil mixing stabilizes soft or organic soils, enhances slope stability, and prevents erosion in embankments and levees.

ii Geosynthetics, including geotextiles, geogrids, and geomembranes, complement mechanical stabilization methods by providing reinforcement and erosion control. A geotextile layer reinforces soil through its dual roles as a tensional membrane and a tensile member, enhancing stability and strength through reinforcement in the engineered system (Archibong et al., 2020). They enhance soil reinforcement and containment, improving the performance and longevity of stabilization systems.

A reinforced soil is a composite material composed of cohesive soil particles interlocked with tension-resistant elements such as sheets, strips, nets, synthetic fabrics, or reinforced plastic fibres, forming a cohesive structure with enhanced mechanical properties (Archibong et al., 2020)

2.2.2 Chemical stabilization:

Soil stabilization primarily depends on chemical interactions between a stabilizing agent (cementitious material) and soil minerals to achieve desired results.

Cementitious materials, such as cement, lime, fly ash, bitumen, or their mixtures, can be used to solidify loose substances through soil stabilization. Comparing the solidified soil materials to the original soil, they show decreased compressibility, decreased permeability, and increased strength. The selection of the appropriate technological approach is contingent upon the specific soil properties requiring modification. Principal soil properties of engineering interest encompass volume stability, strength, compressibility, and permeability.

2.3 Lime

Lime is a product that is git from the breakdown of limestone at elevated temperatures. There are three forms of lime; quick lime (calcium oxide), hydrated lime (calcium hydroxide) and hydrated lime slurry (Bustillo Revuelta, 2021).

All these forms can be used for stabilization of the silty clay soils. Quicklime undergoes a chemical reaction with water, generating heat that aids in soil moisture removal. Hydrated lime and its slurry facilitate moisture extraction from soil through chemical alterations, diminishing its water retention capacity and enhancing stability. Lime application diminishes soil swelling potential, liquid limit, and plasticity while bolstering its strength. Lime stabilization, a method for enhancing soil properties, entails lime addition, inducing a pozzolanic reaction wherein pozzolanic materials react with lime in the presence of water, yielding cementitious compounds. Optimal lime addition and ion exchange lead to stabilization, particularly in clayey soils with moderate to high plasticity. Adequate curing duration is necessary, given the rapid early-stage strength development. Lime usage diminishes expansive soil plasticity, mitigating volume fluctuations associated with moisture content changes, thus regulating soil expansion and contraction. Slurry lime can also be applied to dry soils, where it might be necessary to add water to produce proper compaction (Rao and Thyagaraj, 2003).

There are various types of lime which can be applied in the soil stabilisation of the subgrades. Calcium oxide (quicklime) and calcium hydroxide (hydrated lime) are the two main forms of lime utilized in soil stabilization ($Ca(OH)_2$).

Here are the types and their advantages:

2.3.1 Dry hydrated lime (calcium hydroxide, $CA(OH)_2$)

Through chemical reactions that lower the soil's capacity to store water and increase stability, hydrated lime helps the soil dry out. Following the initial mixing, the water and other ions are displaced by the calcium ions (Ca^{2+}) from the hydrated lime as they rise to the surface of the clay particles.

The pH of the soil rises to values above 10.5 when enough lime and water are supplied, which speeds up the decomposition of the clay particles. Calcium-silicate hydrates (CSH) and calcium-aluminate hydrates (CAH) are the products of the reaction between the calcium in the lime and the liberated silica and alumina. Cementitious materials like CSA and CAH are made from Portland cement.

This can be applied more quickly than slurry, and clays can be dried using the dry hydrated lime.

i The use of this hydrated lime is advatage3ous because it has small particles that cause a great deal of dust, making this kind of application appropriate for most populated regions. Additionally, its less caustic than quick lime, applying it is safer.

ii Hydrated lime reacts more slowly than quick lime, it can react with the soil for a longer amount of time and stabilize the soil over the long run.

iii Decreased heat generation: The risk of thermal damage to the stabilized soil is decreased since the hydration process of hydrated lime produces less heat than the quicklime reaction.

2.3.2 Quicklime (Calcium Oxide - CaO)

When quick lime is added to the soil, it chemical combines with the water and releases heat which dries the soil through the evaporation generated due to the heat that was a product of the water and quicklime reaction (Firoozi et al., 2017). Because quicklime works well in damp environments, it can be used to stabilize soils with a high moisture content.

Quicklime is more concentrated than hydrated lime, having 20% –24% higher "available" lime oxide content, which makes it more advantageous economically. As a result, when the quicklime is fully hydrated with sufficient moisture, roughly 3% quicklime is equal to 4% hydrated lime.

Quicklime is more economically advantageous than hydrated lime because it is more concentrated and has a 20% to 24% greater "available" lime oxide content. Consequently, 3% quicklime is equivalent to 4% hydrated lime when the quicklime is completely hydrated with enough moisture. Because of the heat of hydration, quicklime can lose a significant amount of water through evaporation; 32% of its weight must be dissolved in water for quicklime to become hydrated. Care must be used when applying quicklime to ensure adequate mixing, mellowing, and water addition. These increased water requirements might present logistical or economic challenges in remote areas without access to a nearby water source. Before being thoroughly combined with the soil, the larger quicklime particles must first react with water to create hydrated lime.

Highly plastic clayey soils can be stabilized quite well with hydrated lime. The negative charge on the clay surface attracts positive charge cations from various chemical compounds, forming a very strong bond at the surface and fulfilling necessary requirements. As a result, additional water cations (H+) do not interact with the soil and extra water molecules are eliminated. (Lagaly et al., 2006).

The pH of the soil rapidly rises to over 10.5, allowing the clay particles to separate or disintegrate, when the proper quantity of lime is added to the water. Following their release from the lime, silica and aluminum combine with the calcium to create calcium-silicate hydrates (CSH) and calcium-aluminum hydrates (CAH).

The CAH and CSH are cementitious similar to the one of Portland cement thus forming the matrix that contributes to the strength of the lime stabilised soils (Firoozi et al., 2017).

The reactions are summarized below;

- $Ca^{2+} + OH^{-}$ + Soluble Clay Silica $\longrightarrow$ Calcium Silicate Hydrate (CSH)
- $Ca^{2+} + OH^{-}$ + Soluble Clay Alumina $\longrightarrow$ Calcium Alumina Hydrate (CAH)

The diffuse double layer of clay particle is reduced by lime, which modifies the plasticity behavior of the soil. The stabilization process is brought on by the pozzolanic reaction, which is the reaction of lime and soil in the presence of water to generate cementitious compounds. Lime helps soils become drier and less susceptible to changes in water content.

By increasing the soil's strength, resilience to fracture, fatigue, and permanent deformation, improving its resilient qualities, reducing swelling, and shielding it from moisture's harmful effects, lime stabilization dramatically enhances the engineering features of soils(Little, 1998). Particularly in clayey soils, these gains are most noticeable in soils with moderate to high flexibility.

The use of lime in the stabilisation of the soil is sometimes not effective in the improvement of the strength properties as required by the standards which is highly associated to various factors like;

Organic matter: the concentration of the organic matter in the soil affect the effectiveness if the lime in improvement of the soil engineering properties with lime. The subgrades with soils that are bearing high concertation d of organic matter that are treated with calcium based additives , they don’t achieve the desired improvement or the improvement disappears overtime(Harris et al., 2009)

Sulphate attack: the soils that contain a lot of calcium sulphate or gypsum in large quantities tends to exhibit low strength properties when treated with the common stabilizers like cement and lime. This low strength us responsible for the most damages that are usually encounter in the construction and highways pavement, dams and canal linings (Ehwailat et al., 2021). The sulphate attack is affected by;

i The pH of the soil. Stabilization of the soil using lime and Portland cement usually boosts the pH level above 12. The concentrations of silica and alumina rise exponentially with increasing pH. This not only creates the chemically active alumina required for the synthesis of ettringite during sulphate attack on stabilized materials, but it is also an essential factor in releasing material from the clay particles to engage in the pozzolanic reactions..(Wang, 2002)

ii Sulphate concertation: the sulphate is an important and necessary factor in the formation of the ettringite. The greater the soluble sulphate. the higher the potential for the growth of the ettringite.(Wang, 2002)

Lime can be used on its own or in combination with other materials like fly ash, bitumen, or cement. Sandy soils are stabilized with these mixes as well. Historically, stabilizing subgrades and road bases has been the main use of lime. The pozzolanic qualities of lime change the adsorbed layer's properties. Highly plastic soils usually see a decrease in their plasticity index when lime is added. Furthermore, when the ideal moisture content rises and the maximum compacted density falls, soil strength and durability are increased. When lime and sulphate combine, ettringite is formed, which exacerbates the swelling effect in expansive soils.

The effects of lime on soil strength have been confirmed by researchers all around the world using triaxle testing, CBR (California Bearing Ratio), and UCS (Unconfined Compressive Strength). As pozzolanic compounds that have a cementitious effect on soil particles form, lime-treated clays typically display significant strength gains. The characteristics of clay mineralogy, soil pH, silica-alumina percentage, lime type, moisture content, temperature, and curing time are among those that have a significant impact on strength improvement (Harris et al., 2009).

Soils with large clay fraction require more lime for strength gain as compared to low clay content soils because later ones require lesser lime percentage for plasticity amendment and have more lime available for pozzolanic reactions (Manzoor and Yousuf, 2020).

2.4 Polyethylene Terephthalate (PET) fibre

Polyester fiber, a synthetic fiber derived from polyethylene terephthalate, is commonly referred to as polyethylene terephthalate (PET) fiber. PET is a transparent polymer with good chemical resistance and gas barrier qualities due to its strong mechanical and dimensional stability under changing loading (Sulyman et al., 2016).

Polyethylene terephthalate (PET), sourced from petroleum, serves as the primary raw material for PET fiber production, commonly used in plastic bottles and packaging. Polymerization combines purified terephthalic acid or dimethyl terephthalate with ethylene glycol to produce PET pellets. These pellets are melted, extruded through spinnerets, and then rapidly cooled to form long fibers. Drawing aligns polymer chains for enhanced strength and durability, while texturing can improve elasticity and softness through crimping or heating.

Following these processes, fibers are sliced to desired lengths, baled for convenience, and applied in various industries, including filtration, textiles for upholstery, carpets, and clothing.

Plastics have evolved into a necessary material for daily use, and over the past few decades, the amount of plastic consumed annually has been rising steadily. This growth has been mostly caused by inherent qualities of plastic, including its low cost, ease of use, high durability, lightweight nature, and strength. Basically, there are two alternatives for PET recycling:

i Mechanical methods and chemical methods. 84% of pet is recycled mechanically by gathering, classifying, cleaning, and crushing the material (Forrest, 2019) ii The recycling can be done chemically through a process called depolymerisation. This is the process by which the polymer chains are changed and broken down into monomers through chemical recycling (Xu and Wang, 2022). This process yields an unsaturated polyester resin that is widely utilized in tissue engineering, building, textiles, coatings, and other fields.

It has previously been suggested to employ geotextile, such as fibre made of polyethylene terephthalate, for the mechanical stabilization of expanding soil. By stabilizing the soil using polyethylene terephthalate fibres, the CBR values of the resulting soil are increased, and the thickness of the pavement layer being built is decreased (Mishra and Gupta, 2018). Polyethylene Terephthalate fibres are such a geosynthetic material which is easily available, and ecofriendly, and also cost effective(Mishra and Gupta, 2018).

Polyethylene Terephthalate fibre can substantially improve the strength properties of the highly plastic soils with various advantages like availability, ecofriendly. The Polyethylene Terephthalate fibres are resistant to the biological degradation thus highly effective for a long time even in the presence of microorganisms in the soil that is being stabilized. The use of waste plastic for reuse in the generation the PET fibres helps to reduce the diverse impacts of the waste on the environment due to the reduced amount of the waste that will reach the soils (Bajaj and Sharma, 1997). Plastics are non-degradable and affects the growth of the plants, water infiltration, destruction of the habitant of some organisms and destruction of the soil structure.

Stabilization using Geosynthetic material like Polyethylene Terephthalate Fibres normally takes 2 to 8% of lime for coarse grained soils and 5 to 8% of lime may be required for plastic or fine-grained soils. The amount of fly ash as admixture may vary from 8 to 20% of the weight of the soil(Emmanuel et al., 2022)

The Polyethylene Terephthalate fibres can enhance the cohesion of the soil due to their reinforcing properties and they can act as a binding agent within the soil matrix, increasing its strength and reducing the risk of cracking or erosion this increasing the cohesion and strength of the soil (Puppala et al., 2006). The reinforcement is though:

i Enhanced cohesion: When combined with the soil, the pet serves as a reinforcing element, binding the soil's particles together to reduce particle movement and enhance the soil's overall stability.

ii Enhanced tensile strength: when soils are exposed to tensile stresses such slope instability and erosion, they provide the soil an extra boost in tensile strength. By distributing the tensile tensions in the soil, the PET fibre reduces deformation and increases stability(Botero et al., 2015).

iii Crack arrestment: The fibres keep the soil structure intact by bridging across voids or fractures in the soil matrix (Ghasemi Nezhad and Tabarsa, 2023). This prevents the formation of larger cracks.

In geotechnical engineering, the deployment of randomly distributed fibers in clayey soil for soil enhancement applications has emerged as an intriguing area of study in recent years. It has been discovered that adding these components to the soil increases its carrying capacity, shear strength, and ability to withstand lateral deformations while lowering settlements. Both natural and synthetic fibers have several benefits, including inexpensive costs and the ability to produce synthetic fibers from recycled plastic waste.

Nonetheless, polypropylene fiber material is immune to deterioration from both chemicals and organisms (Mohanan et al., 2020).

CHAPTER 3: METHODOLOGY USED

3.1 Frame work of the methodology used

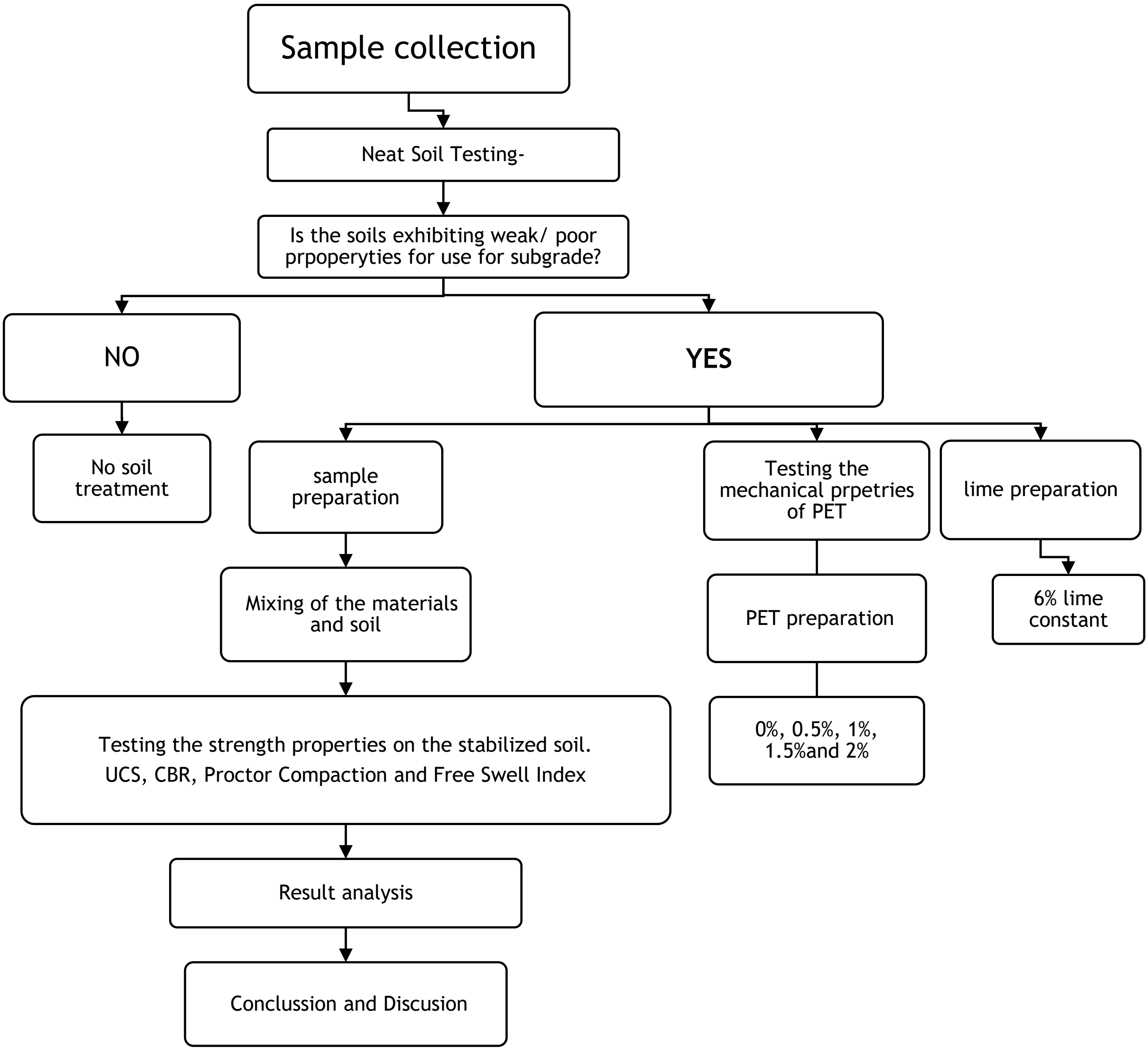

Figure 1:Frame work of the methodology

3.2. Properties of the neat soil sample

3.2.1 Introduction

The soil sample for study was collected from Muyembe-Nakapiripirit road along 47+780 km at a depth of 0.5 m from 2 different sampling points. A sample weighing around 300kg was collected and it was in a disturbed form transported to Stirling laboratory for study on the various properties of the soil.

Before the following tests were conducted, the soil was allowed to air-dry in the sun to eliminate any remaining moisture.

a) Particle size distribution
b) Atterberg limits
c) Compaction tests (proctor tests)
d) California Bearing Ratio test

3.3.2 The preparation of the materials

It was found that the soil was weak and needed fortification, necessitating the design in the addition of lime and PET fiber, based on research from earlier tests conducted on the neat soil samples and the analysis of the results. Under the guidance of our mix design, the samples were prepared. The hydrated lime content was kept constant at 6% with varying percentages of the PET fibre at 0%, 0.5%, 1%, 1.5% and 2% as shown in the table below.

Table 1:summary of the design mix

SAMPLE	PERCENTAGES BY MASS OF MATERIALS (%)			
	Expansive soils	**PET fibre**	**Hydrated Lime**	**Total**
1	94.0	0	6	100
2	93.5	0.5	6	100
3	93.0	1.0	6	100
4	92.5	1.5	6	100
5	92.0	2	6	100

The samples were then subjected to the following tests for the fourth objective:

a) Particle size distribution following BS 1377: Part 2 1990 (as described above)

b) Proctor Compaction following BS 1377: Part 4 1990(as described above)

c) CBR following BS 1377: Part 4 1990. (as described above)

d) Unconfined Compressive Strength (UCS) test following BS 1924: Part 2 1990

e) Free swell index test.

3.2.1.1 Particle size distribution following BS 1377: Part 2 1990

Particle size distribution is a critical factor in soil classification. Soil texture, which is determined by the proportion of sand, silt, and clay particles, is a fundamental property used to classify soils.

The size ranges are likely to control the engineering properties of the soil.

The test is done in reference to BS1377: part 2:1990.

Equipment used:

- Sieves (a set of sieves of different sizes)
- Mechanical sieve shaker
- Weighing balance

procedure followed

1. After soil drying, we took a representative sample and manually removed any large particles and organic debris.
2. Weighed and noted down the weight of a dry clean container (W1).
3. We added soil and the weight was recorded again with both the dirt and the container (W2).
4. We addded enough distilled water to the soil and mixed thoroughly until the soil is completely wet.
5. We screened the soil and water mixture to remove the any big particles
6. Stacked the sieves in decreasing order of sieve size, with the finest sieve on top, using the mechanical sieve shaker.
7. Arranged the shaker to begin after placing the wet soil sample on the top sieve and covering it with a lid.

8. After shaking, we removed each sieve from the stack and brushed the soil particles into a container.
9. We weighed each container with the soil particles from each sieve, and recorded the weight (W3).
10. Dried out the soil particles from each sieve in an oven set at 105-110°C for 24 hours.
11. After drying, each container was weighed with the dry soil particles (W4).
12. The percentage of soil retained on each sieve was calculated as follows:

$$\% \text{ retained on each sieve} = \frac{(W4 - W3)}{(W2 - W1)} \times 100$$

13. We calculated the percentage passing the seive as follows:

% passing through each sieve = 100% - % retained on each sieve

14. The information gathered from steps 12 and 13, plot the particle size distribution curve.

3.2.1.2 Proctor Compaction following BS 1377: Part 4 1990

The Proctor compaction test serves as a foundational laboratory technique employed to ascertain the optimal moisture content and maximum dry density of soils and aggregates pertinent to construction applications. Its primary objective involves assessing the compaction characteristics of a given soil or aggregate by replicating field compaction conditions within a controlled laboratory setting. Through analysis of the interplay between moisture content, dry density, and compaction effort, engineers can discern the most efficient and effective compaction parameters to achieve desired levels of soil compaction in construction endeavors.

This test is instrumental in determining both the Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) of the soil. The test will be performed with reference to the BS 1377: Part 4: 1990.

Standard Proctor Test Apparatus:

- A cylindrical metal mold with an internal diameter of either 4" (10.16 cm) or 6" (15.24 cm), an internal effective height of 4.6" (11.7 cm), and a detachable base plate and collar of 2 inches (5.08 cm) should be included in the mold.
- A rammer with a 2" diameter flat circular face that weighs 2.5 kg
- Sensitive Balance, has a 0.1–1-gram sensitivity range
- An oven with a thermostat
- A straight steel edge.
- Containers for moisture.
- Sieve No. 4.
- Scoop and tray.
- A graduated cylinder
- Combining instruments. (spatula, trowel, and spoon)

Procedure followed

1. Obtain a suitable quantity of representative soil, desiccate it naturally, and pulverize it using a rubber mallet.

2. Sieve the soil through a No. 4 sieve to eliminate larger particles.

3. Take approximately 3 kg of soil and adjust its moisture content to about 5% below the estimated optimal moisture content, aiming for 4% initial water content for coarse-grained soil and 10% for fine-grained soil.

4. Thoroughly mix the soil.

5. Clean the compaction mould, measure its dimensions, and weigh it without the collar.

6. Attach the collar to the mould and compact the moist soil in three equal layers using a rammer, applying uniform blows to each layer.

7. Utilize 25 blows for a 4-inch diameter mould and 56 blows for a 6-inch diameter mould, compacting to the height of the mould with the collar.

8. Ensure that the compaction test equipment is set up.

9. After compaction, remove the collar and trim the compacted soil level with the top of the mould using a straight steel edge.

10. Clean the exterior of the mould and base plate, then weigh them.

11. Extract the soil from the mould, divide it, and take a 100-gram sample for water content determination.

12. Break up soil clumps, mix them with the remaining soil, and adjust the water content by 2 to 3% increments, repeating the compaction process for each increment until the mass of the compacted soil decreases.

13. Calculate the water content and corresponding dry density for each trial.

14. Plot a compaction curve with water content on the x-axis and dry density on the y-axis.

15. Record the water content corresponding to the peak of the curve as the optimum moisture content and the corresponding dry density as the maximum dry density.

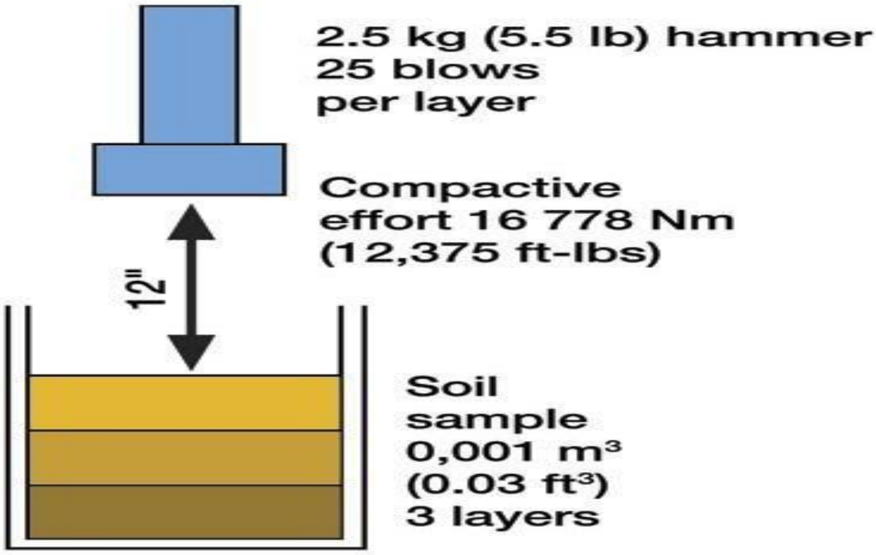

Figure 2: Proctor compaction test equipment . Source:(Hlöðversdóttir, 2019) Geotechdata.info

3.2.1.3 Atterberg Limits (BS 1377: Part 2 1990)

The Atterberg limits are a basic measure of the critical water content levels of fine-grained soils. They are used to classify the behavior and consistency of soils, especially in soil science and geotechnical engineering. The Atterberg limits consist of three discrete boundaries:

a) **Liquid Limit (LL):** This is the water content at which applying increasing shear stress causes soil to change from a plastic to a liquid condition. Its measurement is done using the Casagrande method. A soil sample is cut with a groove, and the quantity of blows required to seal the groove is noted. To find the liquid limit, take the water content and multiply it by 25 blows.

b) **Plastic Limit (PL**): This is the water content at which soil starts to act less like a plastic material and more like a solid. It can be determined by rolling a sample of soil into a thread that has a constant diameter. The water content at which the thread crumbles when rolled to a diameter of 3.2 mm (1/8 inch) is known as the plastic limit.

c) **Shrinkage Limit (SL)**: The water content below which drying soil will not cause additional shrinkage. After drying a sample of soil in an oven, the point at which shrinkage stops is noted. The water content that equals the lowest volume of the soil mass is used to calculate the shrinkage limit.

Understanding the behavior of fine-grained soils, such as their ability to expand or contract in response to changes in water content, is made easier by studying these limitations.

Equipment needed:

Atterberg Limit apparatus (including a grooving tool, a standard liquid limit device, a moisture can, a balance, and a drying oven)

Procedure for liquid limit

1. Obtain a representative soil sample and disaggregate any aggregates to pass through a 2 mm sieve.
2. Measure out 50 g of the prepared soil with precision to 0.01 g and transfer it into a moisture canister.
3. Submerge the soil in the canister under water until completely covered, allowing it to soak for a minimum of 16 hours.
4. Remove the canister from the water bath and thoroughly homogenize the soil until achieving a consistent texture.
5. Take a portion of the soil sample and form it into a thread with a diameter of 3 mm.
6. Utilize a grooving tool to create a groove along the length of the soil thread.

7. Repeat steps 5 and 6 until the groove in the soil thread closes when rolled to a diameter of 2 mm.
8. Document the quantity of drops from the liquid limit apparatus required to close the groove when the soil thread is rolled to a 3 mm diameter.
9. Repeat steps 5-8 for a minimum of two additional soil samples.
10. Weigh the remaining soil in the moisture canister and transfer it to a drying oven.
11. Dry the soil sample in the oven until reaching a constant weight.
12. Weigh the dried soil with precision to 0.01 g and record the measurement.
13. Calculate the liquid limit of the soil by averaging the number of drops needed from the liquid limit apparatus.
14. Conduct the test on other soil samples to establish an average liquid limit value.

3.2.1.4 CBR following BS 1377: Part 4 1990

The primary purpose of the CBR test was to determine the potential strength and resilience of soils and aggregates under load-bearing conditions, particularly in road construction projects. Engineers can determine a material's resistance to applied stress and deformation—a critical factor in guaranteeing the durability and stability of road infrastructure—by exposing samples to controlled loading and penetration.

The following is a summary of the procedure

Step 1: Sample preparation

1. Moisture content Determine and prepare the soil sample to the required moisture content. This is typically done by using the standard Proctor compaction test or Modified Proctor compaction test.

2. Compaction: Compact the soil into the CBR mould in layers. Each layer is compacted to achieve the desired density. The compaction effort is critical to obtaining representative CBR values.

Step 2: Assembling the apparatus

1. CBR mould: The test's CBR mould features a 150 mm base diameter and a 50 mm collar height. Together, the collar and base create a cylindrical chamber that holds the soil sample.
2. penetrating plunger: This tool features a penetrating shaft and a 50 mm diameter. The load is applied to the soil sample using this plunger.
3. Surcharge weight and spacer discs: To replicate the weight of pavement layers, a surcharge weight—typically 10 lbs. or 4.54 kg—is positioned on top of the sample. Another option for ensuring uniform loading is to utilize spacer discs.
4. CBR machine: Typically set at 1.25 mm/min, the CBR machine has a consistent penetration rate. The soil sample is subjected to a vertical load using this machine.

Step 3: Saturation

Soaked conditions: if the test is intended for soaked conditions, the soil sample needs to be saturated before testing. Saturation is often done by immersing the sample in water for a specified duration.

Step 4: Loading

1. Application of the load: The CBR machine applies a load to the penetration plunger at a constant rate of 1.25 mm/min. The load is continuously increased until a specified penetration is achieved.

2. Data recording: Throughout the test, the load and corresponding penetration are recorded at regular intervals. This data is crucial for calculating the CBR value.

Step 5: Calculation of the CBR:

CBR value is calculated as the ratio of the test load to the standard load usually at 2.5 mm penetration, multiplied by 100.

The formula is CBR (%) = (Test Load / Standard Load) x 100.

3.2.2.1 Unconfined Compressive Strength (UCS) test following BS 1924: Part 2 1990

The Unconfined Compressive Strength (UCS) test is a standard laboratory method used to determine the unconfined compressive strength of cohesive soils. The results of this test provide important insights on the soil's capacity to withstand axial compression stresses when it is unconfined or unrestrained. For a variety of construction applications, such as earthworks, slope stability analysis, highway design and foundation design, it is extensively utilized in geo-technical works to assess the strength and stability of earth materials.
The Unconfined Compressive Strength (UCS) test's main goal is to determine the highest compressive stress which a soil specimen is capable of supporting when it is not under any constraints. Engineers can use this information to assess cohesive soils' stability and ability to support loads, especially when they contain clay or silt.

This test was done with reference to the BS 1924: Part 2: 1990.

It is determined by applying increasing loads until failure to prepared specimens that have been mixed, compacted, and cured in accordance with the guidelines and mixing design.

The UCS of a stabilized material is the load in kPa required to crush a cylindrical specimen 127mm high and 152.4mm in diameter to a total failure at a rate of application of load of 140kPa/s(Güllü and Fedakar, 2017).

3.2.2.2 Tensile strength test

This test was done on the pet plastics to evaluate the its mechanical properties especially resistance to tensile forces. It was dine according to the ASTM D638-14 “Standard Test Method for Tensile Properties Of Plastics” standards

Procedure followed

- Sample preparation: The plastics were chopped to strips of 250 mm long with uniform width. We made sure that the samples were free from any defects that may have been generated through the cutting or damage before getting the plastic to avoid the creation of point of weakness that breaks before reaching the maximum breaking point.
- Mounting the strip. The strip was mounted in the machine for testing that was gripped and marked to test the elongation at the testing point. The strip was firmly griped without damaging.
- Setting up the machine: the machine was set by entering the required data and connecting it to the power and commanding computer.
- Testing; the machine was started and an increasing pulling force was exerted on the plastic until its breaking point.
- Data collection; the forced exerted was recorded with the help of the computer and the elongation calculated after measuring the final length of the plastic.

Elongation = final length – initial length.

Once the test is done, the analysis was done to determine the tensile strength, elongation at break, modulus of elasticity as discussed in chapter 4 for results and discussions.

3.2.2.3 Free swell index

Free Swell Index (FSI) is a laboratory test used to measure the volume change (swelling) that expansive soils may experience when they absorb water under specific circumstances.

The free swell index test gives geologists and engineers the crucial data they need to evaluate a soil's capacity to swell, especially expansive clay soils, which can be problematic for building projects because of their large volume changes with variations in water content.

Testing was done with reference to IS 2720 (part-40): 1977as follows

- Sample preparation: this involves taking representative soil samples from the field to make sure they fairly depict the soil characteristics at the construction site.
- Testing:
    1) Two 10grams of oven dried soil was poured in 2 graduated glass cylinders of 100 ml capacity after sieving through 425 micro sieve.
    2) The glasses were filled with kerosene and distilled water up to the 100ml mark for either glass.
    3) They were stirred to remove the air that may be trapped and allowed to settle for 24 hrs to obtain the value without further change in volume of the soils. The final volume if the soils is recorded.

- Calculations: the level of soils in the kerosene will be read as the original volume (VK) because kerosene is a non-polar liquid that does not cause swelling of the soil. The level of the soil with water in the distilled water cylinder as the free swell level.

$$FSI = \frac{(VD)-VK)}{VK} \times 100\%$$

Where:

VD : free swell level

VK : kerosene level

CHAPTER 4: RESULTS AND DISCUSSIONS.

The findings of the soil tests conducted on the soil sample are critically analyzed in this chapter. In addition, tests were conducted to categorize the soil and examine its characteristics, as well as the material's properties and improvements in those attributes following treatment with the addition of hydrated lime and PET fiber. The tests involved covering the four specific objectives of the final year research and design project.

4.1 Neat Sample Tests Analysis

The first specific objective is concerned with the engineering characteristics/ properties of the soil sample that was collected from Muyembe-Nakapiripirit road. The analysis focuses on determining the dealt with the classification of the neat soil sample of the expansive soils, and this classification involved the following:

4.1.1 Particle size distribution.

Particle size distribution(PSD) involved the use of Sieve analysis (BS 1377 Part 2:1990. It was done for coarse soils as the particles can be differentiated by passing through different sieve sizes. This revealed the relative amounts of the several particle sizes—clay, gravel, silt, sand, or sand—that are present in the soil sample and which one is predominant, hence regulating the soil's engineering qualities.

The data was used to plot the graph of percentage pf cumulative passing against the sieve size.

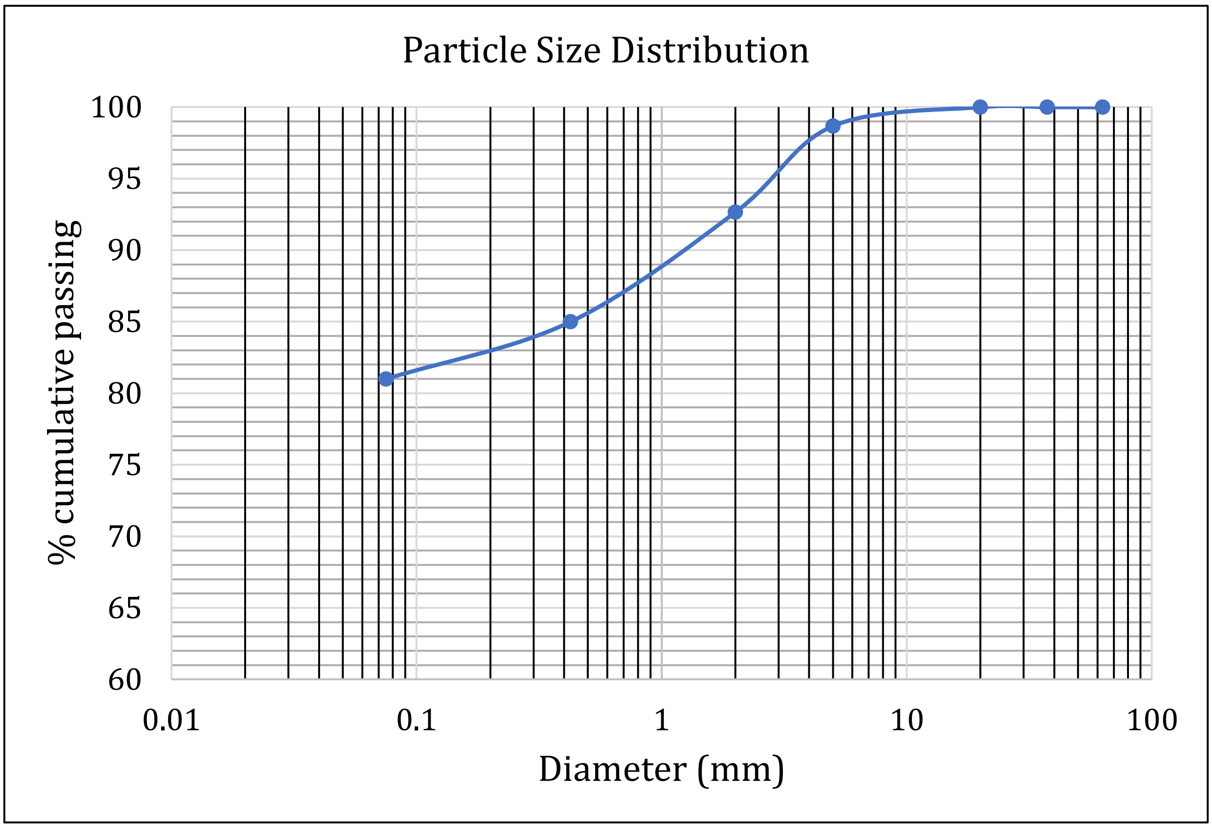

Figure 3: Particle size distribution graph

The percentage of particles passing the 0.075mm sieve was found to be 81% with a Grading Modulus of 0.42. In soil mechanics, the grading modulus, sometimes referred to as the coefficient of gradation, is a metric used to express how uniformly distributed the particle sizes are in a soil sample(Paige-Green, 1999).

It was calculated from the last 3 smallest sieve sizes and the amount passing. A higher grading modulus indicates a wider range of particle sizes, making the soil sample more poor graded while a lower grading modulus indicated a narrower range of particle sizes making it well-graded. Well graded soils have good workability characteristics.

The Particle size distribution chart implied that the percentage passing through the 0.075 mm sieve can be classified as the fine grained soils.

4.1.2 Atterberg limits

The Atterberg limits serve as essential parameters for soil classification in engineering applications. Two soil samples were analyzed to ascertain these limits. The shrinkage limit denotes the moisture content at which the transition from solid to semiliquid state occurs. The plastic limit (PL) corresponds to the moisture content marking the transition from semiliquid to plastic state, while the liquid limit (LL) denotes the point at which the transition from plastic to liquid state occurs.

4.1.2.1 Liquid limit

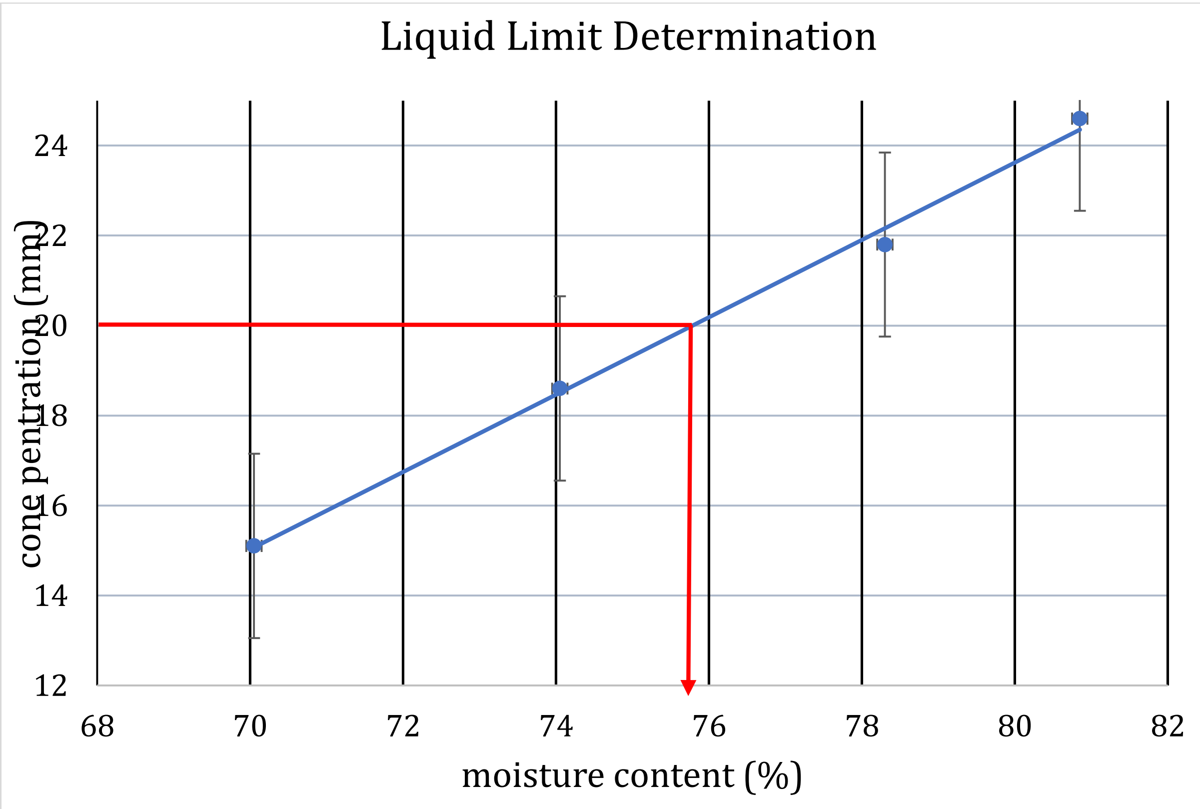

Figure 4: graph of cone penetration against moisture content

The highest liquid limit recorded for neat sample-1 was 81.2% at a depth of 0.5 meters, while the lowest was 69.4%. Neat sample-1 had an average liquid limit of 75.6%. Neat sample-2 showed a maximum liquid limit of 80.5% at a depth of 0.5

meters and a minimum of 70.7% at the same depth. The average liquid limit for neat sample-2 was 76.0%.

The combined average liquid limit for all samples was determined to be 75.8%.

From the chart and data of the average of the 2 neat soils in accordance to the standard cone penetration depth at 20mm, the Liquid Limit was found to be 75.8 %.

4.1.2.2 Plastic limit

The mean plastic limit of neat sample 1 was determined to be 37.5% at a depth of 0.5m, while for neat sample 2, it was measured as 37.6%.

The overall average plastic limit across all samples was calculated to be 37.6%.

4.1.2.3 Plasticity index:

The plastic limit for neat sample-1 was 38.1% and neat sample -2 was 38.4%. The average was 38.2%

4.1.2.4 Shrinkage limit

The linear shrinkage limit for pure sample-1 was determined to be 20% at a depth of 0.5m, while for pure sample-2, it was also 20% at the same depth. The mean linear shrinkage limit across all samples was calculated to be 20%.

These findings suggest that the Atterberg limits were relatively consistent, with the average values for the plastic, liquid, and linear shrinkage limits of pure sample-02 being slightly greater than those for pure sample-01.

Summary of the Atterberg Limits Test results:

Table 2: Atterberg limits

	Liquid Limit	**Plastic Limit**	**Plasticity Index**
Neat Sample 1	75.6	37.5	38.1
Neat Sample 2	76.0	37.6	38.4
Average	75.8	37.6	38.2

The Plasticity chart revealed that soils positioned above the A-line and characterized as inorganic clays with high plasticity, CH. Employing the Unified Soil Classification System (USCS) identified the soils as Fine grained high plasticity inorganic clay soils.

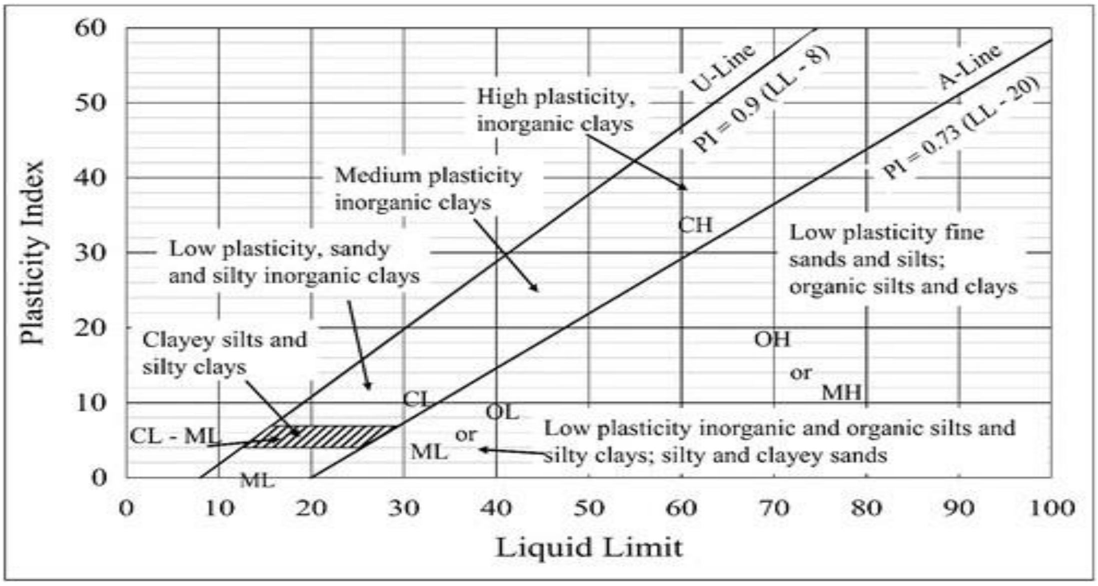

Figure 5: Plasticity chart for classification of fine-grained soils.

Source: Flink.springer.com

The AASHTO soil classification system found the soils to be Clayey soils of Group Classification A-7, A-7-5 and A-7-6. The given soil classification meant that such soils are poor subgrade materials having a high plasticity and likely low bearing capacity hence implying that in order to make such soils viable for subgrade use in road construction. there shall be an aim to use quick lime and PET fibre to improve the strength properties and plasticity of such soils to the allowed standards of subgrade materials.

Highly plastic soils Clayey soils often swell when the amount of moisture increases and shrink when the moisture content decreases(Wan et al., 2002). The structures i.e. highway, bridges and buildings that may be built on such soils are impacted by the volumetric changes which causes cracking due to continuous the swelling and shrinking with variation in the water content of the soil. This can be reduced with treatment of the soil with lime to reduce the plasticity and the pet fibre to act as a reinforcement and reduce the chances of cracking.

4.1.3 California Bearing Ratio (CBR)

The experimental findings derived from tests conducted on the specimens yielded California Bearing Ratio (CBR) values of 8.0% and 7.0% for unaltered sample-1 and unaltered sample-2, respectively. The mean CBR value calculated from these samples was determined to be 7.5%.

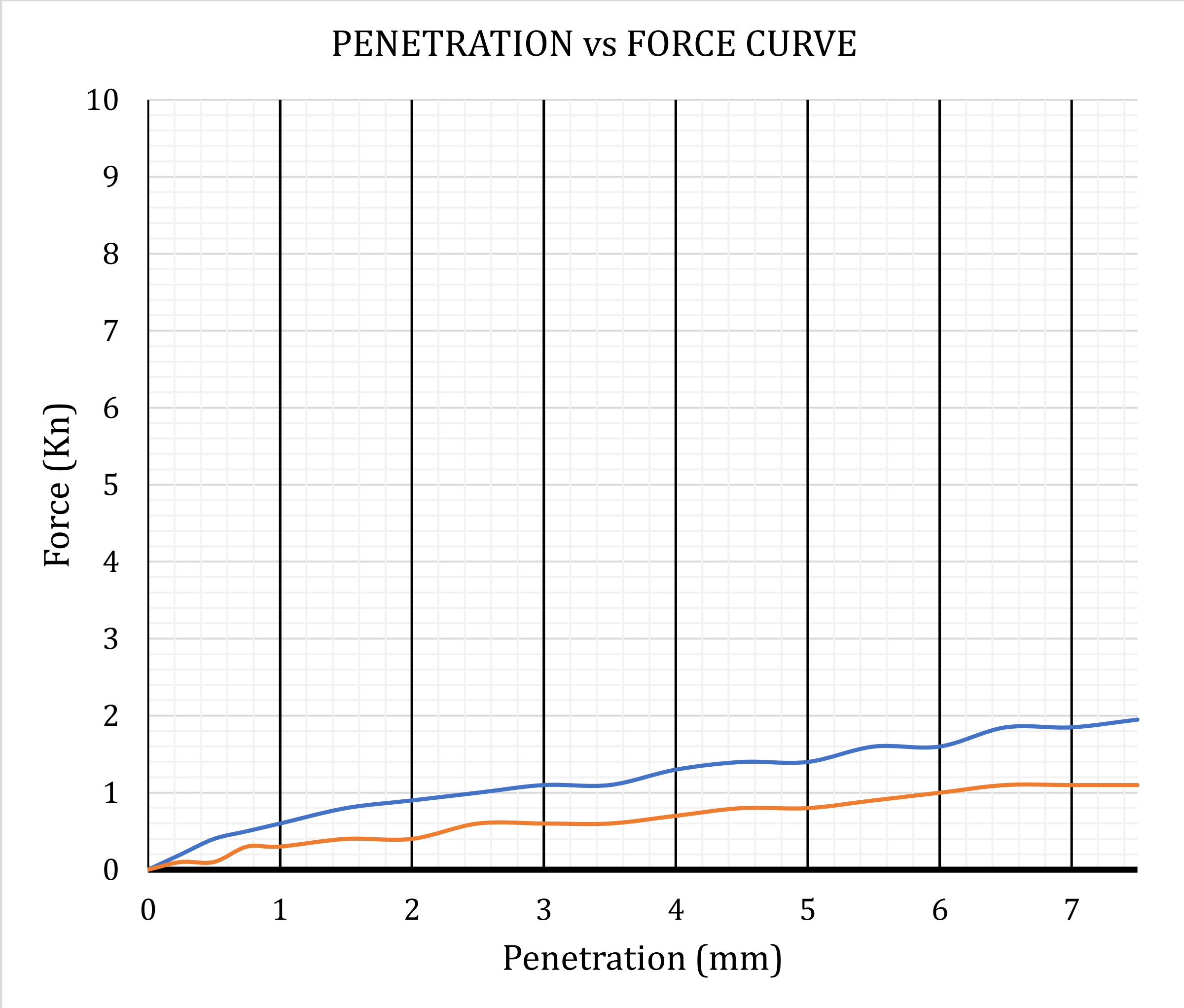

Figure 6: Graph of penetration vs force curve

Bottom

top

In the examination of subgrade soil, a California Bearing Ratio (CBR) measurement of 7.5% indicates a soil condition characterized by diminished strength, rendering it unsuitable for substantial load-bearing applications. The CBR, denoted as a percentage, signifies the quotient of the applied test load to the standard load for a defined penetration depth.

Table 3:General interpretation of the CBR values

CBR Values	Interpretation
Below 5%	Very weak soil, typically unsuitable for supporting heavy loads without significant deformation
5% to 15%	Weak soil, may require stabilization or improvement for construction purposes. It might be suitable for lighter structures or low-traffic areas.
15% to 30%	Moderately strong soil, generally suitable for supporting light to moderate traffic. Stabilization measures may still be considered.
30% and above	Strong soil, suitable for supporting heavy traffic and construction loads. This type of soil is typically well-suited for road construction without extensive stabilization.

The upper subgrade layers are supposed to be a G15 subgrade class which requires a minimum CBR of 15 % and maximum CBR swell (%) of 1.5 (MoWT, 2020). The soil exhibit properties with a CBR of 7.5 % and the CBR swell was 1.07 % which is out of specifications as a proper subgrade material. Thus a need for improvement of the soil properties or stabilization to improve its strength making it suitable for use as a subgrade in road construction or other infrastructure projects. A low CBR value is an indicator of the low bearing capacity of the subgrade thus unable to support the loads that are caused by the daily traffic of the highway that will be constructed(Reddy and Moorthy, 2005).

The objective is to enhance the California Bearing Ratio (CBR) value, thereby augmenting the load-bearing capacity of expansive soils by employing hydrated lime and PET fibers as the focal points of the study.

4.1.4 Proctor Compaction

The tests are carried out to determine the maximum dry density(MDD) of the sample at the optimum moisture content(OMC) for the varying fibre content.

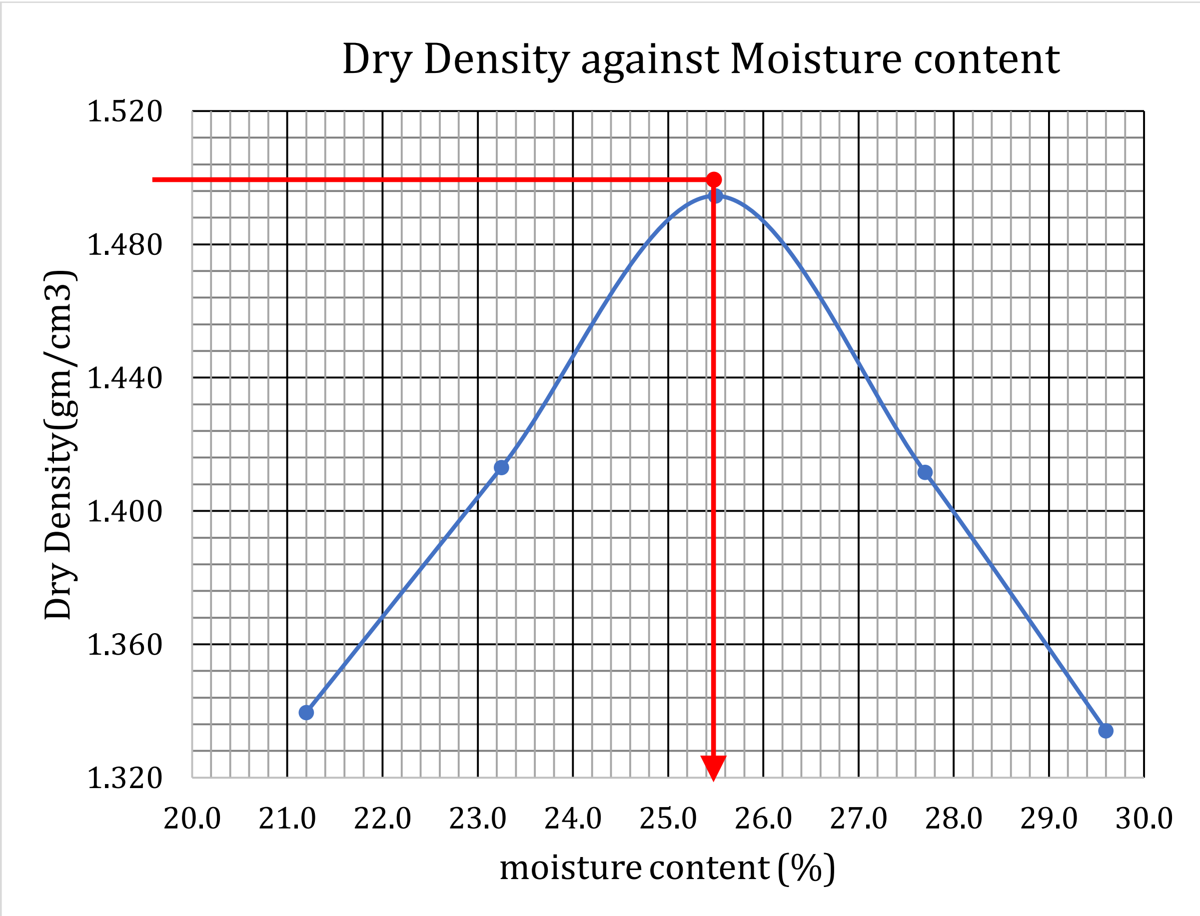

Figure 7: dry density against moisture content

The Optimum Moisture Content of the soil was found to be 25.5 % and the Maximum Dry Density was 1.495 gm/cm3.

Subgrade strength decreases due to increases of moisture content thus indicating a need for a lower OMC that can improve the strength of the soil. The strength of the subgrade is highly associated to the CBR value but it's also affected by the amount of the water in the subgrade(Sabri, 2015). Stabilisation with lime and PET fibre will improve this effect.

4.2 Tensile strength of the fibre

We used 5 different plastic strips to test and obtain to obtain the average tensile strength.

Table 4: The tensile strength results

Sample ID	Cross sectional area (mm^2)	Breaking point force (kN)	Tensile strength (MPa)	Average (MPa)	Elongation (%)	Average Elongation (%)
PET 1	3.45	0.750	217	224.6	64	63.6
PET 2	2.52	0.500	198		59	
PET 3	3.32	0.800	241		62	
PET 4	3.45	0.800	232		68	
PET 5	2.13	0.500	235		65	

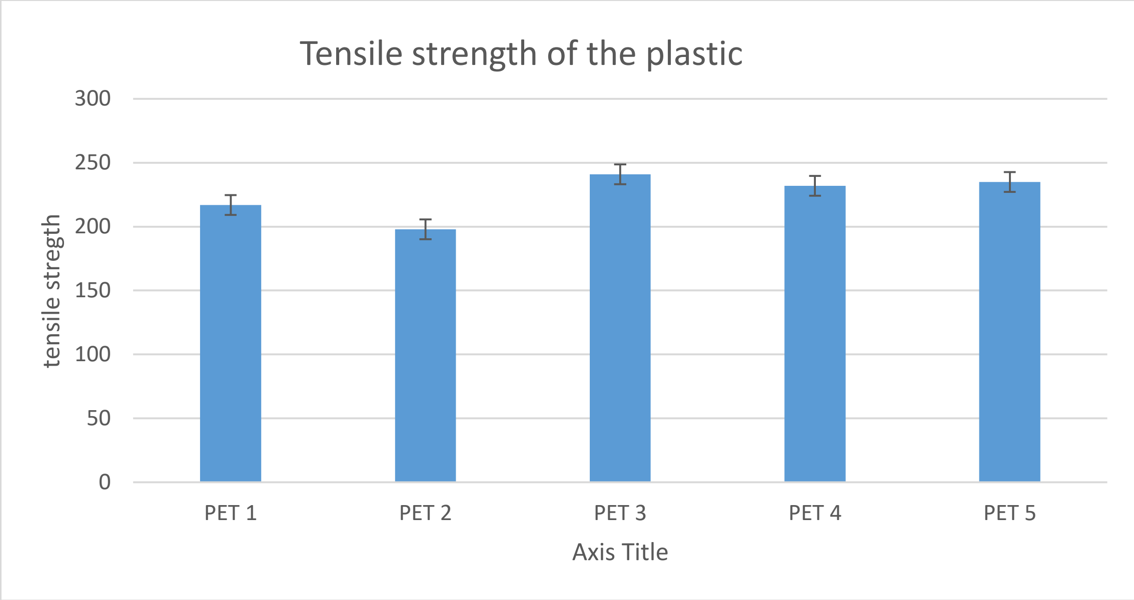

Figure 8: Graph of tensile strength

Tensile strength refers to the maximum stress that a material can withstand before it breaks under tension. The average observed tensile strength of 224.6 MPa shows that the PET fibers are strong enough to prevent failure or deformation under tensional stresses and can bear significant tensile forces without breaking. This effectively reinforces the soil when added.

PET fibers with higher tensile strength are desirable as they can better resist the forces exerted by soil movement, settlement, or external loads (Nezhad et al., 2021).

The elongation at break was found to be 63.6%, indicating that the fibers can deform up to 63.6% of their original length before breaking. This shows that the PET has higher flexibility and can deform before failing, which can be useful for withstanding soil movement or settlement without rupturing.

4.3 Discussion of results of the stabilised soils

After incorporating lime and PET fiber into the soils, a series of tests were conducted to assess the alterations induced by these additives. The subsequent discussion and analysis delve into the results obtained from these diverse tests.

4.3.1 Atterberg Limit Tests

The Atterberg limits are used to determine the plasticity and any soil with a PI ≥ 20% for the soil, it can be classified as highly plastic soil. The neat soil samples indicated a pi of 38.5 a clear indicator of highly plastic soil. The Ministry of Works and Transport (MoWT) recommends that the liquid limit should be 30% or less, and the plasticity index should be 10% or less for materials considered suitable for subgrade.

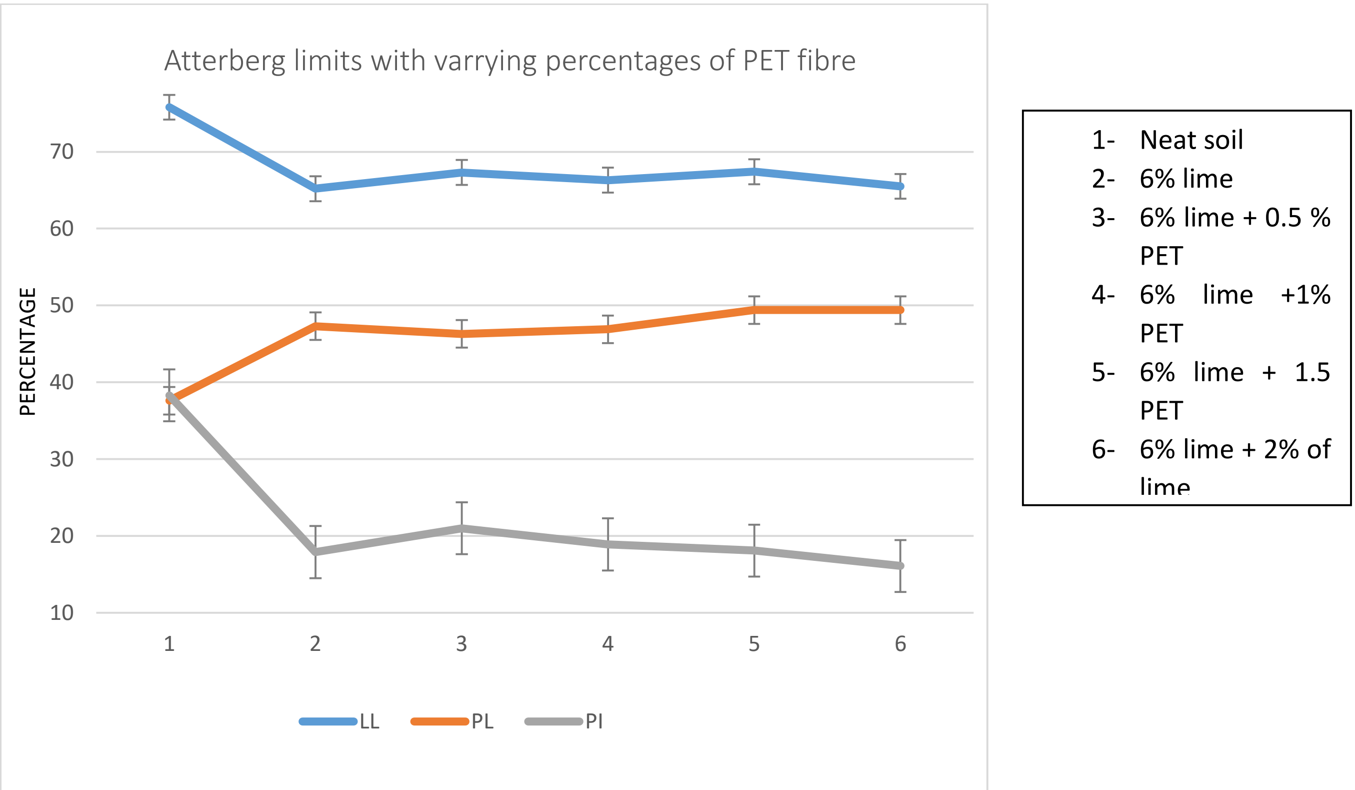

Figure 9: Atterberg limits against varying percentages of PET fibre

The addition of 6% lime alone leads to significant decrease in the Liquid Limit, increase in the Plastic Limit and a reduction in the Plasticity Limit. This is attributed to the increase in the water absorption in the soil. Lime changes the mineralogy and structure of the soil, reducing its affinity for water and thus reducing the plasticity.

Adding different PET fibre contents to the 6% constant lime results in an approximately consistent liquid limit, a slight rise in plastic limit, and a decrease in the plasticity index. The changes are can be attributed to the mixing type, the relative amount of clay content and consistency limits of the mixture changed (Taha et al., 2020).

The observed improvement in the plasticity of the soils is highly influenced by the lime content to a big extent due to its ability to chemically react with the compounds in the clay soils through the pozzolanic reactions when added (Mishra and Gupta, 2018). The Pet fibre has less impact on the plasticity of the soils.

4.3.2 Classification of and grading of the soil

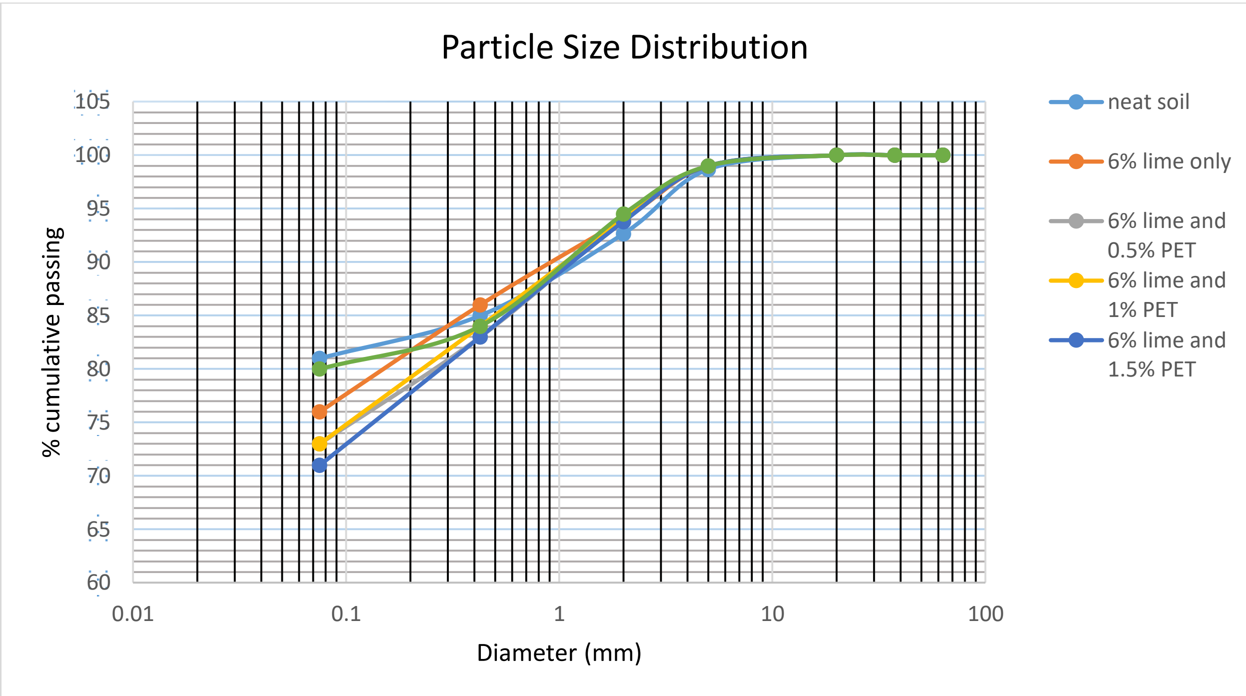

Figure 10: Particle size distribution graph of varying PET fibre

The introduction of lime and PET fibre alters the proportion of soil passing through the 75 μm sieve, reducing it from 82% to an average of 75%. This change is attributed to the increased presence of solid material and the cohesive effect of lime on the soil, resulting in the formation of larger particles. Additionally, it has been suggested that fine-grained soils are unsuitable for subgrade material, indicating that without improvement, these soils are not suitable for subgrade use.

4.3.3 Compaction Parameters.

The standard compaction tests were done on the soils according to the **BS 1377: Part 4 1990** standard to determine the variation in the Optimum Moisture Content and the Maximum Dry Density in the soil with addition of 6% lime and different PET fibre content.

Table 5: OMC and MDD results for treated soils

Mixture	**OMC(%)**	**MDD(g/m^3)**
6% lime + clay soil.	27.4	1.464
6% lime + 0.5% PET fibre + clay soil.	26.7	1.505
6% lime + 1% PET fibre + clay soil.	25.8	1.524
6% lime + 1.5% PET fibre + clay soil.	24.9	1.556
6% lime + 2% PET fibre + clay soil.	27.5	1.492

4.3.3.1 MDD

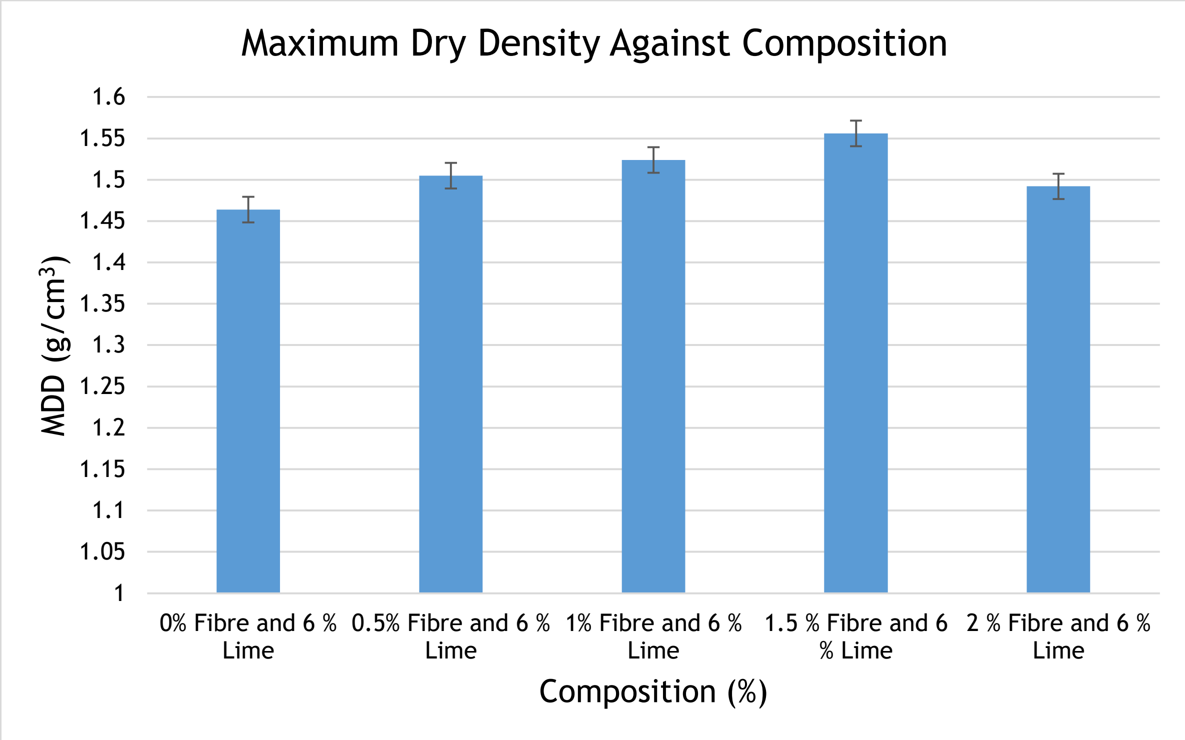

Figure 11:dry densities against varying PET fibre content

The PET fiber was introduced in concentrations ranging from 0.5% to 2%, with incremental values of 0.5%. Initially, the Dry Density decreased when 6% of Hydrated Lime was added to the undisturbed soil sample. However, the Maximum Dry Density (MDD) subsequently increased with an escalation in fiber content up to 1.5%.

The addition of plastic strips into soil decreases the number of voids thus improving effective compaction and cohesion hence leading to an increase in the Maximum Dry Density of the plastic-soil mixture(Kalliyath et al., 2016). From 2% of fibre content, it was observed that Dry Density decreased once again. This drop in the MDD is attributed to the higher water retention properties of the fibre reinforced soil (Aishwarya and Rachel, 2023).

4.3.3.2 Optimum Moisture Content

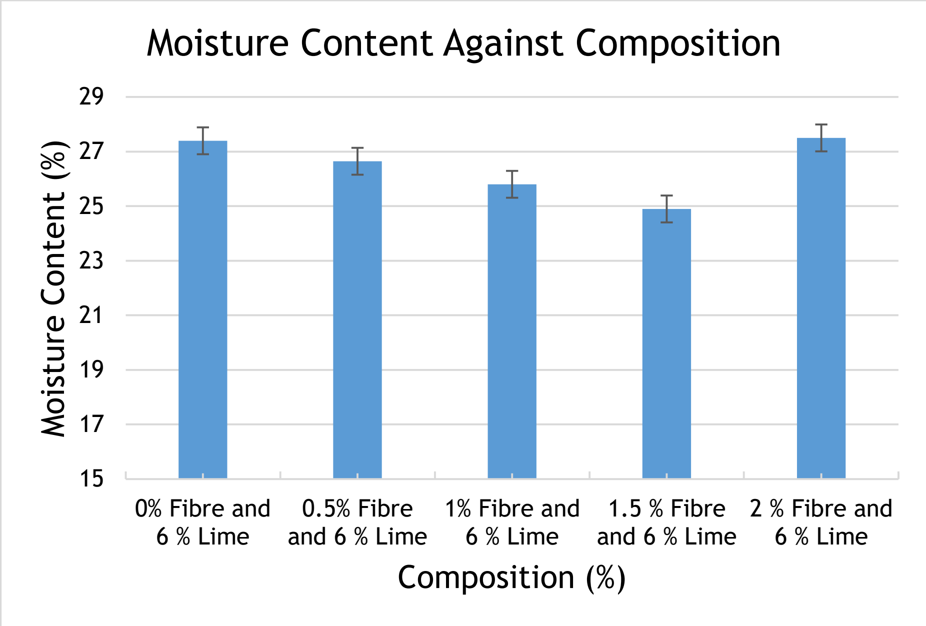

Figure 12:graph of OMC against varying PET fibre content

Initially, the Optimum Moisture content rose upon the introduction of 6% Hydrated Lime alone. This increase can be attributed to the cation exchange and flocculation processes, which result in larger grain sizes. Consequently, there is an increase in the void ratio, leading to a subsequent decrease in maximum dry density and an increase in Optimum Moisture content. However, after further addition of PET fibres to the soil stabilized with 6 % Hydrated Lime it was seen that there was a decrease in the Optimum Moisture Content of the expansive soils till the 2 % of fibre content.

The water demand reduced as the PET content increases since it does not absorb moisture and also reduces the void ratio and porosity (BG and Vageesh, 2017).

Generally, studies on compaction parameters indicate a decrease in Optimum Moisture Content as PET content increases. Conversely, there is a decrease in Maximum Moisture Content with an increase in PET fiber content. This phenomenon arises from the non-absorbent nature of plastics compared to clay soils, which are replaced by the plastic fibers as the clay soils have a high affinity to water due to their surface tension, unlike plastics.(Hassan et al., 2021). The PET fibre has a lower OMC than the clay particles and an increase in the PET fibre content reduces the overall OMC of the stabilised soils(Taha et al., 2020).

At a 2% PET fiber concentration, it was noted that the Maximum Dry Density (MDD) of the soil decreased. This reduction was attributed to the overlapping PET fiber content within the matrix, leading to a decrease in compaction efficiency. (Taha et al., 2020).

The soils indicated good compaction characteristics with an increase in the PET fibre content with 1.5% the optimum. this indicates less water content is required to compact the soil thus good strength properties.

4.3.4 California Bearing Ratio (CBR)

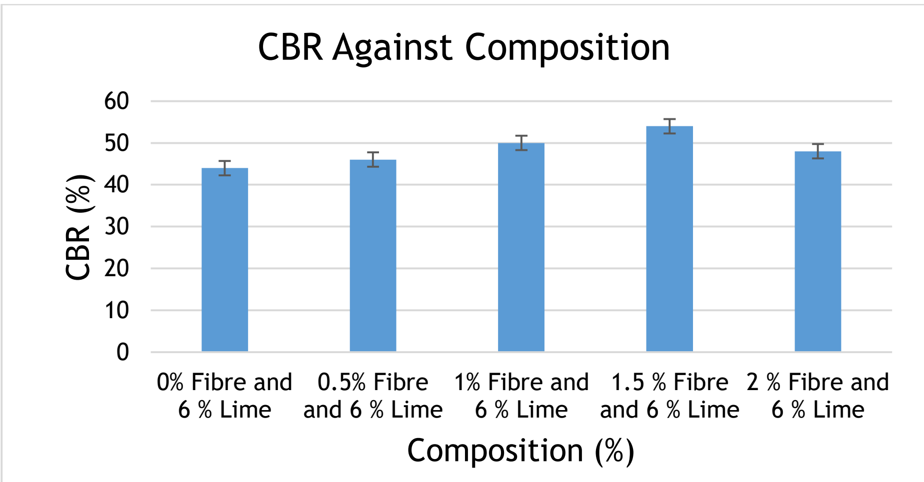

Figure 13: Graph of CBR against varying fibre content

The soil sample was stabilized with a constant amount of 6% concentration of Hydrated Lime, and it was observed that the CBR of the soils increased by 7.5 % to 44 %but failed to meet the required standard of the subgrade of 50 %. An evident increase in stiffness with greater penetration was noted when incorporating fiber content from 0.5% to 1.5%, followed by a decrease upon adding 2% fiber. The decrease of the CBR at 2% PET fibre addition leads to segregation of the soil-plastic matrix during compaction hence causing poor bonding between the materials(Raghu et al., 2015).

The highest CBR value was achieved at 6% lime and 1.5 % PET fibre at 54% meets the required standards. This improvement in the CBR value of soil behavior due to PET fibre addition suggests the potential application of randomly distributed discrete fibres to reinforce soft soil subgrade/sub base under heavy loads for improving the strength which may suffer excessive deformation otherwise (Hasrajain et al., 2015). Enhancing the CBR will enhance the subgrade's strength and decrease costs by reducing the pavement thickness (Al-Obaydi et al., 2022).

4.3.5 Unconfined Compressive Strength (UCS) Test

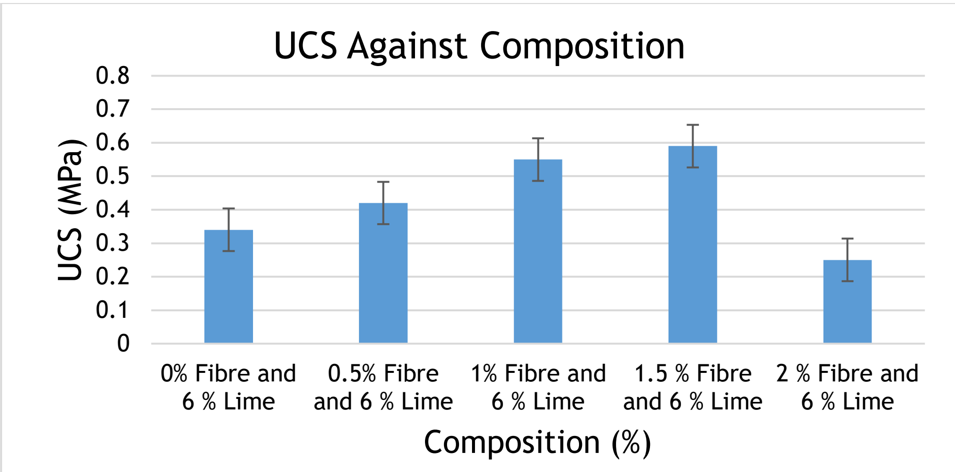

Figure 14: Graph of UCS against varying PET fibre composition

The UCS of the soils continuously improved from 0.42 MPa at 0.5% pet to 0.59 MPa at 1.5% pet fibre while UCS value reduced significantly at 2% PET fibre addition.

Incorporating lime into the soil results in the formation of a highly alkaline environment (with pH exceeding 12) within the pore fluid, leading to the gradual dissolution of Silica (SiO_2) and Alumina ($Al2O_3$) present in the soil. The dissolved Silica and Alumina form a cementitious gel (like CSH and CAH) which coats the coarser particles and the subsequent strong bond between them, leading to an increase in strength and making the material more brittle. Moreover, further increases in lime started to negatively affect strength(Hussain and Dhar, 2019).

The initial UCS value for soils treated with 6 % hydrated lime only was observed to be lower than the remaining UCS values of the expansive soils treated with 6% lime + 0.5%, 1% and 1.5 % of the PET fibre. Fiber reinforcements are capable of bearing tensile stresses, which are activated through the friction between the reinforcements and the soil. The incorporation of the fibres in soils improves its tensile strength and mechanical behavior when compared with soils lime only (Marçal et al., 2020).

At a 2% PET fiber concentration, the Unconfined Compressive Strength (UCS) decreased, leading to failure characterized by diagonal cracking from the top to the bottom of the sample during testing. This was caused by the high PET percentage which change the failure pattern from ductile to brittle(Lawer et al., 2021).

The 6 % lime + 1.5 % PET fibre content was taken to be the best mix ratio with UCS value of 0.59 MPa. It produced the UCS value that confines to the minimum standard UCS value of 0.5 MPa (MoWT, 2020)

4.3.6 Free Swell Index

Discussion

The FSI was carried out on the neat sample, soil treated with 6% lime only and the sample treated with 6% and 1.5 % of PET fibre. The sample with 1.5% PET and 6% lime was considered as the best ration after analysis of results for the compaction parameters (MDD and OMC), CBR and UCS of the different variations of PET fibre with constant 6% lime added.

The FSI of the 6% lime +1.5% PET fibre was lower compared to the FSI of the neat sample and lime alone. The decrease of the Free Swell Index is caused by the addition of lime and PET fibre as indicated in the graph with its falling trend when lime and PET fibre was added

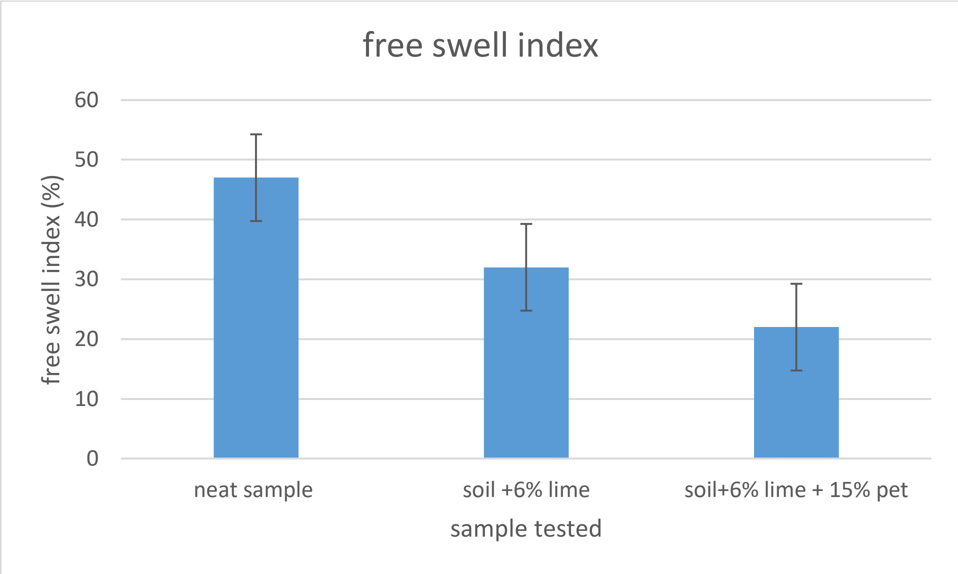

Figure 15: free swell index graph

When the moisture content increases, the soil swells and its volume increases in a wide range from the original because of the capacity of water to break the chemical bonds. The clayey soils swelling potential reduced because of the pozzolanic chemical reaction between the hydrated lime and the clay particles after addition of the lime (Manzoor and Yousuf, 2020).

Additionally, the amount of soil required for the sampling in the 10g sample for the saturation decreased as a result of the PET addition. The PET fibre is a non-swelling material thus reducing the amount of material (soil) with the swelling properties thus a reduction in the free swell index (Kassa et al., 2020). The PET only has a physical effect of replacing while lime has the chemical effect on the soil.

4.4 Project Design and summary of the results for reinforcement.

Table 6:Project Design and summary of results

PERCENTAGES BY MASS OF MATERIALS (%)				TEST RESULTS					
Expansive soils	**PET fibre**	**Hydrated Lime**	**Total**	**CBR (%)**	**FSI (%)**	**MDD (g/cm^3)**	**UCS (MPa)**	**OMC (%)**	**PI (%)**
94.0	0	6	100	44	32	1.464	0.34	27.4	17.9
93.5	0.5	6	100	46	-	1.505	0.42	26.7	21.0
93.0	1.0	6	100	50	-	1.524	0.55	25.8	18.9
92.5	1.5	6	100	54	22	1.556	0.59	24.9	18.1
92.0	2	6	100	48	-	1.492	0.23	27.5	16.1

Table 7:Project Design and summary of results

The table above is a collection of the results obtained with varying material content against the different parameters. One column indicates the mix with the percentages used and the other contains the results for the CBR, FSI, MDD, UCS, OMC and PI for the varying amount of materials used.

4.5 Findings

The characteristics of the undisturbed soil sample indicated its classification as expansive soil, specifically fine-grained clayey soil, evidenced by its high plasticity and low CBR value. The high plasticity of the soils associates it to volume changes when the soils come into contact with water and the low CBR value of 7.5 % indicate the low strength properties that cannot resist the loading stresses on the pavement.

The PET exhibited an average of 224.6 MPa tensile strength and elongation of 63.6 %. The tensile strengths achieved by the plastic is critical in boosting the strength properties if the soil and the high the elongation, the longer the time for soil deformation.

The ideal ratio for usage in stabilization was determined by comparing the engineering and strength properties of the variations of PET and lime added to the soil. The results show the great improvement at 6% lime + 1.5% PET fiber.

The MDD increased by 6.28 % and OMC reduced by 9.12 % in stabilized samples. The California Bearing Ratio (CBR) of the stabilized soil increased to 54% from 7.5% of untreated sample and the UCS raised to 0.59 MPa at the optimum ratio. These results indicate great improvement in the engineering and strength properties if the soil compared to the soil that is untreated.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion:

This research was aiming at improving the strength properties with reinforcement of the lime stabilised soils with the PET fibre. the soils were collected from Muyembe-Nakapiripirit road and was rated as a highly plastic subgrade with poor strength properties. From the above results and discussion, the following conclusions were made:

- Expansive soils from the site was classified as A7-6 with a PI of 38.3%, CBR OF 7.5 which categorized it a s weak subgrade that required improvement or replacement.
- The tensile strength of the 224.6 MPa and an elongation of 63.6 % while testing the plastics which indicated a high resistance to tensile forces and ability to with stand forces for a longer time without breaking due to higher elongation.
- The combination of 6% lime and 1.5 % produced the best ratio in the design with UCS of 0.59 MPa, CBR 54%, 18.1% of PI, MDD and OMC of 1556g/cm3 and 24.9%. This was considered as the best ration because it was producing the best results while meeting the required standards.
- The UCS values for 6% lime only 0.34MPa is below the standard of 0.5MPa UCS according to MoWT but the addition of PET with different percentages increased the USC to 0.59 MPa at 1.5% of PET fibre. The optimum percentage that gives the maximum unconfined compressive strength is 6% Lime with 1.5 % PET fibre both after 14 days was at 0.59 MPa and a CBR of 54%. These qualified the material to be used as a subgrade for the roads according the MoWT standards. the rise in the values indicates an improvement in the soil

properties influenced by the materials – (lime and PET fibre) added during the research.

5.2 Recommendations

More research should be done with varying fiber sizes to explore the effect of the sizes on the effectiveness of the fibre to improve the soil. This could assist in determining the ideal fiber size for stabilizing soil with lime.

There is need to utilize the addition of PET fibre in the lime stabilised soils while improving the engineering properties of expansive subgrades with the study indicating the optimum of 1.5% pet fibre and 6% lime. these produced a UCS of 0.59 MPa and 54 % CBR which qualify to be used as a subgrade according to the MoWT standards. This will reduce the amount of plastic waste that is disposed of in the environment as well as lime.

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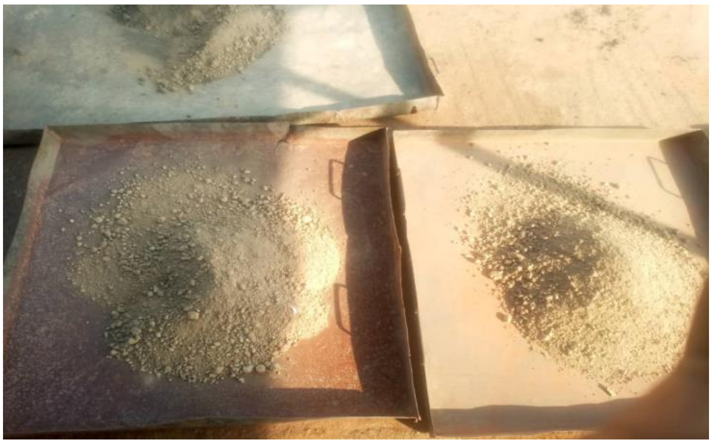
Appendix 1 Tables and pictures

Activities	2023				2024			
	September	October	November	December	January	February	March	April
Proposal writing								
Material collection								
Literature review								
Collection of data								
Data analysis								
Supervisor consultation								
Report writing								
Project Presentation								
Report Submission								

Table for the work schedule

Weighing the compacted soil during the proctor test



Sun drying the soil sample

Proctor test during the compaction

Fixing the PET plastic in the tensile strength testing machine

The tested plastics after breaking.

Appendix 2 – Laboratory results

INSTITUTION	STUDENTS	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT: ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

SUMMARY OF TEST RESULTS FOR EXPANSIVE MATERIAL OF NEAT SAMPLE

LOCATION: MUYEMBE-NAKAPIRIPIRIT ROAD | Depth 0.5m

LOCATION	BLENDED %	SAMPLING DATE	GRADING								ATTERBERG LIMITS				MDD		CBR	CBR SWELL	NATURAL MOISTURE CONTENT
			63	37.5	20	5	2	0.425	0.075	GM	LL	PL	PI	LS	MDD	OMC		62	AVERAGE
MUYEMBE-NAKAPIRIPIRIT ROAD	NEAT SAMPLE	Sample 01	100	100	100	99	93	85	81	0.41	75.6	37.5	38.1	20.0	1.498	25.5	8.0	1.13	37.75
		Sample 02	100	100	100	99	93	84	80	0.43	76.0	37.6	38.4	20.0	1.492	25.4	7.0	1.01	39.19
			100	100	100	98.72	92.94	84.64	80.62	0.42	75.8	37.6	38.2	20.0	1.495	25.5	7.5	1.07	38.5
		1/8/2024																	
	AVERAGE		100	100	100	99	93	85	81	0.418	75.8	37.6	38.2	20.0	1.495	25.5	7.5	1.07	38.47

FOR LAB

Lab Technician

STUDENTS

STIRLING CIVIL ENGINEERING LTD
Materials Engineer
19 JAN 2024
P.O. BOX 796, KAMPALA (U)

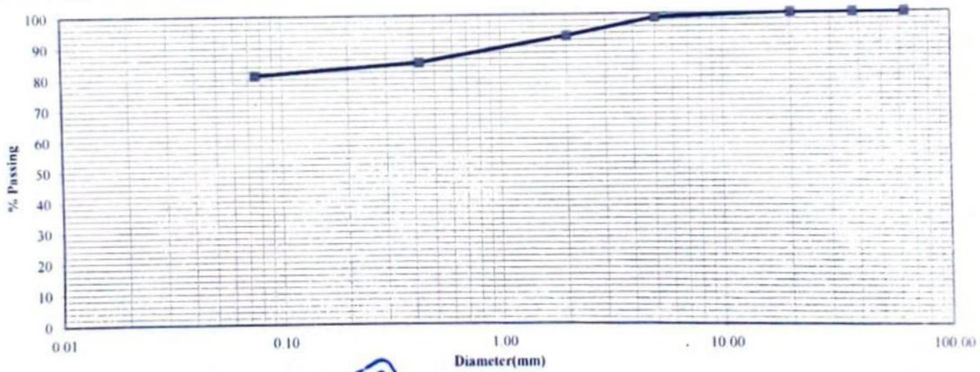
INSTITUTION	STUDENTS NAMES	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT : ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

PARTICLE SIZE DISTRIBUTION (BS 1377 - 2 - 90)

Location :	MUYEMBE-NAKAPIRIPIRIT ROAD	Lab. Refernece No.:		
Location :(km)	NEAT SAMPLE TP 01	Dry wt. of sample before washing: (g)		4296.2
Depth: (m)	0.5m	Dry wt. of sample after washing: (g)		826.9
Material description:	MUYEMBE-NAKAPIRIPIRIT ROAD	Date Sampled:	Date Tested:	Technician
		8/Jan/2024	13/Jan/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	52.9	1.2	99	30	65
2.00	237.5	5.5	93	20	50
0.425	353.1	8.2	85	10	30
0.075	172.1	4.0	81	5	15
Total fines	3480.6	81.0			
Bottom Pan	11.3				
Extracted fines	3469.3				
Total sample	4296.2				
Grading Modulus		0.41			



Testing Lab	STUDENTS
Lab Technician	
Materials Engineer	

STIRLING CIVIL ENGINEERING LTD
19 JAN 2024
P. O. BOX 796, KAMPALA (U)

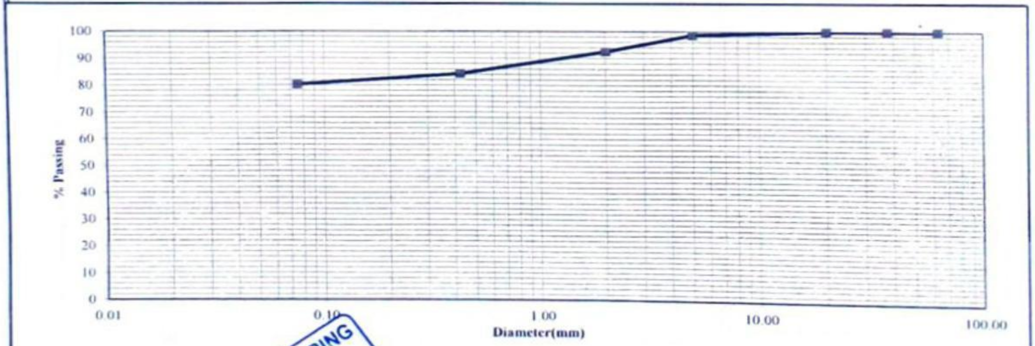
INSTITUTION	STUDENTS NAMES	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	**ASIIMWE CALEB & MANANA MARK**	Stirling

PROJECT : **ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS**

PARTICLE SIZE DISTRIBUTION (BS 1377 - 2 - 90)

Location :	MUYEMBE-NAKAPIRIPIRIT ROAD	Lab. Refernece No.:		
Location :(km)	NEAT SAMPLE TP 02	Dry wt. of sample before washing: (g)		4130.9
Depth: (m)	0.5m	Dry wt. of sample after washing: (g)		818.6
Material description:	MUYEMBE-NAKAPIRIPIRIT ROAD	Date Sampled:	Date Tested:	Technician
		8/Jan/2024	13/Jan/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	54.6	1.3	**99**	30	65
2.00	249.7	6.0	**93**	20	50
0.425	345.9	8.4	**84**	10	30
0.075	166.9	4.0	**80**	5	15
Total fines	3313.8	80.2			
Bottom Pan	1.5				
Extracted fines	3312.3				
Total sample	4130.9				
Grading Modulus		**0.43**			



Testing Lab		STUDENTS
Lab Technician	Materials Engineer	

STIRLING CIVIL ENGINEERING LTD
19 JAN 2024
P.O. BOX 79E, KAMPALA (U)

INSTITUTION	STUDENTS	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT: ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

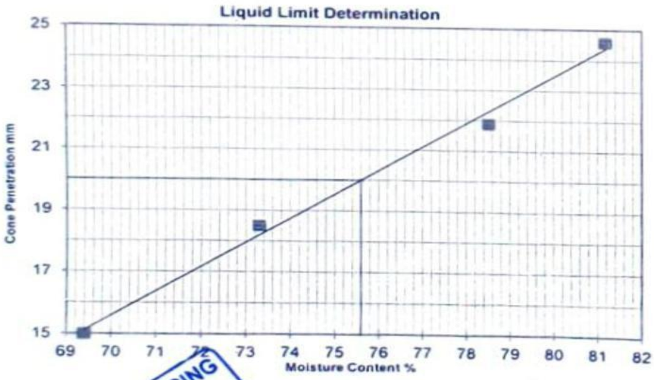
ATTERBERG LIMITS

Liquid limit (cone penotrometer) and plastic limit

SOURCE:	MUYEMBE-NAKAPIRIPIRIT ROAD	Technician:	Lab Team
mix	NEAT SAMPLE TP 01	Sample Date	8/Jan/2024
Test method	BS 1377: Part 2, 1990 4.3/4.4	Test Date	11/Jan/2024
LAYER	EXPANSIVE SOILS		
Depth	0.5m		

PLASTIC LIMIT	Test No	TN	DT		Average
Mass of wet soil + container (g)		26.31	27.62		26.965
Mass of dry soil + container (g)		25.19	26.31		25.75
Mass of container (g)		22.25	22.76		22.505
Mass of moisture (g)		1.12	1.3		1.215
Mass of dry soil (g)		2.94	3.55		3.245
Moisture content %		38.1	36.9		37.5
AVERAGE					

LIQUID LIMIT	Test No	1	2	3	4
Initial gauge reading (mm)		0	0	0	0
Final gauge reading (mm)		15.0	18.5	21.9	24.6
penetration (mm)		15.0	18.5	21.9	24.6
AVERAGE		15.0	18.5	21.9	24.6
Container No		PI66	A6	PI46	PP
Mass of wet soil + container (g)		45.02	53.52	47.54	46.51
Mass of dry soil + container (g)		29.46	33.75	29.81	28.74
Mass of container (g)		7.04	6.78	7.23	6.85
Mass of moisture (g)		15.56	19.77	17.73	17.77
Mass of dry soil (g)		22.42	26.97	22.58	21.89
Moisture content (%)		69.4	73.3	78.5	81.2
AVERAGE		69.4	73.3	78.5	81.2



Liquid limit (%)	75.6
Plastic limit (%)	37.5
Plasticity Index (%)	38.1
Linear shrinkage	
Trough No.	4
Trough length (cm)	14.0
Specimen length (cm)	11.2
L.shringage =	2.8
% L.shrinkage =	20.0

Remarks:

TESTING LAB

Materials Engineer

Lab Technician

STUDENTS

STIRLING CIVIL ENGINEERING LTD
15 JAN 2024
P.O. BOX 790, KAMPALA (U)

INSTITUTION	STUDENTS	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT:	ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

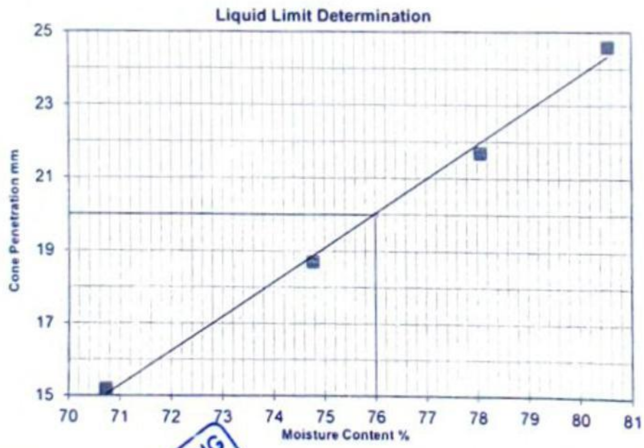
ATTERBERG LIMITS

Liquid limit (cone penotrometer) and plastic limit

SOURCE:	MUYEMBE-NAKAPIRIPIRIT ROAD	Technician:	Lab Team
mix	NEAT SAMPLE TP 02	Sample Date	8/Jan/2024
Test method	BS 1377: Part 2, 1990 4 3/4 4	Test Date	11/Jan/2024
LAYER	EXPANSIVE SOILS		
Depth	0.5m		

PLASTIC LIMIT	Test No.	SO	PL		Average
Mass of wet soil + container (g)		44.23	36.25		40.24
Mass of dry soil + container (g)		38.4	32.22		35.31
Mass of container (g)		22.9	21.5		22.2
Mass of moisture (g)		5.83	4.0		4.93
Mass of dry soil (g)		15.5	10.72		13.11
Moisture content %		37.6	37.6		37.6
AVERAGE					

LIQUID LIMIT	Test No	1	2	3	4
Initial gauge reading (mm)		0	0	0	0
Final gauge reading (mm)		15.2	18.7	21.7	24.6
penetration (mm)		15.2	18.7	21.7	24.6
AVERAGE		15.2	18.7	21.7	24.6
Container No.		PI28	PI33	PI33	AT
Mass of wet soil + container (g)		49.76	40.88	56.72	56.63
Mass of dry soil + container (g)		32.02	26.30	34.91	35.51
Mass of container (g)		6.94	6.80	6.97	9.29
Mass of moisture (g)		17.74	14.58	21.81	21.12
Mass of dry soil (g)		25.08	19.5	27.94	26.22
Moisture content (%)		70.7	74.8	78.1	80.5
AVERAGE		70.7	74.8	78.1	80.5



Liquid limit (%)	76.0
Plastic limit (%)	37.6
Plasticity Index (%)	38.4
Linear shrinkage	
Trough No	4
Trough length (cm)	14.0
Specimen length (cm)	11.2
L.shringage =	2.8
% L.shrinkage =	20.0

Remarks

TESTING LAB	STUDENTS
Materials Engineer	
Lab Technician	

STIRLING CIVIL ENGINEERING LTD
JAN 2024
P.O. BOX 796, KAMPALA (U)

INSTITUTION	STUDENTS NAMES	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT:	ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS				
Test Reference No	Depth 0.5m		Date Sampled	Date Tested	Technician
Mix	NEAT SAMPLE TP 01		8/Jan/24	13/Jan/24	Lab team
SOURCE	*MUYEMBE-NAKAPIRIPIRIT ROAD*				
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	27	5	457	100	1,000

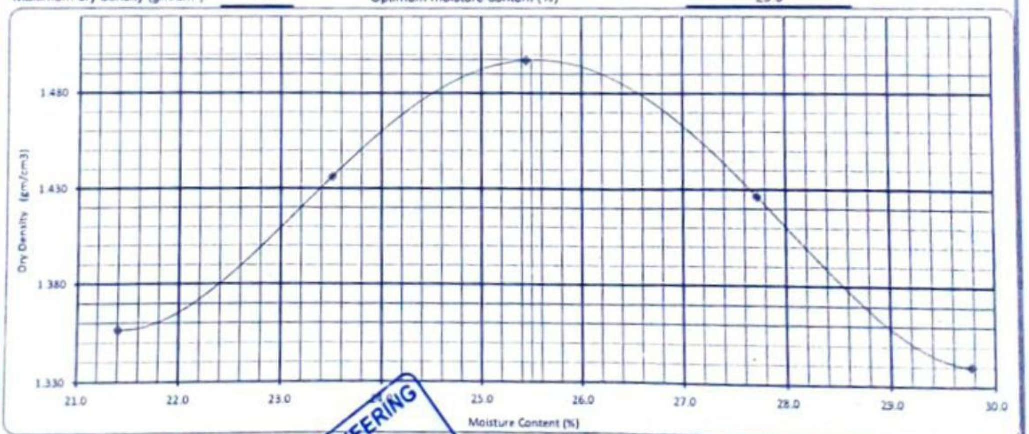
MOISTURE CONTENT DATA

Test No		1	2	3	4	5
Tin No		A	A	A	A	A
Water Added	cm^3	120	220	320	420	520
Mass of Compacted soil + mould	gm	5,929	6,056	6,160	6,104	6,021
Mass of Mould	gm	4,282	4,282	4,282	4,282	4,282
Mass of Compacted soil	gm	1647	1774	1878	1822	1739
Volume of mould	cm^3	1,000	1,000	1,000	1,000	1,000
Wet density of soil	g/cm^3	1.647	1.774	1.878	1.822	1.739

DATA FOR PROCTOR CURVE

Container No		2I	NMT	KT	CMI	MJR
Mass of wet soil + Container	gm	2,073.0	1,928.0	2,145.0	2,030.0	2,198.0
Mass of dry soil + container	gm	1,850.0	1,707.0	1,872.0	1,755.0	1,875.0
Mass of container	gm	808.0	767.0	799.0	763.0	790.0
Mass of water added	gm	223	221	273	275	323
Mass of dry soil	gm	1042	940	1073	992	1085
Moisture content	%	21.4	23.5	25.4	27.7	29.8
Dry density	g/cm^3	1.357	1.436	1.497	1.427	1.340

Maximum dry density (gm/cm^3) 1.498 Optimum moisture content (%) 25.5



Remarks:

FOR TESTING LAB		STUDENTS
Lab Technician	Materials Engineer	

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

INSTITUTION	STUDENTS NAMES	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT:	ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS			
Test Reference No	Depth 0.5m	Date Sampled	Date Tested	Technician
Mix	NEAT SAMPLE TP 02	8/Jan/24	13/Jan/24	Lab team
SOURCE	MUYEMBE-NAKAPIRIPIRIT ROAD			
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	27	5	457	100	1,000

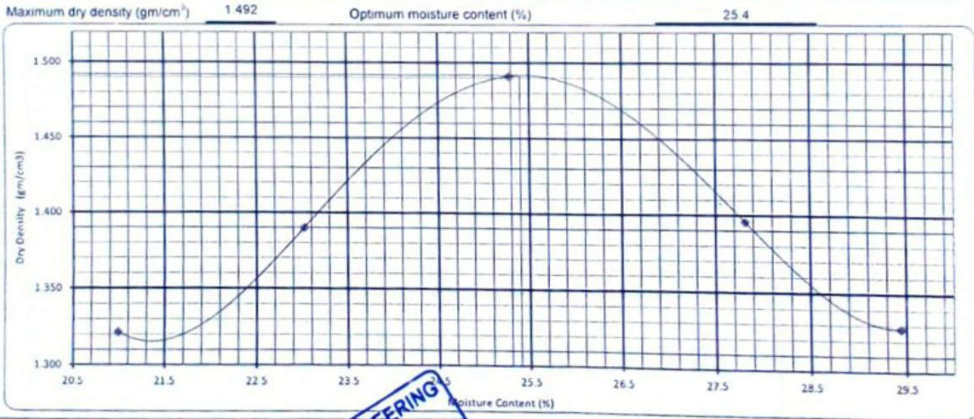
MOISTURE CONTENT DATA

Test No		1	2	3	4	5
Tin No		A	A	A	A	A
Water Added	cm^3	200	300	400	500	600
Mass of Compacted soil + mould	gm	4,815	4,926	5,084	5,000	4,935
Mass of Mould	gm	3,216	3,216	3,216	3,216	3,216
Mass of Compacted soil	gm	1599	1710	1868	1784	1719
Volume of mould	cm^3	1,000	1,000	1,000	1,000	1,000
Wet density of soil	g/cm^3	1.599	1.710	1.868	1.784	1.719

DATA FOR PROCTOR CURVE

Container No		ACB	CB	NBM	NUK	UPC
Mass of wet soil + Container	gm	1,952.0	2,005.0	1,915.0	1,735.0	2,165.0
Mass of dry soil + container	gm	1,753.0	1,772.0	1,690.0	1,525.0	1,855.0
Mass of container	gm	805.0	760.0	800.0	770.0	802.0
Mass of water added	gm	199	233	225	210	310
Mass of dry soil	gm	948	1012	890	755	1053
Moisture content	%	21.0	23.0	25.3	27.8	29.4
Dry density	g/cm^3	1.322	1.390	1.491	1.396	1.328

Maximum dry density (gm/cm^3) 1.492 Optimum moisture content (%) 25.4



Remarks:

FOR TESTING LAB		STUDENTS
Lab Technician	Materials Engineer	

STIRLING CIVIL ENGINEERING LTD
P. O. BOX 796, KAMPALA (U)
2024

Institution	Students Names	Testing Lab
UGANDA CHRISTIAN UNIVERSITY	ASHMWE CALEB & MANANA MARK	Stirling

ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

CALIFORNIA BEARING RATIO TEST (BS 1377 Part 4)

Test sample reference	Depth 0.5m	Sampling Date	8/Jan/24
mix	NEAT SAMPLE TP 01	Casting date	14/Jan/24
Source	MUYEMBE-NAKAPIRIPIRIT ROAD	Testing Date	18/Jan/24
		Technician	Lab team
Sample Description	EXPANSIVE SOILS	**Volume of Mould used (m^3)**	2305

Natural moisture of air dried sample			**Volume of water added**	
Tin No	UCJ		Mass of air dried soil (g)	6000
Tin + air dried soil sample (g)	2025		MDD (Mg/m^3)	1.498
Tin + oven dry soil sample (g)	1845		N.M.C (%)	17.3
Tin (g)	807		OMC (%)	25.5
Dry soil sample	1038		Added OMC (%)	8.2
Water (g)	180		Calculated dry wt of soil (g)	4959.5
N.M.C (%)	17.3		Water added (g)	417
Average (%)	17.3		**Water added (mL)**	417

Number of blows		62							
Number of layer		5							
Water Content Determination		Before Soaking		After Soaking					
Tare No		XZM	-	MU	-				
Mass of wet sample + Tare	g	2005	-	2460	-				
Mass of dry sample + Tare	g	1756	-	2096	-				
Mass of Tare	g	805	-	807	-				
Mass of water	g	249	-	364	-				
Mass of dry sample	g	951	-	1289	-				
Water content	%	26.2	-	28.2	-				
Average water Content	%	26.2		28.2					
Density determination									
Mould No		NO							
Mass of mould + soil	g	11625		11720					
Mass of mould	g	6999		6999					
Mass of soil	g	4626		4721					
Volume of the mould	cm3	2305		2305					
Moist density	g/cm3	2.007		2.048					
Dry density	g/cm3	1.591		1.597					
Swell Determination									
Date		Hour		D.Gauge Reding					
Initial reading		96 hrs		18.22					
Final reading				19.66					
Height of the specimen				127					
Height of swell				1.44					
		Swelling(%)		1.13					

Observations

For the Lab	For Students
Lab Technician / Materials Engineer	

STIRLING CIVIL ENGINEERING LTD. P.O. BOX 795, KAMPALA (U) JAN 2024

Institution	Students Names	Testing Lab
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

CALIFORNIA BEARING RATIO TEST (BS1377 Part 4)

Test sample reference :	Depth 0.5m	Sampling Date	8/Jan/24
mix	NEAT SAMPLE TP 01	Penetration Date	18/Jan/24
Source	MUYEMBE-NAKAPIRIPIRIT ROAD	Technician	Lab team
Sample Description :	**EXPANSIVE SOILS**		

Number of blows per layer		62					
Number of layers		5				5	5
Mould No		NO					
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 *10³mm	Force (KN)	Reading *10³mm	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	2	0.4		
1	**47**	2	0.4	3	0.6		
1.5	**71**	3	0.6	4	0.8		
2	**94**	3	0.6	5	1.0		
2.5	**118**	4	0.8	5	1.0		
3	**142**	4	0.8	6	1.2		
3.5	**165**	4	0.8	6	1.2		
4	**189**	5	1.0	7	1.4		
4.5	**213**	5	1.0	8	1.6		
5	**236**	5	1.0	8	1.6		
5.5	**260**	6	1.2	9	1.8		
6	**283**	6	1.2	9	1.8		
6.5	**307**	7	1.4	10	2.1		
7	**331**	7	1.4	10	2.1		
7.5	**354**	7	1.4	11	2.3		

Observations

For the Contractor		For Students
Lab. Technician	Materials Engineer	

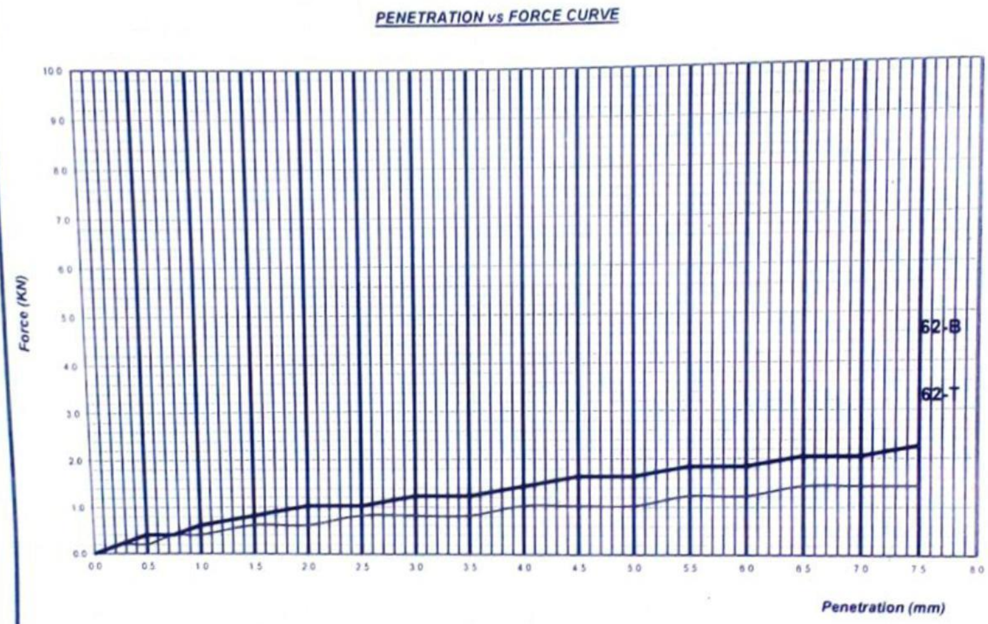
STIRLING CIVIL ENGINEERING LTD
2024
P.O. BOX 796, KAMPALA (U)

Institution	Students Names	Testing Lab
UGANDA CHRISTIAN UNIVERSITY	ASHIMWE CALEB & MANANA MARK	Stirling

ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

CALIFORNIA BEARING RATIO TEST (BS1377 Part 4)

Test sample reference	Depth 0.5m	Sampling Date	8/Jan/24
mix	NEAT SAMPLE TP 01	Testing Date	18/Jan/24
Source	MUYEMBE-NAKAPIRIPIRIT ROAD	Technician	Lab team
Sample Description	EXPANSIVE SOILS		



	62 blows			
	Force		CBR	
	Bottom	Top	Bottom	Top
2.5 mm Penetration	1.0	0.8	8	6
5.0 mm Penetration	1.6	1.0	8	5
Average	1.3	0.9	8.0	5.7
Retained CBR				
Observations	CBR= 8.0			

For the Lab — Lab. Technician — Materials Engineer

For Students

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

Institution	Students Names	Testing Lab
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

CALIFORNIA BEARING RATIO TEST (BS 1377 Part 4)

Test sample reference :	Depth. 0.5m	Sampling Date :	8/Jan/24
mix:	NEAT SAMPLE TP 02	Casting date :	14/Jan/24
Source:	MUYEMBE-NAKAPIRIPIRIT ROAD	Testing Date :	18/Jan/24
Sample Description	EXPANSIVE SOILS	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)	3280		MDD (Mg/m^3)	1.492
Tin + oven dry soil sample (g)	3093		N.M.C (%)	8.0
Tin (g)	765		OMC (%)	25.4
Dry soil sample	2328		Added OMC (%)	17.4
Water (g)	187		Calculated dry wt of soil (g)	5518.0
N.M.C (%)	8.0		Water added (g)	965
Average (%)	8.0		**Water added (mL)**	965

Number of blows		62									
Number of layer		5									
Water Content Determination		Before Soaking		After Soaking							
Tare No		BOJ	-	Z6T	-						
Mass of wet sample + Tare	g	2260	-	2460	-						
Mass of dry sample + Tare	g	1963	-	2099	-						
Mass of Tare	g	804	-	815	-						
Mass of water	g	297	-	361	-						
Mass of dry sample	g	1159	-	1284	-						
Water content	%	25.6	-	28.1	-						
Average water Content	%	25.6		28.1							
Density determination											
Mould No		T4									
Mass of mould + soil	g	10213		10331							
Mass of mould	g	5477		5477							
Mass of soil	g	4736		4854							
Volume of the mould	cm3	2305		2305							
Moist density	g/cm3	2.055		2.106							
Dry density	g/cm3	1.636		1.644							
Swell Determination											
Date		Hour		D.Gauge Reding							
Initial reading		96 hrs		4.71							
Final reading				5.99							
Height of the specimen				127							
Height of swell				1.28							
		Swelling(%)		1.01							

Observations		
	For the Lab	**For Students**
Lab. Technician	Materials Engineer	

STIRLING CIVIL ENGINEERING LTD
18 JAN 2024
P. O. BOX 796, KAMPALA (U)

Institution	Students Names	Testing Lab
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

CALIFORNIA BEARING RATIO TEST (BS1377 Part 4)

Test sample reference :	Depth 0.5m	Sampling Date	8/Jan/24
mix	NEAT SAMPLE TP 02	Penetration Date	18/Jan/24
Source	MUYEMBE-NAKAPIRIPIRIT ROAD	Technician	Lab team
Sample Description :	EXPANSIVE SOILS		

Number of blows per layer		62				5			5		
Number of layers		5									
Mould No		T4							50		
Capacity of the Proving Ring (KN)		50				50			0.2052		
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	Force (KN)						
0	0	0	0.0	0	0.0						
0.25	12	0	0.0	1	0.2						
0.5	24	0	0.0	2	0.4						
0.75	35	1	0.2	3	0.6						
1	47	1	0.2	3	0.6						
1.5	71	1	0.2	4	0.8						
2	94	1	0.2	4	0.8						
2.5	118	2	0.4	5	1.0						
3	142	2	0.4	5	1.0						
3.5	165	2	0.4	5	1.0						
4	189	2	0.4	6	1.2						
4.5	213	3	0.6	6	1.2						
5	236	3	0.6	6	1.2						
5.5	260	3	0.6	7	1.4						
6	283	4	0.8	7	1.4						
6.5	307	4	0.8	8	1.6						
7	331	4	0.8	8	1.6						
7.5	354	4	0.8	8	1.6						

Observations

For the Contractor		For Students
Lab. Technician	Materials Engineer	

STIRLING CIVIL ENGINEERING LTD
2024
P. O. BOX 796, KAMPALA (U)

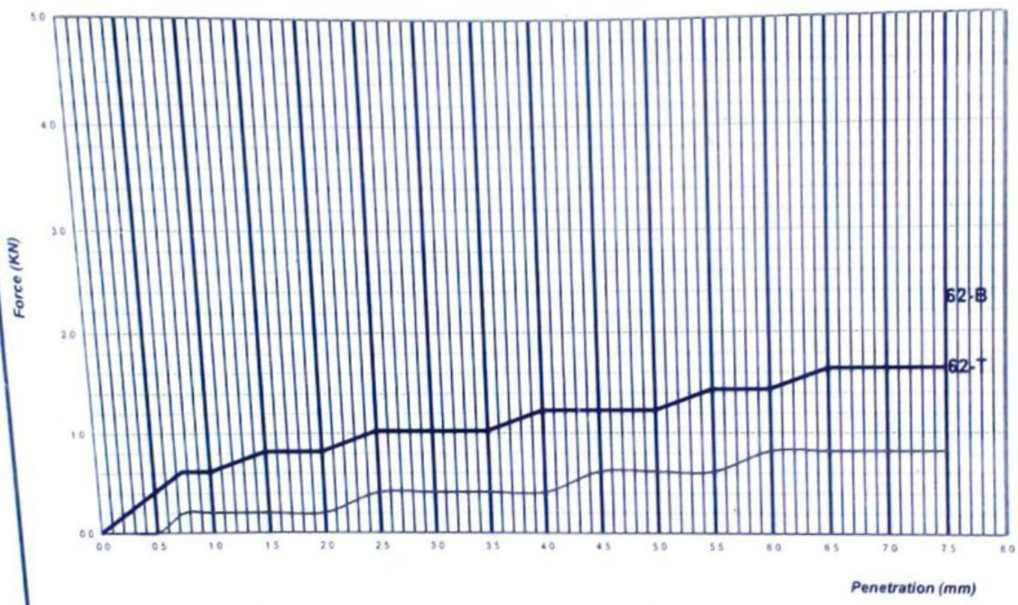
Institution	Students Names	Testing Lab
UGANDA CHRISTIAN UNIVERSITY	ASHIMWE CALEB & MANANA MARK	Stirling

ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

CALIFORNIA BEARING RATIO TEST (BS1377 Part 4)

Test sample reference	Depth 0.5m	Sampling Date	8/Jan/24
mix	NEAT SAMPLE TP 02	Testing Date	18/Jan/24
Source	MUYEMBE-NAKAPIRIPIRIT ROAD	Technician	Lab team
Sample Description	EXPANSIVE SOILS		

PENETRATION vs FORCE CURVE



	62 blows			
	Force		CBR	
	Bottom	Top	Bottom	Top
2.5 mm Penetration	1.0	0.4	8	3
5.0 mm Penetration	1.2	0.6	6	3
Average	1.1	0.5	7.0	3.1
Retained CBR				
Observations				

CBR= 7.0

Lab Technician

Materials Engineer

For Students

STIRLING CIVIL ENGINEERING LTD
P. O. BOX 756, KAMPALA (U)

INSTITUTION	STUDENTS NAMES	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT:	ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS			
Test Reference No	Depth. 0.5	Date Sampled	Date Tested	Technician
Mix	NATURAL MOISTURE CONTENT	9/Jan/24	11/Jan/24	Lab team
SOURCE:	MUYEMBE-NAKAPIRIPIRIT ROAD			
Material description:	EXPANSIVE SOILS			

DATA FOR FIELD MOISTURE CONTENT

Container No		NMT	Y6Y	UCJ	CR7	
Mass of wet soil + Container	gm	2,409.0	2,295.0	2,125.0	2,152.0	
Mass of dry soil + container	gm	1,955.0	1,895.0	1,750.0	1,767.0	
Mass of container	gm	768.0	821.0	808.0	769.0	
Mass of water added	gm	454	400	375	385	
Mass of dry soil	gm	1187	1074	942	998	
Moisture content	%	38.2	37.2	39.8	38.6	
Average Moisture content				38.5		

FOR TESTING LAB	STUDENTS
Lab Technician	

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

CENTRAL MATERIALS LABORATORY

CLIENT/ STUDENT NAMES: M/S ASIIMWE CALEB AND MANANA MARK
UNIVERSITY : UGANDA CHRISTIAN UNIVERSITY – MUKONO
COURSE : BACHELOR OF SCIENCE IN CIVIL AND ENVIRONMENT ENGINEERING
RESEARCH PROJECT : ASSESSING THE USE OF POLYETHYLENE TEREPHTHALATE FIBER AND HYDRATED LIME FOR THE STABILISATION OF EXPANSIVE SOILS
DATE : 12 APRIL 2024

TEST RESULTS FOR SAMPLES OF POLYETHYLENE TEREPHTHALATE (PET PLASTIC)

Test Standard/ Method: ASTM D638-14 "Standard Test Method for Tensile properties of plastics"

Sample Ref.	Strip Size		Cross-sectional Area (mm^2)	Force at Breaking (kN)	Tensile Strength (MPa)	Average Strength (MPa)	Elongation (%)	Average Elongation (%)
	Width (mm)	Thickness (mm)						
PET 1	11.5	0.3	3.45	0.750	217	224.6	64	63.6
PET 2	8.4	0.3	2.52	0.500	198		59	
PET 3	11.1	0.3	3.33	0.800	241		62	
PET 4	11.5	0.3	3.45	0.800	232		68	
PET 5	7.1	0.3	2.13	0.500	235		65	

Note: - Results relate to only the samples as delivered by the student

12.04.2024

CHIEF MATERIALS ENGINEER

MATERIALS
CHIEF MATERIALS ENGINEER
MINISTRY OF WORKS
AND TRANSPORT
KAMPALA
CENTRAL MATERIALS LABORATORY KIREKA

INSTITUTION	STUDENTS	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT: ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

SUMMARY OF ALL THE TEST RESULTS FOR EXPANSIVE SOIL STABILISED WITH LIME & FIBRE

LOCATION	BLENDED %	SAMPLING DATE	GRADING								ATTERBERG LIMITS				MDD		CBR	CBR SWELL
			63	37.5	20	5	2	0.425	0.075	GM	LL	PL	PI	LS	MDD	OMC	62Blows	62
	NEAT LATERATIC GRAVEL		100	100	100	99	93	85	81	0.41	75.6	37.5	38.1	20.0	1.498	25.5	8.0	1.13
			100	100	100	99	93	84	80	0.43	76.0	37.6	38.4	20.0	1.492	25.4	7.0	1.01
0	EXPANSIVE SOIL STABILISED WITH 6% LIME & 0% FIBRE	12/9/2023	100	100	100	98	94	86	76	0.451	65.1	47.2	17.9	10.5	1.464	27.4	44	0.50
			100	100	100	99	94	86	71	0.490	65.2	47.3	17.9	10.5				
	EXPANSIVE SOIL STABILISED WITH 6% LIME & 0.5% FIBRE		100	100	100	99	95	83	73	0.486	67.2	46.4	20.8	20.0	1.505	26.7	46	0.46
			100	100	100	99	92	84	78	0.452	67.3	46.2	21.1	20.0				
	EXPANSIVE SOIL STABILISED WITH 6% LIME & 1% FIBRE		100	100	100	99	94	85	73	0.480	66.0	47.0	19.0	20.0	1.524	25.8	50	0.5
			100	100	100	99	94	85	74	0.476	65.6	46.8	18.8	20.0				
	EXPANSIVE SOIL STABILISED WITH 6% LIME & 1.5% FIBRE		100.0	100.0	100.0	99.0	94.1	84.4	70.7	0.508	67.4	49.3	18.1	9.4	1.556	24.9	54	0.31
			100.0	100.0	100.0	99.0	93.2	82.8	75.4	0.486	67.4	49.3	18.1	9.4				
	EXPANSIVE SOIL STABILISED WITH 6% LIME & 2% FIBRE		100.0	100.0	100.0	98.9	94.4	84.9	80.1	0.406	65.5	49.4	16.0	9.0	1.492	27.5	48	0.43
			100.0	100.0	100.0	99.1	94.5	83.8	77.6	0.441	65.5	49.3	16.2	9.0				

FOR LAB

Lab Technician

Materials Engineer

STIRLING CIVIL ENGINEERING LTD
P.O. BOX [illegible] KAMPALA (U)

INSTITUTION	STUDENTS	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT: ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

SUMMARY OF TEST RESULTS FOR EXPANSIVE SOIL STABILISED WITH 6% LIME & 0% FIBRE

LOCATION: MUYEMBE-NAKAPIRIPIRIT ROAD — Depth 0.5m

LOCATION	BLENDED %	SAMPLING DATE	GRADING 63	37.5	20	5	2	0.425	0.075	GM	ATTERBERG LIMITS LL	PL	PI	LS	MDD	OMC	CBR	CBR SWELL	NATURAL MOISTURE CONTENT
																		[illegible]	AVERAGE
MUYEMBE-NAKAPIRIPIRIT ROAD	EXPANSIVE SOIL STABILISED WITH 6% LIME & 0% FIBRE	Sample 01	100	100	100	98	94	86	76	0.45	65.1	47.2	17.9	10.5	1.464	27.4	43.8	0.50	37.75
		Sample 02	100	100	100	99	94	86	71	0.49	65.2	47.3	17.9	10.5					
			100	100	100	98.59	93.75	85.78	73.44	0.47	65.2	47.2	17.9	10.5	1.464	27.4	43.8	0.50	37.7
		1/8/2024																	
AVERAGE			100	100	100	99	94	86	73	0.470	65.2	47.3	17.9	10.5	1.464	27.4	43.8	0.50	37.75

FOR LAB

Lab Technician

Materials Engineer

STUDENTS

STIRLING CIVIL ENGINEERING LTD P.O. BOX 7... KAMPALA (U)

Institution	Students Names	Testing Lab
UGANDA CHRISTIAN UNIVERSITY	ASHIMWE CALEB & MANANA MARK	Stirling

ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

CALIFORNIA BEARING RATIO TEST (BS1377 Part 4)

Test sample reference	Depth 0.5m	Sampling Date	8/Jan/24
mix	EXPANSIVE SOIL STABILISED WITH 6% LIME & 0% FIBRE	Penetration Date	12/Mar/24
Source	MUYEMBE-NAKAPIRIPIRIT ROAD	Technician	Lab team
Sample Description	**EXPANSIVE SOILS**		

Number of blows per layer	62		
Number of layers	5	5	5
Mould No	MM		
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	2	0.4
0.5	**24**	2	0.4	5	1.0
0.75	**35**	2	0.4	8	1.6
1	**47**	4	0.8	10	2.1
1.5	**71**	10	2.1	13	2.7
2	**94**	15	3.1	16	3.3
2.5	**118**	21	4.3	22	4.5
3	**142**	26	5.3	26	5.3
3.5	**165**	32	6.6	32	6.6
4	**189**	37	7.6	40	8.2
4.5	**213**	44	9.0	49	10.1
5	**236**	49	10.1	52	10.7
5.5	**260**	52	10.7	57	11.7
6	**283**	56	11.5	61	12.5
6.5	**307**	58	11.9	65	13.3
7	**331**	59	12.1	69	14.2
7.5	**354**	62	12.7	72	14.8

Observations

For the Contractor		For Students	
Lab. Technician	*Material Engineer*		

STIRLING CIVIL ENGINEERING ... P.O. BOX ... UGANDA (U)

Institution	Students Names	Testing Lab
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

CALIFORNIA BEARING RATIO TEST (BS 1377 Part 4)

Test sample reference	Depth. 0.5m	Sampling Date	8/Jan/24
mix	EXPANSIVE SOIL STABILISED WITH 6% LIME & 0% FIBRE	Casting date	27/Feb/24
Source	MUYEMBE-NAKAPIRIPIRIT ROAD	Testing Date	12/Mar/24
Sample Description	EXPANSIVE SOILS	Technician	Lab team
		Volume of Mould used (m^3)	**2305**

Natural moisture of air dried sample			**Volume of water added**	
Tin No	Z6T		Mass of air dried soil (g)	6000
Tin + air dried soil sample (g)	2475		MDD (Mg/m^3)	1.464
Tin + oven dry soil sample (g)	2273		N.M.C (%)	13.8
Tin (g)	810		OMC (%)	27.4
Dry soil sample	1463		Added OMC (%)	13.6
Water (g)	202		Calculated dry wt of soil (g)	5171.6
N.M.C (%)	13.8		Water added (g)	717
Average (%)	13.8		**Water added (mL)**	717

Number of blows		62								
Number of layer		5								
Water Content Determination		Before Soaking		After Soaking						
Tare No		Y6Y	-	Z6T	-					
Mass of wet sample + Tare	g	2228	-	1937	-					
Mass of dry sample + Tare	g	1915	-	1668	-					
Mass of Tare	g	820	-	810	-					
Mass of water	g	313	-	269	-					
Mass of dry sample	g	1095	-	858	-					
Water content	%	28.6	-	31.4	-					
Average water Content	%	28.6		31.4						
Density determination										
Mould No		MM								
Mass of mould + soil	g	10421		10542						
Mass of mould	g	6050		6050						
Mass of soil	g	4371		4492						
Volume of the mould	cm3	2305		2305						
Moist density	g/cm3	1.896		1.949						
Dry density	g/cm3	1.475		1.484						
Swell Determination										
Date		Hour		D.Gauge Reding						
Initial reading		96 hrs		9.36						
Final reading				10						
Height of the specimen				127						
Height of swell				0.64						
		Swelling(%)		**0.50**						

Observations	

For the Lab		**For Students**	
Lab. Technician	Materials Engineer		

P.O. BOX

INSTITUTION	STUDENTS NAMES	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT	ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS				
Test Reference No	Depth	0.5m	Date Sampled	Date Tested	Technician
Mix	EXPANSIVE SOIL STABILISED WITH 6% LIME & 0% FIBRE		8/Jan/24	26/Feb/24	Lab team
SOURCE	MUYEMBE-NAKAPIRIPIRIT ROAD				
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	27	5	457	100	1,000

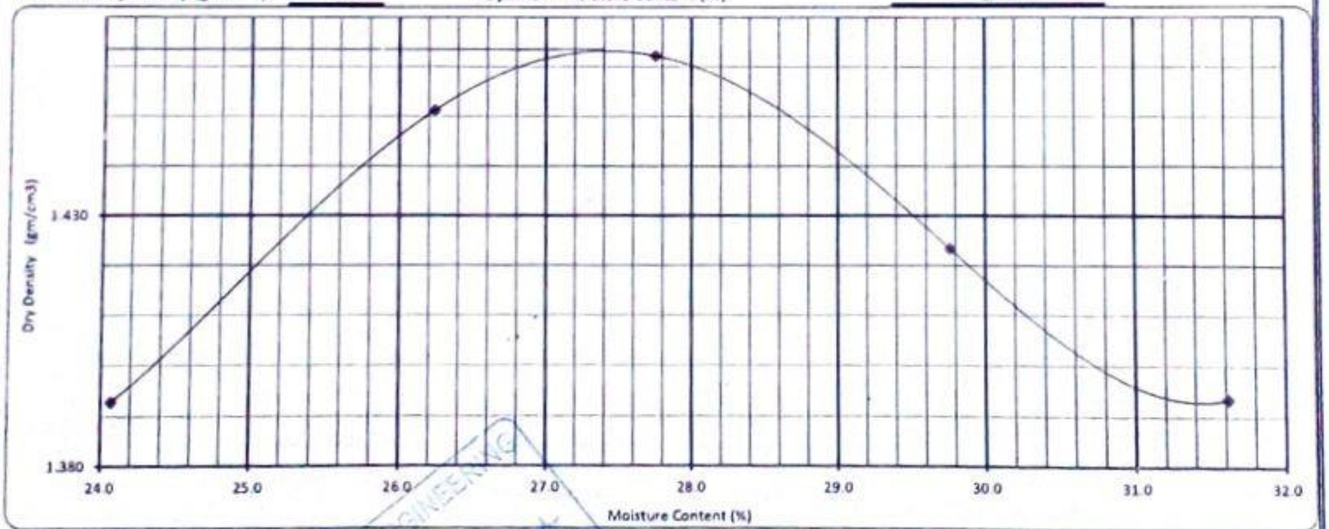
MOISTURE CONTENT DATA

Test No		1	2	3	4	5
Tin No		A	A	A	A	A
Water Added	cm^3	260	320	380	440	500
Mass of Compacted soil + mould	gm	4,946	5,050	5,086	5,065	5,052
Mass of Mould	gm	3,218	3,218	3,218	3,218	3,218
Mass of Compacted soil	gm	1728	1832	1868	1847	1834
Volume of mould	cm^3	1,000	1,000	1,000	1,000	1,000
Wet density of soil	g/cm^3	1.728	1.832	1.868	1.847	1.834

DATA FOR PROCTOR CURVE

Container No		KT	CMD	Y6Y	ACB	BAK
Mass of wet soil + Container	gm	2,130.0	2,009.0	2,301.0	2,089.0	2,158.0
Mass of dry soil + container	gm	1,872.0	1,750.0	1,981.0	1,789.0	1,833.0
Mass of container	gm	800.0	763.0	828.0	781.0	805.0
Mass of water added	gm	258	259	320	300	325
Mass of dry soil	gm	1072	987	1153	1008	1028
Moisture content	%	24.1	26.2	27.8	29.8	31.6
Dry density	g/cm^3	1.393	1.451	1.462	1.423	1.393

Maximum dry density (gm/cm^3) 1.464 Optimum moisture content (%) 27.4



Remarks:

FOR TESTING LAB			STUDENTS
Lab Technician	Materials Engineer		

INSTITUTION	STUDENTS	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT:	ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

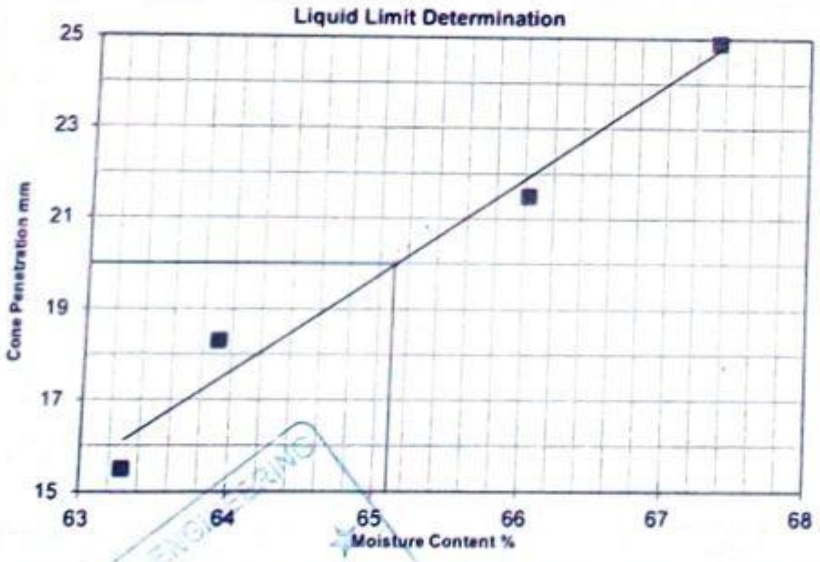
ATTERBERG LIMITS

Liquid limit (cone penotrometer) and plastic limit

SOURCE	MUYEMBE-NAKAPIRIPIRIT ROAD	Technician	Lab Team
mix	XPANSIVE SOIL STABILISED WITH 6% LIME & 0% FIBR	Sample Date	8/Jan/2024
Test method	BS 1377 Part 2 1990 4 3/4 4	Test Date	11/Jan/2024
LAYER	EXPANSIVE SOILS		
Depth	0.5m		

PLASTIC LIMIT	Test No	VP	AB		Average
Mass of wet soil + container (g)		39.49	33.52		36.505
Mass of dry soil + container (g)		33.73	29.5		31.615
Mass of container (g)		21.53	20.99		21.26
Mass of moisture (g)		5.76	4.0		4.89
Mass of dry soil (g)		12.2	8.51		10.355
Moisture content %		47.2	47.2		47.2
AVERAGE					

LIQUID LIMIT	Test No	1	2	3	4
Initial gauge reading (mm)		0	0	0	0
Final gauge reading (mm)		15.5	18.3	21.5	24.9
penetration (mm)		15.5	18.3	21.5	24.9
AVERAGE		15.5	18.3	21.5	24.9
Container No		BB	A7	BC	PI86
Mass of wet soil + container (g)		57.10	61.87	59.74	66.88
Mass of dry soil + container (g)		37.62	41.40	38.79	42.81
Mass of container (g)		6.84	9.37	7.06	7.07
Mass of moisture (g)		19.48	20.47	20.95	24.07
Mass of dry soil (g)		30.78	32.03	31.73	35.74
Moisture content (%)		63.3	63.9	66.0	67.3
AVERAGE		63.3	63.9	66.0	67.3



Liquid limit (%)	65.1
Plastic limit (%)	47.2
Plasticity Index (%)	17.9
Linear shrinkage	
Trough No	4
Trough length (cm)	14.0
Specimen length (cm)	12.5
L.shringage =	1.5
% L.shrinkage =	10.5

Remarks:

TESTING LAB

Materials Engineer

Lab Technician

STUDENTS

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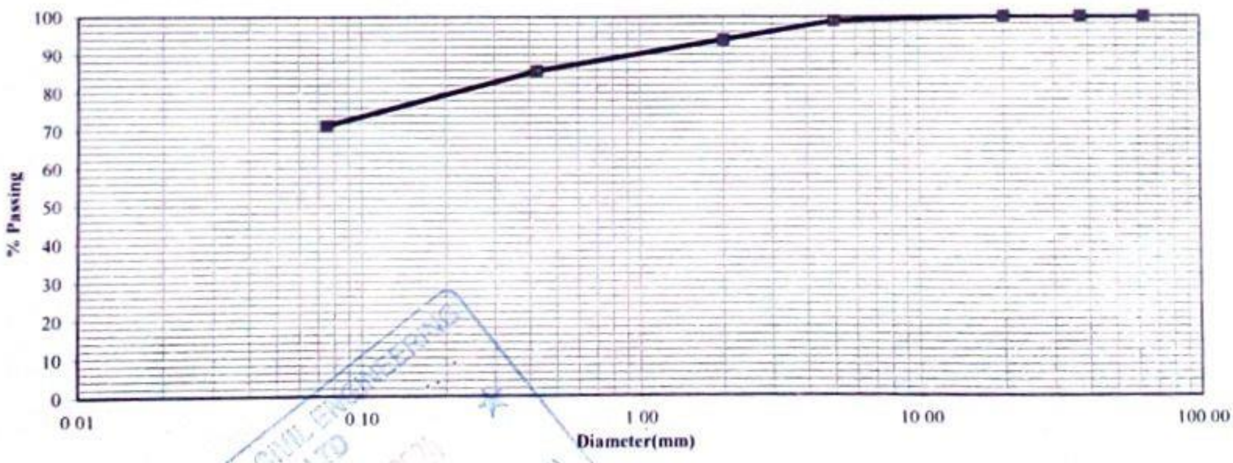
PROJECT : ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

PARTICLE SIZE DISTRIBUTION (BS 1377 - 2 - 90)

Location :	MUYEMBE-NAKAPIRIPIRIT ROAD	Lab. Refernece No.:		
Location :(km)	NEAT SAMPLE TP 02	Dry wt. of sample before washing: (g)		2733.9
Depth: (m)	0.5m	Dry wt. of sample after washing: (g)		811.0
Material description:	MUYEMBE-NAKAPIRIPIRIT ROAD	Date Sampled:	Date Tested:	Technician
		8/Jan/2024	26/Feb/2024	Lab team

Sieve Size (mm)	Weight Retained (g)	Retained (%)	Passing (%)	Grading Limits (G60 & 80)	
63.0	0.0	0	100		
37.5	0.0	0.0	100		
20.0	0.0	0.0	100		
5.0	32.6	1.2	99		
2.00	133.3	4.9	94		
0.425	224.7	8.2	86		
0.075	392.6	14.4	71		
Total fines	1950.7	71.4			
Bottom Pan	27.8				
Extracted fines	1922.9				
Total sample	2733.9				
Grading Modulus		0.49			



Testing Lab

Lab Technician | *Materials Engineer*

STUDENTS

STIRLING CIVIL ENGINEERING LTD ... KAMPALA (U) P.O. ...

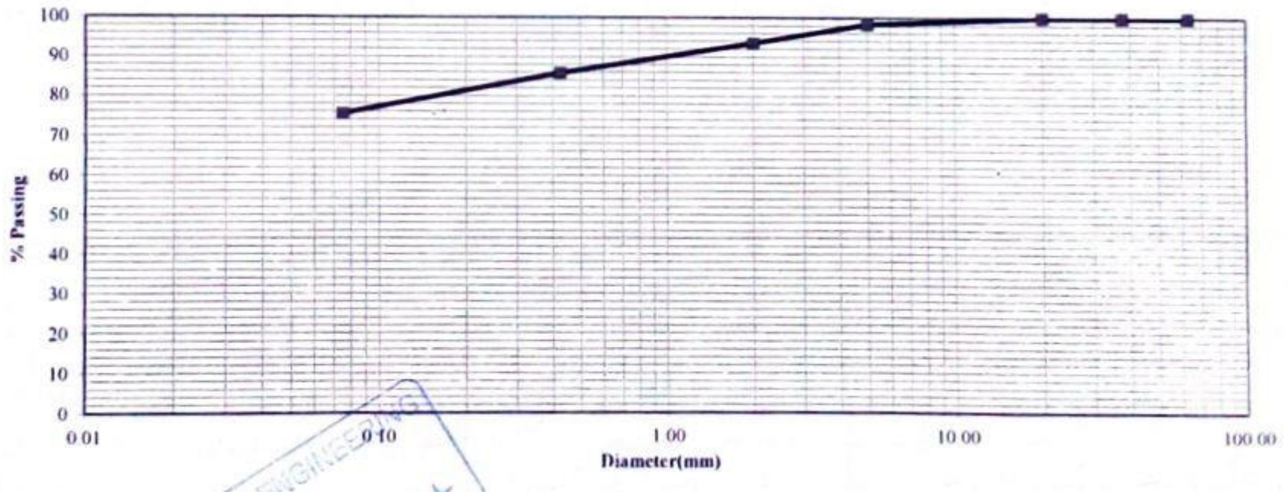
INSTITUTION	STUDENTS NAMES	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT : ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

PARTICLE SIZE DISTRIBUTION (BS 1377 - 2 - 90)

Location :	MUYEMBE-NAKAPIRIPIRIT ROAD	Lab. Refernece No.:		
Location :(km)	EXPANSIVE SOIL STABILISED WITH 6% LIME & 0% FIBRE	Dry wt. of sample before washing: (g)		2320.6
Depth: (m)	0.5m	Dry wt. of sample after washing: (g)		586.7
Material description:	MUYEMBE-NAKAPIRIPIRIT ROAD	Date Sampled:	Date Tested:	Technician
		8/Jan/2024	26/Feb/2024	Lab team

Sieve Size (mm)	Weight Retained (g)	Retained (%)	Passing (%)	Grading Limits (G60 & 80)	
63.0	0.0	0	100		
37.5	0.0	0.0	100		
20.0	0.0	0.0	100		
5.0	37.7	1.6	98		
2.00	111.7	4.8	94		
0.425	179.0	7.7	86		
0.075	239.5	10.3	76		
Total fines	1752.7	75.5			
Bottom Pan	18.8				
Extracted fines	1733.9				
Total sample	2320.6				
Grading Modulus		0.45			



Testing Lab

Lab Technician *Materials Engineer*

STIRLING CIVIL ENGINEERING LTD P.O. BOX 7... KAMPALA (U)

STUDENTS

INSTITUTION	STUDENTS	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT: ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

SUMMARY OF TEST RESULTS FOR EXPANSIVE MATERIAL OF EXPANSIVE SOIL STABILISED WITH 6% LIME & 0.5% FIBRE

LOCATION: MUYEMBE-NAKAPIRIPIRIT ROAD Depth 0.5m

LOCATION	BLENDED %	SAMPLING DATE	GRADING								ATTERBERG LIMITS				MDD		CBR	CBR SWELL	NATURAL MOISTURE CONTENT
			63	37.5	20	5	2	0.425	0.075	GM	LL	PL	PI	LS	MDD	OMC		62	AVERAGE
MUYEMBE-NAKAPIRIPIRIT ROAD	EXPANSIVE SOIL STABILISED WITH 6% LIME & 0.5% FIBRE	Sample 01	100	100	100	99	95	83	73	0.49	67.2	46.4	20.8	20.0	1.505	26.7	45.8	0.46	
			100	100	100	99	92	84	78	0.45	67.3	46.2	21.1	20.0					
			100	100	100	99.38	93.65	83.86	75.6	0.47	67.3	46.3	21.0	20.0	1.505	26.7	45.8	0.46	
		1/8/2024																	
	AVERAGE		100	100	100	99	94	84	76	0.469	67.3	46.2	21.0	20.0	1.505	26.7	45.8	0.46	#DIV/0!

FOR LAB

Lab Technician

Materials Engineer

STUDENTS

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

INSTITUTION	STUDENTS NAMES	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT:	ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS				
Test Reference No.	Depth 0.5m		Date Sampled	Date Tested	Technician
Mix	EXPANSIVE SOIL STABILISED WITH 6% LIME & 0.5% FIBRE		8/Jan/24	26/Feb/24	Lab team
SOURCE:	MUYEMBE-NAKAPIRIPIRIT ROAD				
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 (cm³)
4.5	27	5	457	100	1,000

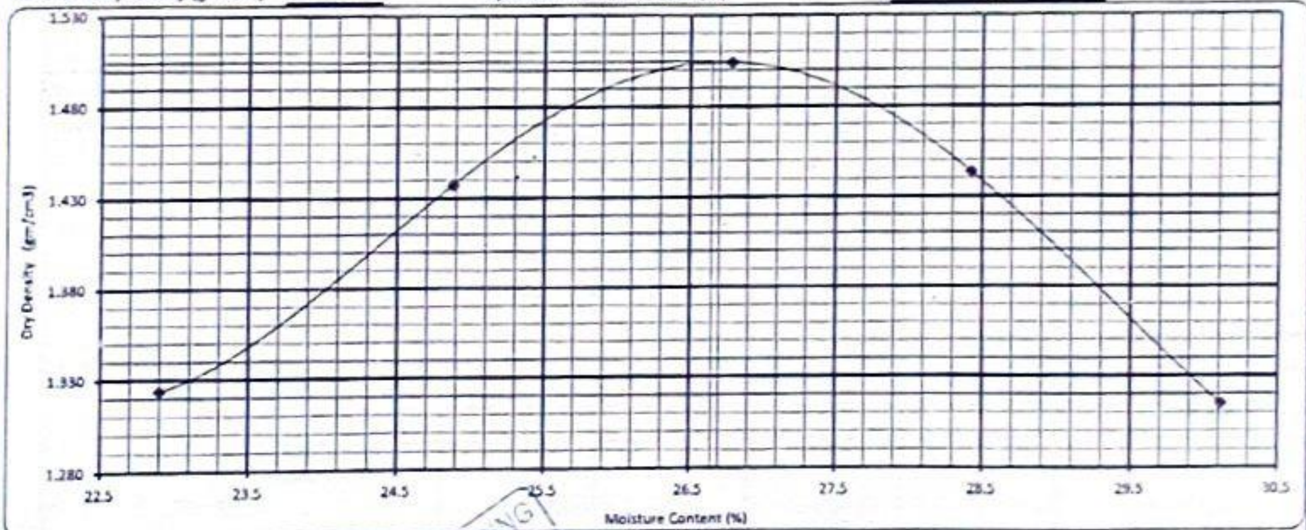
MOISTURE CONTENT DATA

Test No.		1	2	3	4	5
Tin No.		A	A	A	A	A
Water Added	cm³	250	310	370	430	490
Mass of Compacted soil + mould	gm	4,912	5,080	5,192	5,139	4,996
Mass of Mould	gm	3,285	3,285	3,285	3,285	3,285
Mass of Compacted soil	gm	1627	1795	1907	1854	1711
Volume of mould	cm³	1,000	1,000	1,000	1,000	1,000
Wet density of soil	g/cm³	1.627	1.795	1.907	1.854	1.711

DATA FOR PROCTOR CURVE

Container No		AT	UCJ	Y64	BBC	BA
Mass of wet soil + Container	gm	2,864.0	3,234.0	3,180.0	2,822.0	2,735.0
Mass of dry soil + container	gm	2,480.0	2,770.0	2,681.0	2,376.0	2,280.0
Mass of container	gm	803.0	905.0	818.0	807.0	769.0
Mass of water added	gm	384	464	499	446	455
Mass of dry soil	gm	1677	1865	1863	1569	1511
Moisture content	%	22.9	24.9	26.8	28.4	30.1
Dry density	g/cm³	1.324	1.437	1.504	1.444	1.315

Maximum dry density (gm/cm³) 1.505 Optimum moisture content (%) 26.7



Remarks:

FOR TESTING LAB		STUDENTS	
Lab Technician	Materials Engineer		

Institution	Students Names	Testing Lab
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

CALIFORNIA BEARING RATIO TEST (BS 1377 Part 4)

Test sample reference :	Depth. 0.5m	Sampling Date :	8/Jan/24
mix:	EXPANSIVE SOIL STABILISED WITH 6% LIME & 0.5% FIBRE	Casting date :	27/Feb/24
Source:	MUYEMBE-NAKAPIRIPIRIT ROAD	Testing Date :	12/Mar/24
		Technician :	Lab team
Sample Description:	EXPANSIVE SOILS	**Volume of Mould used (m^3)**	2305

Natural moisture of air dried sample			Volume of water added	
Tin No.	Y6Y5		Mass of air dried soil (g)	6000
Tin + air dried soil sample (g)	2566		MDD (Mg/m^3)	1.505
Tin + oven dry soil sample (g)	2415		N.M.C (%)	9.4
Tin (g)	802		OMC (%)	26.65
Dry soil sample	1613		Added OMC (%)	17.3
Water (g)	151		Calculated dry wt of soil (g)	5438.3
N.M.C (%)	9.4		Water added (g)	949
Average (%)	9.4		**Water added (mL)**	949

Number of blows		62											
Number of layer		5											
Water Content Determination		Before Soaking		After Soaking									
Tare No		DR	-	PU	-								
Mass of wet sample + Tare	g	1456	-	1968	-								
Mass of dry sample + Tare	g	1255	-	1700	-								
Mass of Tare	g	505	-	756	-								
Mass of water	g	201	-	268	-								
Mass of dry sample	g	750	- -	944	-								
Water content	%	26.8	-	28.4	-								
Average water Content	%	26.8		28.4									
Density determination													
Mould No		L											
Mass of mould + soil	g	11580		11650									
Mass of mould	g	7155		7155									
Mass of soil	g	4425		4495									
Volume of the mould	cm3	2305		2305									
Moist density	g/cm3	1.920		1.950									
Dry density	g/cm3	1.514		1.519									
Swell Determination													
Date		Hour		D.Gauge Reding									
Initial reading		96 hrs		12									
Final reading		-		12.58									
Height of the specimen		- -		127									
Height of swell				0.58									
		Swelling(%)		**0.46**									

Observations	

For the Lab		For Students	
Lab Technician	*Materials Engineer*		

Institution	Students Names	Testing Lab
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

CALIFORNIA BEARING RATIO TEST (BS1377 Part 4)

Test sample reference :	Depth 0.5m	Sampling Date	8/Jan/24
mix	EXPANSIVE SOIL STABILISED WITH 6% LIME & 0.5% FIBRE	Penetration Date	12/Mar/24
Source	MUYEMBE-NAKAPIRIPIRIT ROAD	Technician	Lab team
Sample Description	**EXPANSIVE SOILS**		

Number of blows per layer		62							
Number of layers		5				5		5	
Mould No		L							
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 *10³mm	Force (KN)	Reading *10³mm	Force (KN)				
0	**0**	0	0.0	0	0.0				
0.25	**12**	1	0.2	2	0.4				
0.5	**24**	2	0.4	5	1.0				
0.75	**35**	2	0.4	10	2.1				
1	**47**	3	0.6	14	2.9				
1.5	**71**	6	1.2	19	3.9				
2	**94**	7	1.4	21	4.3				
2.5	**118**	9	1.8	26	5.3				
3	**142**	11	2.3	30	6.2				
3.5	**165**	12	2.5	35	7.2				
4	**189**	14	2.9	39	8.0				
4.5	**213**	16	3.3	45	9.2				
5	**236**	17	3.5	50	10.3				
5.5	**260**	18	3.7	54	11.1				
6	**283**	19	3.9	58	11.9				
6.5	**307**	20	4.1	62	12.7				
7	**331**	22	4.5	66	13.5				
7.5	**354**	23	4.7	67	13.7				

Observations

For the Contractor		For Students	
Lab. Technician	Materials Engineer		

STIRLING CIVIL ENGINEERING LTD. P.O. BOX ... (U)

INSTITUTION	STUDENTS	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT: ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

SUMMARY OF TEST RESULTS FOR EXPANSIVE SOIL STABILISED WITH 6% LIME & 1% FIBRE

LOCATION: MUYEMBE-NAKAPIRIPIRIT ROAD   Depth 0.5m

LOCATION	BLENDED %		GRADING								ATTERBERG LIMITS				MDD		CBR	CBR SWELL	NATURAL MOISTURE CONTENT
		SAMPLING DATE	63	37.5	20	5	2	0.425	0.075	GM	LL	PL	PI	LS	MDD	OMC		62	AVERAGE
MUYEMBE-NAKAPIRIPIRIT ROAD	EXPANSIVE SOIL STABILISED WITH 6% LIME & 1% FIBRE	Sample 01	100	100	100	99	94	85	73	0.48	66	47.0	19.0	20.0	1.524	25.8	50.0	0.54	
		Sample 02	100	100	100	99	94	85	74	0.48	65.6	46.8	18.8	20.0					
			100	100	100	98.74	93.82	85.07	73.34	0.48	65.8	46.9	18.9	20.0	1.524	25.8	50.0	0.54	
		1/8/2024																	
	AVERAGE		100	100	100	99	94	85	73	0.478	65.8	46.8	18.9	20.0	1.524	25.8	50.0	0.54	#DIV/0!

FOR LAB

Lab Technician

Materials Engineer

STIRLING CIVIL ENGINEERING LTD P.O. BOX 7... KAMPALA (U)

STUDENTS

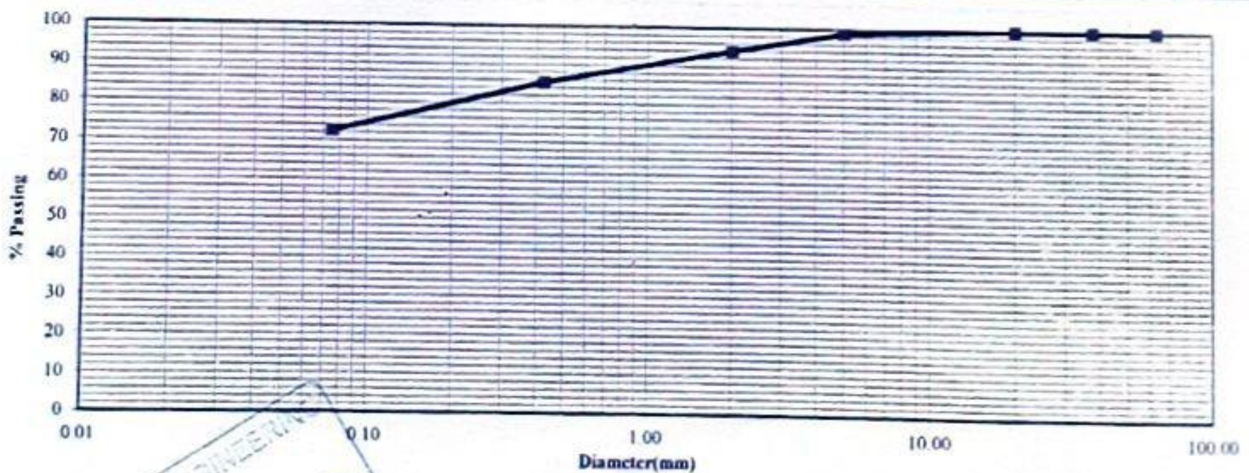
INSTITUTION	STUDENTS NAMES	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT : ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

PARTICLE SIZE DISTRIBUTION (BS 1377 - 2 - 90)

Location :	MUYEMBE-NAKAPIRIPIRIT ROAD	Lab. Refernece No.:		
Location :(km)	EXPANSIVE SOIL STABILISED WITH 6% LIME & 1% FIBRE	Dry wt. of sample before washing: (g)		3009.6
Depth: (m)	0.5m	Dry wt. of sample after washing: (g)		828.0
Material description:	MUYEMBE-NAKAPIRIPIRIT ROAD	Date Sampled:	Date Tested:	Technician
		8/Jan/2024	26/Feb/2024	Lab team

Sieve Size (mm)	Weight Retained (g)	Retained (%)	Passing (%)	Grading Limits (G60 & 80)	
63.0	0.0	0	100		
37.5	0.0	0.0	100		
20.0	0.0	0.0	100		
5.0	32.2	1.1	99		
2.00	148.3	4.9	94		
0.425	257.3	8.5	85		
0.075	388.1	12.9	73		
Total fines	2183.7	72.6			
Bottom Pan	2.1				
Extracted fines	2181.6				
Total sample	3009.6				
Grading Modulus		0.48			



Testing Lab

Lab Technician

Materials Engineer

STUDENTS

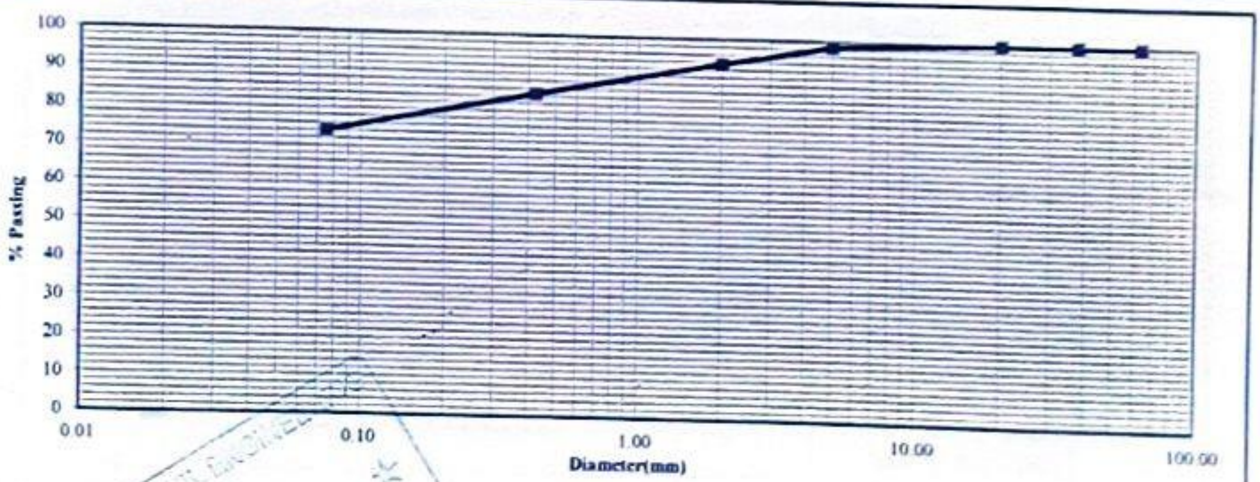
INSTITUTION	STUDENTS NAMES	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT : ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

PARTICLE SIZE DISTRIBUTION (BS 1377 - 2 - 90)

Location :	MUYEMBE-NAKAPIRIPIRIT ROAD	Lab. Refernece No.:		
Location :(km)	EXPANSIVE SOIL STABILISED WITH 6% LIME & 1% FIBRE	Dry wt. of sample before washing: (g)		2474.9
Depth: (m)	0.5m	Dry wt. of sample after washing: (g)		643.5
Material description:	MUYEMBE-NAKAPIRIPIRIT ROAD	Date Sampled:	Date Tested:	Technician
		8/Jan/2024	26/Feb/2024	Lab team

Sieve Size (mm)	Weight Retained (g)	Retained (%)	Passing (%)	Grading Limits (G60 & 80)	
63.0	0.0	0	100		
37.5	0.0	0.0	100		
20.0	0.0	0.0	100		
5.0	35.9	1.5	99		
2.00	121.6	4.9	94		
0.425	221.5	8.9	85		
0.075	261.5	10.6	74		
Total fines	1834.4	74.1			
Bottom Pan	3.0				
Extracted fines	1831.4				
Total sample	2474.9				
Grading Modulus		0.48			



Testing Lab		STUDENTS	
Lab Technician	Materials Engineer		

INSTITUTION	STUDENTS NAMES	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT	ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS			
Test Reference No	Depth [illegible]	Date Sampled	Date Tested	Technician
ID	EXPANSIVE SOIL STABILISED WITH 6% LIME & 1% FIBRE	[illegible]	[illegible]	[illegible]
SOURCE	[illegible]			
Material description	EXPANSIVE SOILS	Natural moisture (%)	[illegible]	

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 (cm³)
[illegible]	27	3	457	[illegible]	1,000

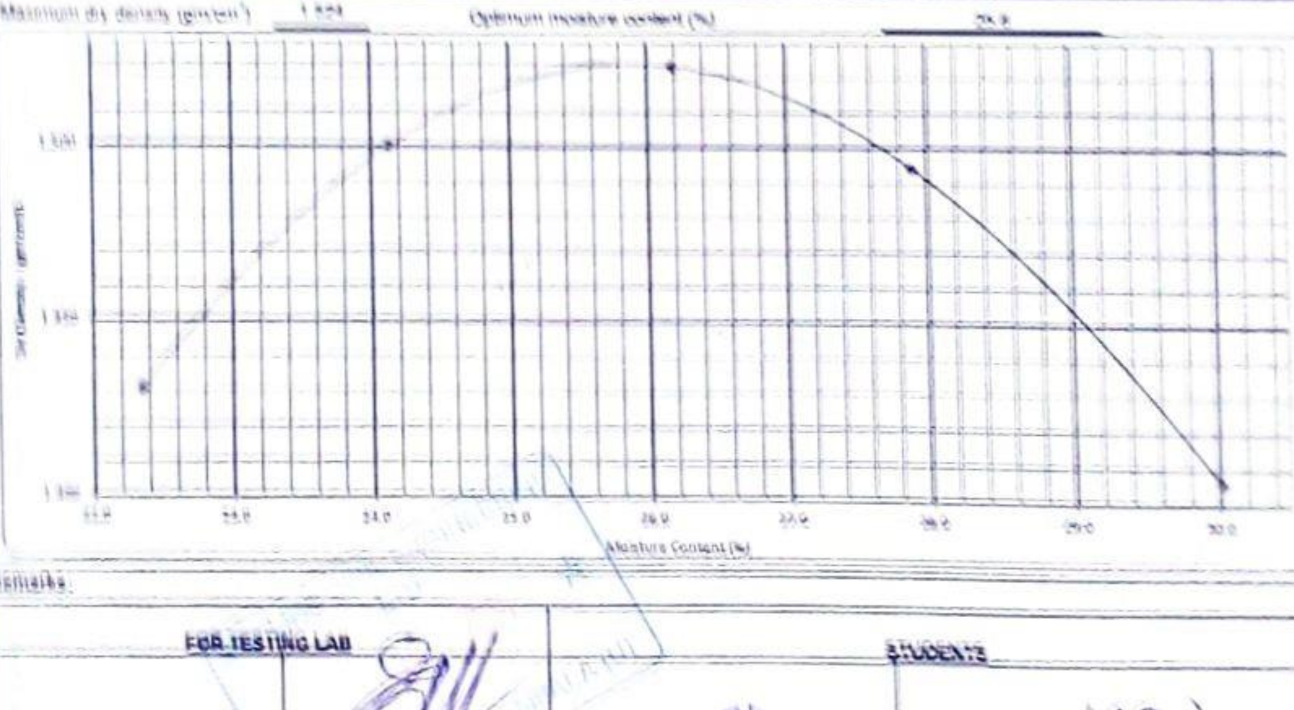
MOISTURE CONTENT DATA

Test No		1	2	3	4	5
Tin No		A	A	A	A	A
Water Added	cm³	360	420	480	542	600
Mass of Compacted soil + mould	gm	6,028	6,140	6,200	6,199	6,106
Mass of Mould	gm	4,278	4,278	4,278	4,278	4,278
Mass of Compacted soil	gm	1750	1862	1922	1921	1828
Volume of mould	cm³	1,000	1,000	1,000	1,000	1,000
Wet density of soil	g/cm³	1.750	1.862	1.922	1.921	1.828

DATA FOR PROCTOR CURVE

Container No		BKN	CR7	YY	NBM	FDC
Mass of wet soil + Container	gm	2,263.0	2,161.0	2,030.0	2,274.2	2,321.0
Mass of dry soil + container	gm	1,996.0	1,915.0	1,930.0	1,905.2	1,971.0
Mass of container	gm	801.0	771.0	784.0	797.2	805.0
Mass of water added	gm	267	276	300	308	350
Mass of dry soil	gm	1195	1144	1146	1108	1166
Moisture content	%	22.3	24.1	26.2	27.8	30.0
Dry density	g/cm³	1.430	1.500	1.523	[illegible]	[illegible]

Maximum dry density (gm/cm³) [illegible] Optimum moisture content (%) [illegible]



Remarks:

FOR TESTING LAB		STUDENTS	
Lab Technician	Materials Engineer		

Institution	Students Names	Testing Lab
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

CALIFORNIA BEARING RATIO TEST (BS 1377 Part 4)

Test sample reference :	Depth. 0.5m	Sampling Date :	8/Jan/24
mix:	EXPANSIVE SOIL STABILISED WITH 6% LIME & 1% FIBRE	Casting date :	27/Feb/24
Source	MUYEMBE-NAKAPIRIPIRIT ROAD	Testing Date :	12/Mar/24
Sample Description	EXPANSIVE SOILS	Technician :	Lab team
		Volume of Mould used (m^3)	2305

Natural moisture of air dried sample			**Volume of water added**	
Tin No.	UPC		Mass of air dried soil (g)	6000
Tin + air dried soil sample (g)	2393		MDD (Mg/m^3)	1.524
Tin + oven dry soil sample (g)	2191		N.M.C (%)	14.6
Tin (g)	807		OMC (%)	25.8
Dry soil sample	1384		Added OMC (%)	11.2
Water (g)	202		Calculated dry wt of soil (g)	5124.3
N.M.C (%)	14.6		Water added (g)	587
Average (%)	14.6		**Water added (mL)**	587

Number of blows		62								
Number of layer		5								
Water Content Determination		Before Soaking		After Soaking						
Tare No		ACB	-	KT	-					
Mass of wet sample + Tare	g	2078	-	2120	-					
Mass of dry sample + Tare	g	1778	-	1803	-					
Mass of Tare	g	781	-	800	-					
Mass of water	g	300	-	317	-					
Mass of dry sample	g	997	-	1003	-					
Water content	%	30.1	-	31.6	-					
Average water Content	%	30.1		31.6						
Density determination										
Mould No		WR								
Mass of mould + soil	g	10397		10463						
Mass of mould	g	6041		6041						
Mass of soil	g	4356		4422						
Volume of the mould	cm3	2305		2305						
Moist density	g/cm3	1.890		1.918						
Dry density	g/cm3	1.453		1.458						
Swell Determination										
Date		Hour		D Gauge Reding						
Initial reading		96 hrs		9.86						
Final reading				10.55						
Height of the specimen				127						
Height of swell				0.69						
		Swelling(%)		**0.54**						

Observations

For the Lab		For Students	
Lab Technician	Materials Engineer		

Institution	Students Names	Testing Lab
UGANDA CHRISTIAN UNIVERSITY	ASHMWE CALEB & MANANA MARK	Stirling

ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

CALIFORNIA BEARING RATIO TEST (BS1377 Part 4)

Test sample reference	Depth 0.5m	Sampling Date	8/Jan/24
mix	EXPANSIVE SOIL STABILISED WITH 6% LIME & 1% FIBRE	Penetration Date	12/Mar/24
Source	MUYEMBE-NAKAPIRIPIRIT ROAD	Technician	Lab team
Sample Description	**EXPANSIVE SOILS**		

Number of blows per layer	62		
Number of layers	5	5	5
Mould No	WR		
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	2	0.4				
0.5	**24**	2	0.4	3	0.6				
0.75	**35**	4	0.8	5	1.0				
1	**47**	5	1.0	8	1.6				
1.5	**71**	10	2.1	12	2.5				
2	**94**	16	3.3	18	3.7				
2.5	**118**	22	4.5	26	5.3				
3	**142**	29	6.0	33	6.8				
3.5	**165**	34	7.0	40	8.2				
4	**189**	40	8.2	48	9.8				
4.5	**213**	43	8.8	53	10.9				
5	**236**	46	9.4	58	11.9				
5.5	**260**	48	9.8	62	12.7				
6	**283**	49	10.1	64	13.1				
6.5	**307**	50	10.3	66	13.5				
7	**331**	51	10.5	69	14.2				
7.5	**354**	52	10.7	71	14.6				

Observations

For the Contractor		For Students	
Lab. Technician	Materials Engineer		

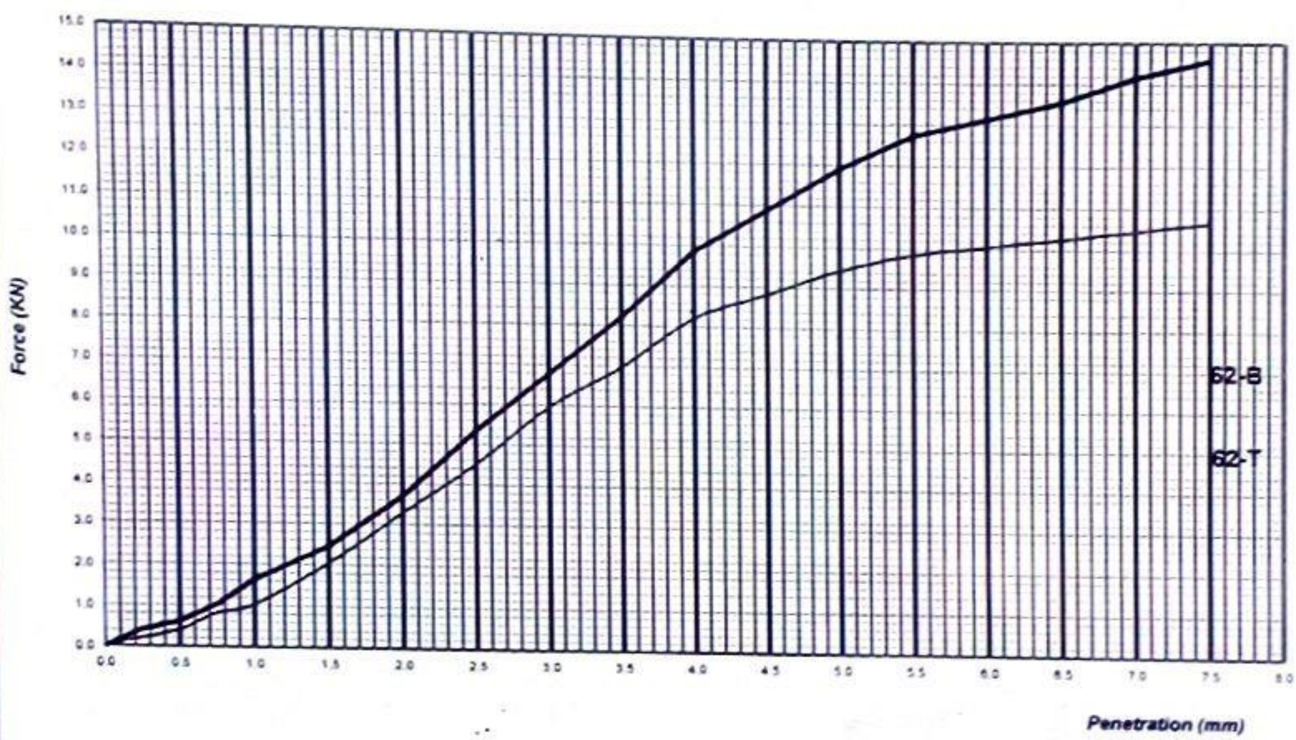
Institution	Students Names	Testing Lab
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

CALIFORNIA BEARING RATIO TEST (BS1377 Part 4)

Test sample reference :	Depth : 0.5m	Sampling Date	8/Jan/24
mix:	EXPANSIVE SOIL STABILISED WITH 6% LIME &	Testing Date	12/Mar/24
Source:	MUYEMBE-NAKAPIRIPIRIT ROAD	Technician	: Lab team
Sample Description:	EXPANSIVE SOILS		

PENETRATION vs FORCE CURVE



	62 blows													
	Force		CBR											
	Bottom	Top	Bottom	Top										
2.5 mm Penetration	5.3	4.5	40	34										
5.0 mm Penetration	11.9	9.4	60	47										
Average	8.6	7.0	50.0	40.7										
Retained CBR	50.0													
Observations	CBR= 50.0													

For the Lab			For Students	
Lab. Technician	*Materials Engineer*			

INSTITUTION	STUDENTS	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT: ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

SUMMARY OF TEST RESULTS FOR EXPANSIVE SOIL STABILISED WITH 6% LIME & 1.5% FIBRE

LOCATION: MUYEMBE-NAKAPIRIPIRIT ROAD   Depth 0.5m

LOCATION	BLENDED %		GRADING								ATTERBERG LIMITS				MDD		CBR	CBR SWELL	
		SAMPLING DATE	63	37.5	20	5	2	0.425	0.075	GM	LL	PL	PI	LS	MDD	OMC		62	
MUYEMBE-NAKAPIRIPIRIT ROAD	EXPANSIVE SOIL STABILISED WITH 6% LIME & 1.5% FIBRE	Sample 01	100	100	100	99	94	84	71	0.51	67.4	49.3	18.1	9.4	1.556	24.9	53.6	0.31	
		Sample 02	100	100	100	99	93	83	75	0.49	67.4	49.3	18.1	9.4					
			100	100	100	98.99	93.61	83.59	73.07	0.50	67.4	49.3	18.1	9.4	1.556	24.9	53.6	0.31	
		1/8/2024																	
	AVERAGE		100	100	100	99	94	84	73	0.497	67.4	49.3	18.1	9.4	1.556	24.9	53.6	0.31	#DIV/0!

FOR LAB

Lab Technician   Materials Engineer

STUDENTS

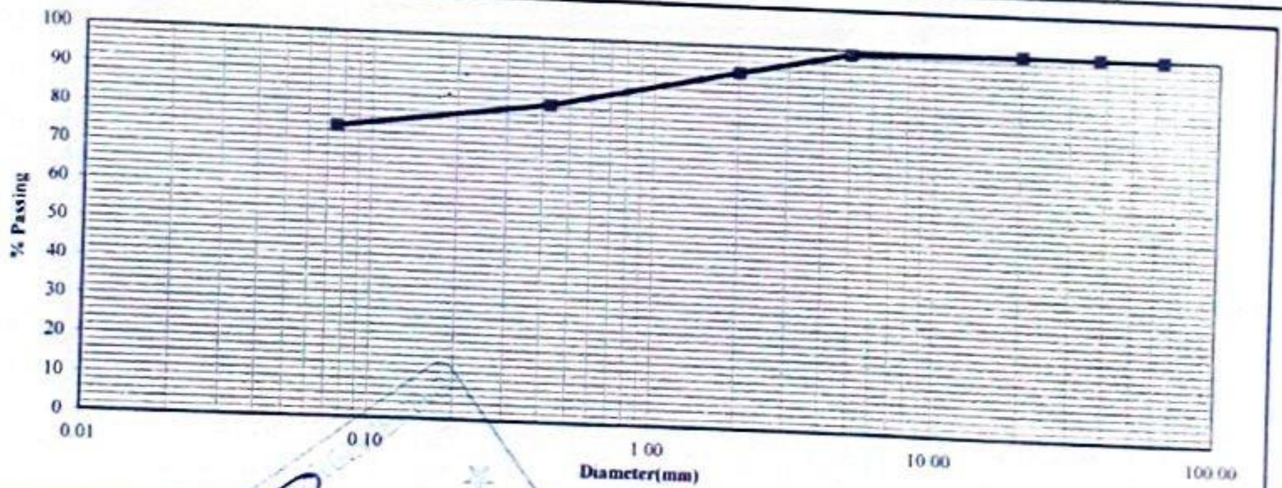
INSTITUTION	STUDENTS NAMES	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT : ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

PARTICLE SIZE DISTRIBUTION (BS 1377 - 2 - 90)

Location :	MUYEMBE-NAKAPIRIPIRIT ROAD	Lab. Refernece No.:			
Location :(km)	EXPANSIVE SOIL STABILISED WITH 6% LIME & 1.5% FIBRE				
Depth: (m)	0.5m	Dry wt. of sample before washing: (g)			2756.3
		Dry wt. of sample after washing: (g)			695.0
Material description:	MUYEMBE-NAKAPIRIPIRIT ROAD	Date Sampled:	Date Tested:		Technician
		8/Jan/2024	26/Feb/2024		Lab team

Sieve Size (mm)	Weight Retained (g)	Retained (%)	Passing (%)	Grading Limits (G60 & 80)	
63.0	0.0	0			
37.5	0.0	0.0	100		
20.0	0.0	0.0	100		
5.0	28.1	1.0	100		
2.00	160.5	5.8	99		
0.425	286.0	10.4	93		
0.075	202.7	7.4	83		
Total fines	2079.0	75.4	75		
Bottom Pan	17.7				
Extracted fines	2061.3				
Total sample	2756.3				
Grading Modulus		0.49			



Testing Lab

Lab Technician — *Materials Engineer*

STUDENTS

INSTITUTION	STUDENTS	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT:	ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

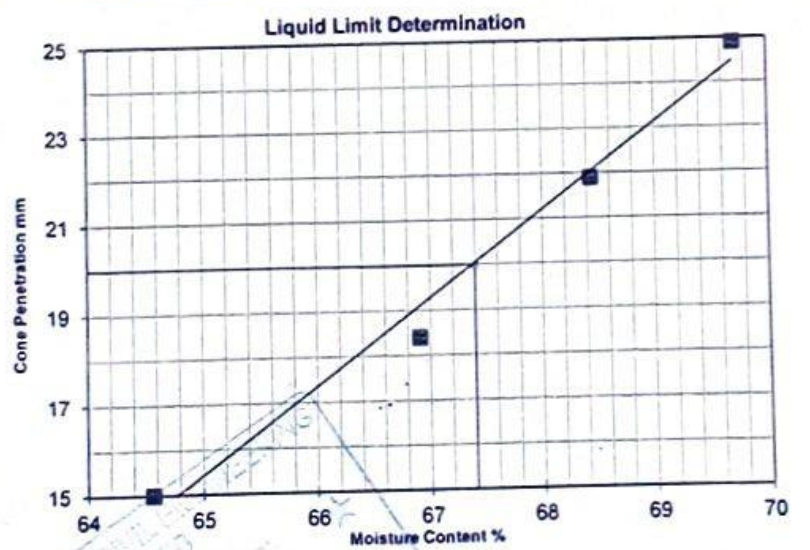
ATTERBERG LIMITS

Liquid limit (cone penotrometer) and plastic limit

SOURCE :	MUYEMBE-NAKAPIRIPIRIT ROAD		Technician:	Lab Team
mix	PANSIVE SOIL STABILISED WITH 6% LIME & 1.5% FIB		Sample Date	8/Jan/2024
Test method	BS 1377: Part 2, 1990:4.3/4.4		Test Date	11/Jan/2024
LAYER	EXPANSIVE SOILS			
Depth	0.5m			

PLASTIC LIMIT	Test No.	SI	RAD		Average
Mass of wet soil + container (g)		41.01	40.7		40.855
Mass of dry soil + container (g)		35.05	34.5		34.775
Mass of container (g)		22.94	21.97		22.455
Mass of moisture (g)		5.96	6.2		6.08
Mass of dry soil (g)		12.11	12.53		12.32
Moisture content %		49.2	49.5		49.3
AVERAGE					

LIQUID LIMIT	Test No	1	2	3	4
Initial gauge reading (mm)		0	0	0	0
Final gauge reading (mm)		15.0	18.4	21.9	24.9
penetration (mm)		15.0	18.4	21.9	24.9
AVERAGE		15.0	18.4	21.9	24.9
Container No.		A2	PIOE	28PI	P153
Mass of wet soil + container (g)		64.29	79.00	71.70	75.70
Mass of dry soil + container (g)		42.06	50.25	45.60	48.32
Mass of container (g)		7.63	7.28	7.46	9.04
Mass of moisture (g)		22.23	28.75	26.1	27.38
Mass of dry soil (g)		34.43	42.97	38.14	39.28
Moisture content (%)		64.6	66.9	68.4	69.7
AVERAGE		64.6	66.9	68.4	69.7



Liquid limit (%)	67.4
Plastic limit (%)	49.3
Plasticity Index (%)	18.1
Linear shrinkage	
Trough No.	p
Trough length (cm)	14.0
Specimen length (cm)	12.7
L.shringage =	1.3
% L.shrinkage =	9.4

Remarks:

TESTING LAB		STUDENTS
Materials Engineer.		
Lab Technician		

INSTITUTION	STUDENTS	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT:	ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

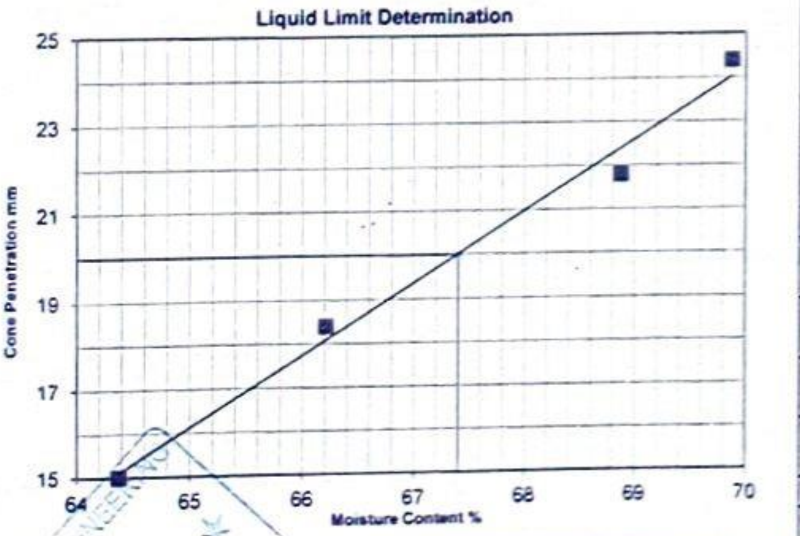
ATTERBERG LIMITS

Liquid limit (cone penotrometer) and plastic limit

SOURCE:	MUYEMBE-NAKAPIRIPIRIT ROAD	Technician:	Lab Team
mix	NEAT SAMPLE TP 02	Sample Date	8/Jan/2024
Test method	BS 1377: Part 2, 1990 4.3/4.4	Test Date	11/Jan/2024
LAYER	EXPANSIVE SOILS		
Depth:	0.5m		

PLASTIC LIMIT	Test No	JL	2F		Average
Mass of wet soil + container (g)		38.74	41.22		39.98
Mass of dry soil + container (g)		33.35	35		34.175
Mass of container (g)		22.53	22.27		22.4
Mass of moisture (g)		5.39	6.2		5.805
Mass of dry soil (g)		10.82	12.73		11.775
Moisture content %		49.8	48.9		49.3
AVERAGE					

LIQUID LIMIT	Test No	1	2	3	4
Initial gauge reading (mm)		0	0	0	0
Final gauge reading (mm)		15.0	18.4	21.8	24.4
penetration (mm)		15.0	18.4	21.8	24.4
AVERAGE		15.0	18.4	21.8	24.4
Container No.		P160	AS	A3	PIBB
Mass of wet soil + container (g)		55.39	67.00	71.33	69.86
Mass of dry soil + container (g)		36.58	43.25	45.24	44.09
Mass of container (g)		7.36	7.38	7.36	7.21
Mass of moisture (g)		18.81	23.75	26.09	25.77
Mass of dry soil (g)		29.22	35.87	37.88	36.88
Moisture content (%)		64.4	66.2	68.9	69.9
AVERAGE		64.4	66.2	68.9	69.9



Liquid limit (%)	67.4
Plastic limit (%)	49.3
Plasticity Index (%)	18.1
Linear shrinkage	
Trough No.	p
Trough length (cm)	14.0
Specimen length (cm)	12.7
L.shrinkage =	1.3
% L.shrinkage =	9.4

Remarks:

TESTING LAB		STUDENTS
Materials Engineer		
Lab Technician		

[illegible]	STUDENTS NAMES	TESTING LAB
[illegible]	ASHIMWE CALEB & MANANA MARK	Stirling

[illegible]	ASSESSING THE USE OF POLYETHYLENE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS				
[illegible]	Depth	0.5m	Date Sampled	Date Tested	Technician
[illegible]	EXPANSIVE SOIL STABILISED WITH [illegible] LIME & 1.5% FIBRE		[illegible]/Jan/24	26/Feb/24	Lab team
[illegible]	[illegible] ROAD				
[illegible]	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	27	5	457	100	1,000

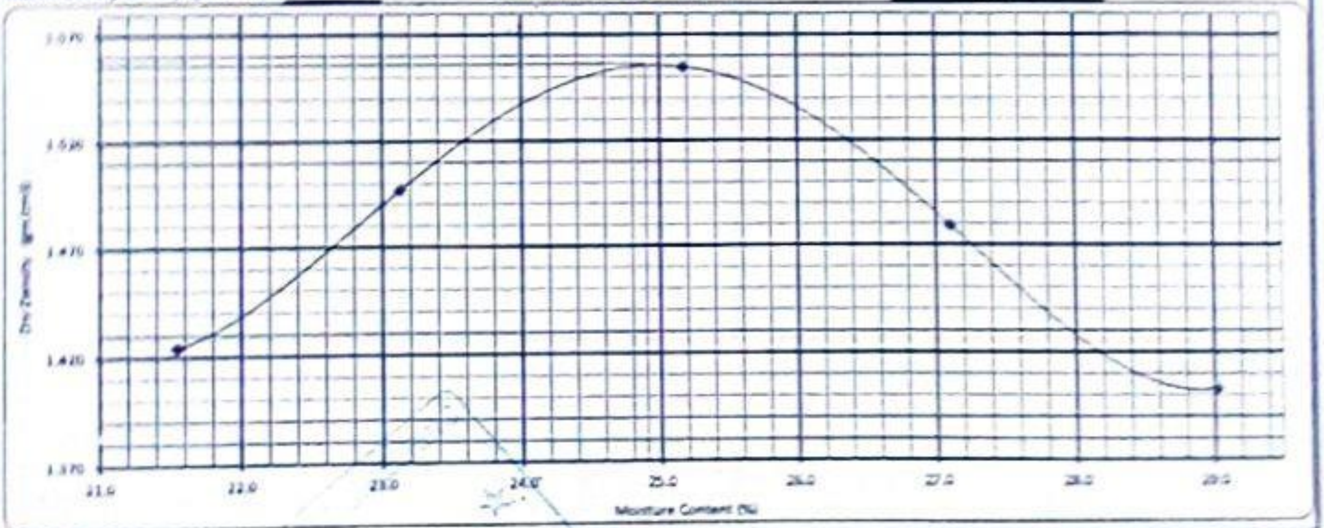
MOISTURE CONTENT DATA

Test No.		1	2	3	4	5
[illegible]		A	A	A	A	A
Water Added	cm^3	240	300	360	420	480
Mass of Compacted soil + mould	gm	4,949	5,061	5,164	5,098	5,028
Mass of Mould	gm	3,218	3,218	3,218	3,218	3,218
Mass of Compacted soil	gm	1731	1843	1946	1880	1810
Volume of mould	cm^3	1,000	1,000	1,000	1,000	1,000
Wet density of soil	g/cm^3	1.731	1.843	1.946	1.880	1.810

DATA FOR PROCTOR CURVE

Container No		MANU	ZION	LDU	AA	NQ
Mass of wet soil + Container	gm	1,461.0	1,755.0	1,878.0	1,502.0	924.0
Mass of dry soil + container	gm	1,299.0	1,508.0	1,584.0	1,270.0	729.0
Mass of container	gm	547.0	440.0	416.0	414.0	57.0
Mass of water added	gm	162	247	294	232	195
Mass of dry soil	gm	752	1068	1168	856	672
Moisture content	%	21.5	23.1	25.2	27.1	29.0
Dry density	g/cm^3	1.424	1.497	1.555	1.479	1.403

Maximum dry density (gm/cm^3) 1.556 Optimum moisture content (%) 24.9



Remarks:

FOR TESTING LAB		STUDENTS	
Lab Technician	Materials Engineer		

Institution	Students Names	Testing Lab
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

CALIFORNIA BEARING RATIO TEST (BS 1377 Part 4)

Test sample reference:	Depth. 0.5m	Sampling Date:	8/Jan/24
mix:	EXPANSIVE SOIL STABILISED WITH 6% LIME & 1.5% FIBRE	Casting date:	27/Feb/24
Source:	MUYEMBE-NAKAPIRIPIRIT ROAD	Testing Date:	12/Mar/24
Sample Description	EXPANSIVE SOILS	Technician:	Lab team
		Volume of Mould used (m^3)	**2305**

Natural moisture of air dried sample			**Volume of water added**	
Tin No	21		Mass of air dried soil (g)	6000
Tin + air dried soil sample (g)	2118		MDD (Mg/m^3)	1.556
Tin + oven dry soil sample (g)	1953		N.M.C (%)	14.2
Tin (g)	790		OMC (%)	24.9
Dry soil sample	1163		Added OMC (%)	10.7
Water (g)	165		Calculated dry wt of soil (g)	5148.8
N.M.C (%)	14.2		Water added (g)	**563**
Average (%)	14.2		**Water added (mL)**	**563**

Number of blows		**62**										
Number of layer		5										
Water Content Determination		Before Soaking		After Soaking								
Tare No		KAU	-	KT	-							
Mass of wet sample + Tare	g	2060	-	2069	-							
Mass of dry sample + Tare	g	1772	-	1743	-							
Mass of Tare	g	799	-	800	-							
Mass of water	g	288	-	326	-							
Mass of dry sample	g	973	-	943	-							
Water content	%	29.6	-	34.6	-							
Average water Content	%	29.6		34.6								
Density determination												
Mould No		XT										
Mass of mould + soil	g	10514		10732								
Mass of mould	g	6134		6134								
Mass of soil	g	4380		4598								
Volume of the mould	cm3	2305		2305								
Moist density	g/cm3	1.900		1.995								
Dry density	g/cm3	1.466		1.482								
Swell Determination												
Date		Hour		D.Gauge Reding								
Initial reading		96 hrs		9								
Final reading				9.39								
Height of the specimen				127								
Height of swell				0.39								
		Swelling(%)		**0.31**								
Observations												

For the Lab		**For Students**	
Lab Technician	Materials Engineer		

Institution	Students Names	Testing Lab
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

CALIFORNIA BEARING RATIO TEST (BS1377 Part 4)

Test sample reference	Depth 0.5m	Sampling Date	8/Jan/24
...	EXPANSIVE SOIL STABILISED WITH 6% LIME & 1.5% FIBRE	Penetration Date	12/Mar/24
Source	MUYEMBE-NAKAPIRIPIRIT ROAD	Technician	Lab team
Sample Description	EXPANSIVE SOILS		

Number of blows per layer		62							
Number of layers		5				5		5	
Mould No		X7							
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 *10⁻²mm	Force (KN)	Reading *10⁻²mm	Force (KN)				
0	0	0	0.0	0	0.0				
0.25	12	2	0.4	2	0.4				
0.5	24	5	1.0	7	1.4				
0.75	35	9	1.8	11	2.3				
1	47	11	2.3	15	3.1				
1.5	71	16	3.3	18	3.7				
2	94	20	4.1	25	5.1				
2.5	118	23	4.7	34	7.0				
3	142	28	5.7	38	7.8				
3.5	165	32	6.6	42	8.6				
4	189	36	7.4	45	9.2				
4.5	213	41	8.4	50	10.3				
5	236	45	9.2	53	10.9				
5.5	260	49	10.1	56	11.5				
6	283	53	10.9	62	12.7				
6.5	307	55	11.3	64	13.1				
7	331	57	11.7	65	13.3				
7.5	354	59	12.1	67	13.7				

Observations

For the Contractor		For Students	
Lab. Technician	Materials Engineer		

STIRLING ... ENGINEERING P.O. BOX ...

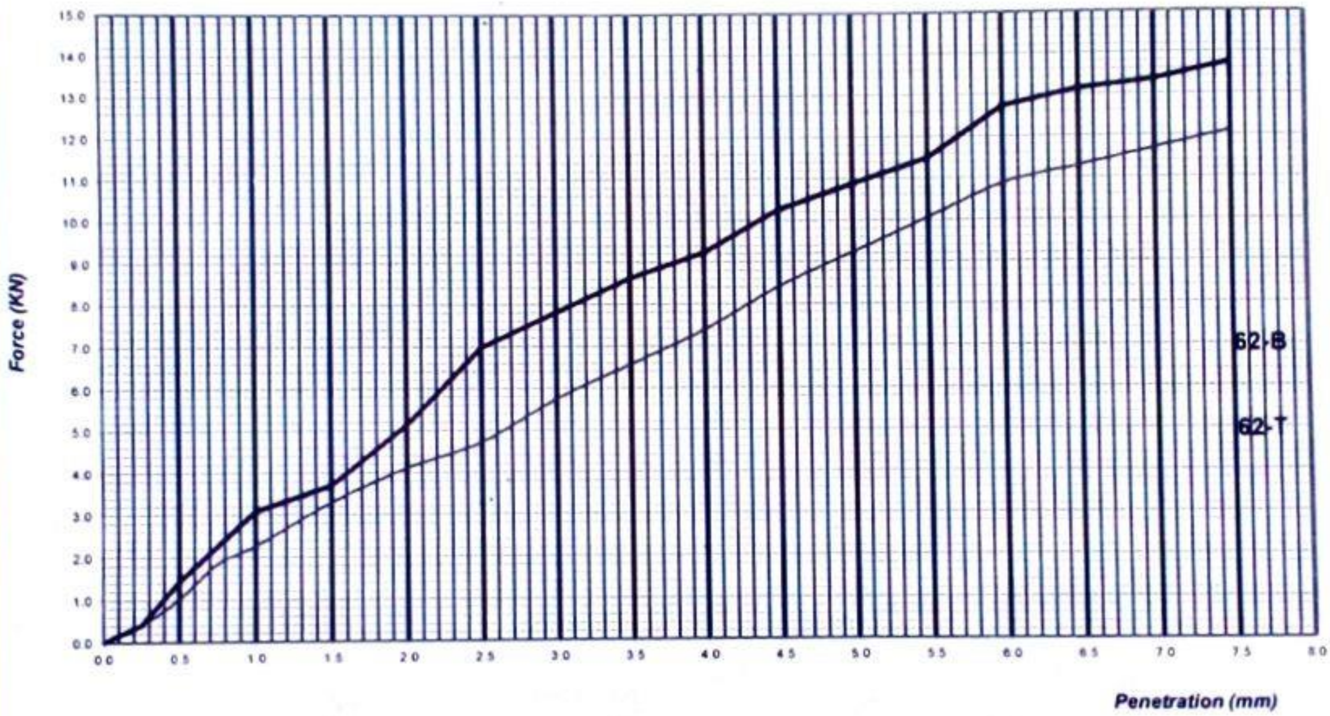
Institution	Students Names	Testing Lab
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

CALIFORNIA BEARING RATIO TEST (BS1377 Part 4)

Test sample reference	Depth 0.5m	Sampling Date	8/Jan/24
mix	EXPANSIVE SOIL STABILISED WITH 6% LIME &	Testing Date	12/Mar/24
Source	MUYEMBE-NAKAPIRIPIRIT ROAD	Technician	Lab team
Sample Description	EXPANSIVE SOILS		

PENETRATION vs FORCE CURVE



	62 blows			
	Force		CBR	
	Bottom	Top	Bottom	Top
2.5 mm Penetration	7.0	4.7	53	36
5.0 mm Penetration	10.9	9.2	54	46
Average	8.9	7.0	53.6	41.0
Retained CBR	53.6			
Observations	CBR= 53.6			

For the Lab		For Students	
Lab. Technician	*Materials Engineer*		

INSTITUTION	STUDENTS	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT: ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

SUMMARY OF TEST RESULTS FOR EXPANSIVE SOIL STABILISED WITH 6% LIME & 2% FIBRE

LOCATION: MUYEMBE-NAKAPIRIPIRIT ROAD   Depth: 0.5m

LOCATION	BLENDED %	SAMPLING DATE	GRADING								ATTERBERG LIMITS				MDD		CBR	CBR SWELL	
			63	37.5	20	5	2	0.425	0.075	GM	LL	PL	PI	LS	MDD	OMC		62	
MUYEMBE-NAKAPIRIPIRIT ROAD	EXPANSIVE SOIL STABILISED WITH 6% LIME & 2% FIBRE	Sample 01	100	100	100	99	94	85	80	0.41	65.45	49.4	16.0	9.0	1.492	27.5	47.7	0.43	
		Sample 02	100	100	100	99	94	84	78	0.44	65.5	49.3	16.2	9.0					
			100	**100**	**100**	**98.99**	**94.42**	**84.32**	**78.89**	**0.42**	**65.5**	**49.3**	**16.1**	**9.0**	**1.492**	**27.5**	**47.7**	**0.43**	
		1/8/2024																	
	AVERAGE		**100**	**100**	**100**	**99**	**94**	**84**	**79**	**0.424**	**65.5**	**49.3**	**16.1**	**9.0**	**1.492**	**27.5**	**47.7**	**0.43**	**#DIV/0!**

FOR LAB

Lab Technician   Materials Engineer

STUDENTS

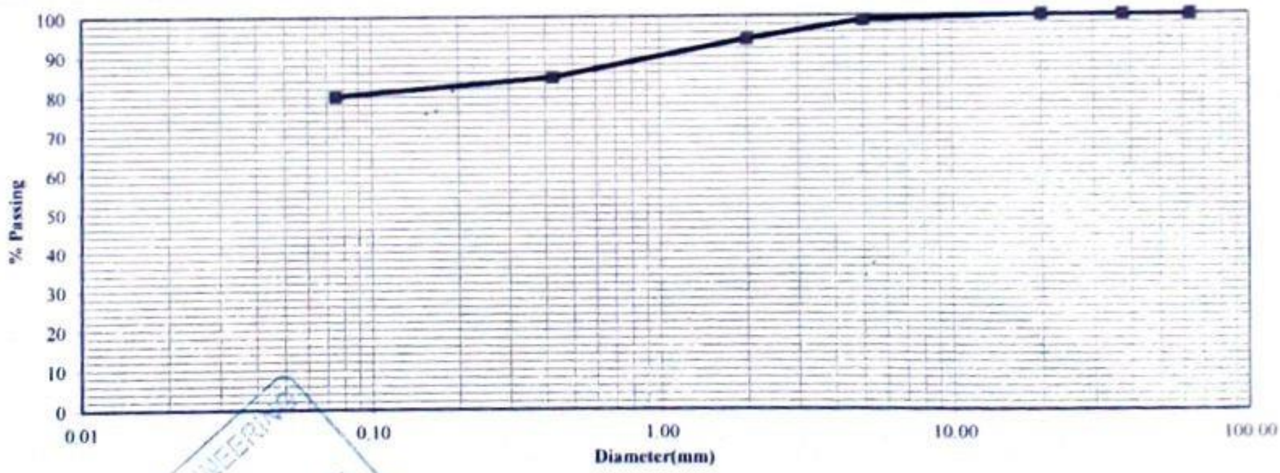
INSTITUTION	STUDENTS NAMES	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT : ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

PARTICLE SIZE DISTRIBUTION (BS 1377 - 2 - 90)

Location :	MUYEMBE-NAKAPIRIPIRIT ROAD	Lab. Refernece No.:		
Location :(km)	EXPANSIVE SOIL STABILISED WITH 6% LIME & 2% FIBRE	Dry wt. of sample before washing: (g)		3057.1
Depth: (m)	0.5m	Dry wt. of sample after washing: (g)		609.2
Material description:	MUYEMBE-NAKAPIRIPIRIT ROAD	Date Sampled:	Date Tested:	Technician
		8/Jan/2024	26/Feb/2024	Lab team

Sieve Size (mm)	Weight Retained (g)	Retained (%)	Passing (%)	Grading Limits (G60 & 80)	
63.0	0.0	0	**100**		
37.5	0.0	0.0	**100**		
20.0	0.0	0.0	**100**		
5.0	34.9	1.1	**99**		
2.00	136.9	4.5	**94**		
0.425	290.9	9.5	**85**		
0.075	144.2	4.7	**80**		
Total fines	2450.2	80.1			
Bottom Pan	2.3				
Extracted fines	2447.9				
Total sample	3057.1				
Grading Modulus		**0.41**			



Testing Lab

Lab Technician — *Materials Engineer*

STUDENTS

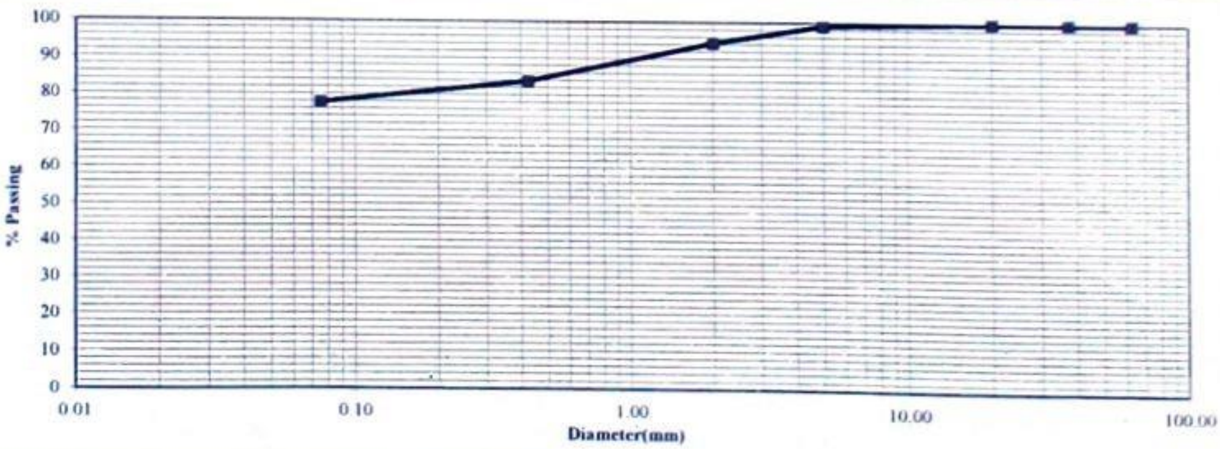
INSTITUTION	STUDENTS NAMES	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT : ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

PARTICLE SIZE DISTRIBUTION (BS 1377 - 2 - 90)

Location :	MUYEMBE-NAKAPIRIPIRIT ROAD	Lab. Refernece No.:		
Location :(km)	EXPANSIVE SOIL STABILISED WITH 6% LIME & 2% FIBRE	Dry wt. of sample before washing: (g)		2623.3
Depth: (m)	0.5m	Dry wt. of sample after washing: (g)		588.7
Material description:	MUYEMBE-NAKAPIRIPIRIT ROAD	Date Sampled:	Date Tested:	Technician
		8/Jan/2024	26/Feb/2024	Lab team

Sieve Size (mm)	Weight Retained (g)	Retained (%)	Passing (%)	Grading Limits (G60 & 80)	
63.0	0.0	0	**100**		
37.5	0.0	0.0	**100**		
20.0	0.0	0.0	**100**		
5.0	22.8	0.9	**99**		
2.00	122.6	4.7	**94**		
0.425	280.3	10.7	**84**		
0.075	160.9	6.1	**78**		
Total fines	2036.7	77.6			
Bottom Pan	2.1				
Extracted fines	2034.6				
Total sample	2623.3				
Grading Modulus		**0.44**			



Testing Lab

Lab Technician *Materials Engineer*

STUDENTS

INSTITUTION	STUDENTS	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT:	ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

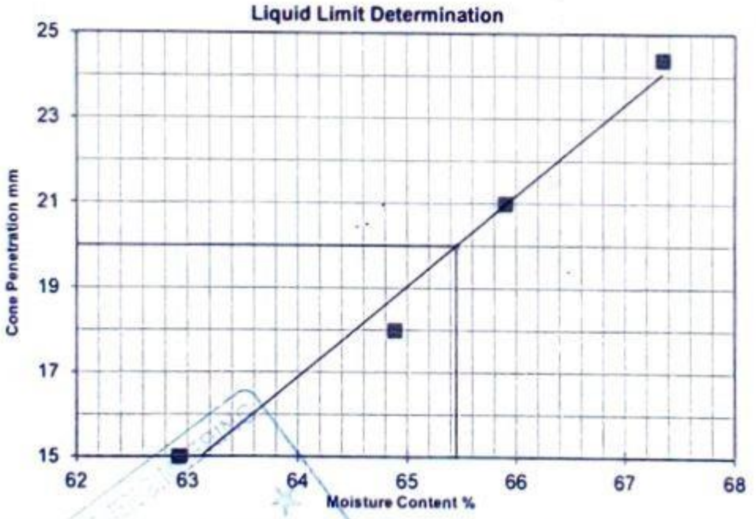
ATTERBERG LIMITS

Liquid limit (cone penotrometer) and plastic limit

SOURCE:	MUYEMBE-NAKAPIRIPIRIT ROAD	Technician:	Lab Team
mix	XPANSIVE SOIL STABILISED WITH 6% LIME & 2% FIBR	Sample Date	8/Jan/2024
Test method	BS 1377: Part 2, 1990:4.3/4.4	Test Date	11/Jan/2024
LAYER	EXPANSIVE SOILS		
Depth	0.5m		

PLASTIC LIMIT	Test No.	BA	FT		Average
Mass of wet soil + container (g)		39.74	43.68		41.71
Mass of dry soil + container (g)		34.31	36.69		35.5
Mass of container (g)		23.29	22.58		22.935
Mass of moisture (g)		5.43	7.0		6.21
Mass of dry soil (g)		11.02	14.11		12.565
Moisture content %		49.3	49.5		49.4
AVERAGE					

LIQUID LIMIT	Test No	1	2	3	4
Initial gauge reading (mm)		0	0	0	0
Final gauge reading (mm)		15.0	18	21	24.4
penetration (mm)		15.0	18.0	21.0	24.4
AVERAGE		15.0	18.0	21.0	24.4
Container No.		MB	FORD	PI600	A3
Mass of wet soil + container (g)		69.12	55.52	70.70	75.37
Mass of dry soil + container (g)		45.14	36.36	45.38	47.86
Mass of container (g)		7.03	6.83	6.96	7.01
Mass of moisture (g)		23.98	19.16	25.32	27.51
Mass of dry soil (g)		38.11	29.53	38.42	40.85
Moisture content (%)		62.9	64.9	65.9	67.3
AVERAGE		62.9	64.9	65.9	67.3



Liquid limit (%)	65.5
Plastic limit (%)	49.4
Plasticity Index (%)	16.0
Linear shrinkage	
Trough No.	2
Trough length (cm)	14.0
Specimen length (cm)	12.7
L.shringage =	1.3
% L.shrinkage =	9.0

Remarks:

TESTING LAB

Materials Engineer

Lab Technician

STUDENTS

INSTITUTION	STUDENTS	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling

PROJECT:	ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS

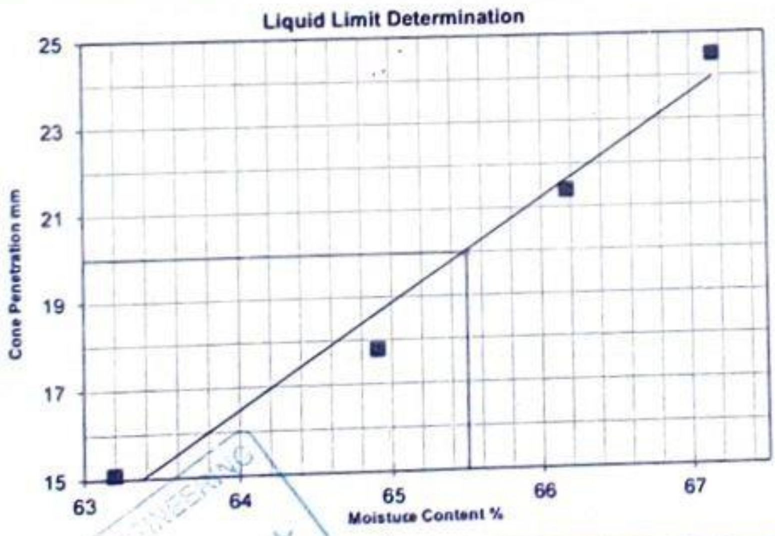
ATTERBERG LIMITS

Liquid limit (cone penotrometer) and plastic limit

SOURCE	MUYEMBE-NAKAPIRIPIRIT ROAD	Technician	Lab Team
mix	NEAT SAMPLE TP 02	Sample Date	8/Jan/2024
Test method	BS 1377: Part 2: 1990:4.3/4.4	Test Date	11/Jan/2024
LAYER	EXPANSIVE SOILS		
Depth	0.5m		

PLASTIC LIMIT	Test No.	O	RAD		Average
Mass of wet soil + container (g)		35.78	30.56		33.17
Mass of dry soil + container (g)		31.05	27.71		29.38
Mass of container (g)		21.38	21.97		21.675
Mass of moisture (g)		4.73	2.9		3.79
Mass of dry soil (g)		9.67	5.74		7.705
Moisture content %		48.9	49.7		49.3
AVERAGE					

LIQUID LIMIT	Test No	1	2	3	4
Initial gauge reading (mm)		0	0	0	0
Final gauge reading (mm)		15.1	17.8	21.4	24.5
penetration (mm)		15.1	17.8	21.4	24.5
AVERAGE		15.1	17.8	21.4	24.5
Container No.		BE	P132	P152	P133
Mass of wet soil + container (g)		53.01	70.80	73.92	64.65
Mass of dry soil + container (g)		35.17	45.61	47.26	42.41
Mass of container (g)		6.94	6.80	6.97	9.29
Mass of moisture (g)		17.84	25.19	26.66	22.24
Mass of dry soil (g)		28.23	38.81	40.29	33.12
Moisture content (%)		63.2	64.9	66.2	67.1
AVERAGE		63.2	64.9	66.2	67.1



Liquid limit (%)	65.5
Plastic limit (%)	49.3
Plasticity Index (%)	16.2
Linear shrinkage	
Trough No.	2
Trough length (cm)	14.0
Specimen length (cm)	12.7
L.shringage =	1.3
% L.shrinkage =	9.0

Remarks:

TESTING LAB

Materials Engineer

Lab Technician

STUDENTS

INSTITUTION	STUDENTS NAMES	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling
PROJECT	ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS	

STABLISED CBR

(BS 1924 PART 2 1)

EXPANSIVE SOIL STABILISED WITH 6% LIME & 0% FIBRE

M/c of air dried sample				M/c After Mixing		
Tin No		Z6T		Stabliser	6% LIME & 0% FIBRE	
Tin + Wet soil	gm	2475		Content	6.0	
Tin + Dry Soil	gm	2273		Tin No	Y6Y	
Tin	gm	810		Tin + Wet Soil	2228	
Water	gm	202.0		Tin + Dry Soil	1915	
Dry Soil	gm	1,463.0		Tin	820	
M/c	%	13.8		Water	313.0	
Av. M/c	%	13.8		Dry Soil	1,095.0	
				M/c	28.6	

(a)MDD	1.464	kg/m3	(b)Air Dry M/c	13.8	%
(c)WD	4,010	kg/m3	(e)M/c to add	13.6	%
(d)OMC	27.4	%	(F) volume	2.305	

Date prepared 1/Mar/24 Date immerse 8/Mar/24 Date tested 15/Mar/24

Mould No.			
Factor(f)	2.305		
(h)Wet Soil to fill mould c x f x %comp	9,243.0		
(j) Wt of air dried soil	6,000		
Air dry M/c	13.8		
(k) soil dry wt (100j/100+b)	5,272.1		
Stabliser	6% LIME & 0% FIBRE		
(m)Stablisers content %	6.0		
(n) Stabliser to add k x(m/100)	316.3		
Water Addition((j+n)x(d-b))/(100+b)	754.4		
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	
Stabliser	6% LIME & 0% FIBRE	6% LIME & 0% FIBRE	
Content %	6.0	6.0	
Mould g	A	B	
Wet Soil g	4,534.0	4,496.0	
Compaction M/c %	28.6	28.6	
Dry density kg/m3	1.530	1.517	
%Compaction	104.5	103.7	
FORCE	6.2	6.3	
UCS	0.338	0.343	0.34

STIRLING CIVIL ENGINEERING LTD P.O. BOX 700, KAMPALA (U)

INSTITUTION	STUDENTS NAMES	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling
PROJECT	ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS	

STABLISED CBR

(BS 1924 PART 2 1)

EXPANSIVE SOIL STABILISED WITH 6% LIME & 0.5% FIBRE

M/c of air dried sample			
Tin No		Y6Y5	
Tin + Wet soil	gm	2566	
Tin + Dry Soil	gm	2415	
Tin	gm	802	
Water	gm	151.0	
Dry Soil	gm	1,613.0	
M/c	%	9.4	
Av. M/c	%	9.4	

M/c After Mixing			
Stabliser	6% LIME & 0% FIBRE		
Content	6.0		
Tin No	DR		
Tin + Wet Soil	1456		
Tin + Dry Soil	1255		
Tin	505		
Water	201.0		
Dry Soil	750.0		
M/c	26.8		

(a)MDD	1.505	kg/m3	(b)Air Dry M/c	9.4	%
(c)WD	4,009	kg/m3	(e)M/c to add	17.3	%
(d)OMC	26.7	%	(F) volume	2.305	

Date prepared 1/Mar/24 Date immerse 8/Mar/24 Date tested 15/Mar/24

Mould No.			
Factor(f)	2.305		
(h)Wet Soil to fill mould c x f x %comp	9,241.9		
(j) Wt of air dried soil	6,000		
Air dry M/c	9.4		
(k) soil dry wt (100j/100+b)	5,486.4		
Stabliser	6% LIME & 0% FIBRE		
(m)Stablisers content %	6.0		
(n) Stabliser to add k x(m/100)	329.2		
Water Addition((j+n)x(d-b))/(100+b)	1,000.6		
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	
Stabliser	6% LIME & 0% FIBRE	6% LIME & 0% FIBRE	
Content %	6.0	6.0	
Mould g	A	B	
Wet Soil g	4,455.0	4,505.0	
Compaction M/c %	26.8	26.8	
Dry density kg/m3	1.524	1.541	
%Compaction	101.3	102.5	
FORCE	7.4	8.0	
UCS	0.405	0.439	0.42

STIRLING CIVIL ENGINEERING LTD P.O. BOX 793, KAMPALA (U)

INSTITUTION	STUDENTS NAMES	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling
PROJECT	ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS	

STABLISED CBR

(BS 1924 PART 2 1)

EXPANSIVE SOIL STABILISED WITH 6% LIME & 1% FIBRE

M/c of air dried sample				M/c After Mixing			
Tin No	UPC			Stabliser	6% LIME & 1% FIBRE		
Tin + Wet soil gm	2393			Content	6 0		
Tin + Dry Soil gm	2191			Tin No	ACB		
Tin gm	807			Tin + Wet Soil	2078		
Water gm	202.0			Tin + Dry Soil	1778		
Dry Soil gm	1,384.0			Tin	781		
M/c %	14.6			Water	300.0		
Av. M/c %	14.6			Dry Soil	997.0		
				M/c	30.1		

(a)MDD	1.519	kg/m3	(b)Air Dry M/c	14.6	%
(c)WD	4,419	kg/m3	(e)M/c to add	14.5	%
(d)OMC	29.1	%	(F) volume	2.305	

Date prepared	1/Mar/24 Date immerse	8/Mar/24 Date tested	15/Mar/24
Mould No.			
Factor(f)	2.305		
(h)Wet Soil to fill mould c x f x %comp	10,185.4		
(j) Wt of air dried soil	6,000		
Air dry M/c	14.6		
(k) soil dry wt (100j/100+b)	5,235.8		
Stabliser	6% LIME & 1% FIBRE		
(m)Stablisers content %	6.0		
(n) Stabliser to add k x(m/100)	314.1		
Water Addition((j+n)x(d-b))/(100+b)	799.2		
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	
Stabliser	6% LIME & 1% FIBRE	6% LIME & 1% FIBRE	
Content %	6.0	6.0	
Mould g	A	B	
Wet Soil g	4,392.0	4,356.0	
Compaction M/c %	30.1	30.1	
Dry density kg/m3	1.465	1.453	
%Compaction	96.5	95.7	
FORCE	10.1	9.8	
UCS	0.551	0.540	0.55

STIRLING CIVIL ENGINEERING LTD
P.O. BOX 793, KAMPALA (U)

INSTITUTION	STUDENTS NAMES	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling
PROJECT	ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS	

STABLISED CBR

(BS 1924 PART 2 1)

EXPANSIVE SOIL STABILISED WITH 6% LIME & 1.5% FIBRE

M/c of air dried sample					M/c After Mixing		
Tin No		21		Stabliser	6% LIME & 1.5% FIBRE		
Tin + Wet soil	gm	2118		Content	6.0		
Tin + Dry Soil	gm	1953		Tin No	KAU		
Tin	gm	790		Tin + Wet Soil	2060		
Water	gm	165.0		Tin + Dry Soil	1772		
Dry Soil	gm	1,163.0		Tin	799		
M/c	**%**	**14.2**		**Water**	**288.0**		
Av. M/c	**%**	**14.2**		**Dry Soil**	**973.0**		
				M/c	**29.6**		

(a)MDD	**1.426**	**kg/m3**	**(b)Air Dry M/c**	**14.2**	**%**
(c)WD	**3.907**	**kg/m3**	**(e)M/c to add**	**13.2**	**%**
(d)OMC	**27.4**	**%**	**(F) volume**	**2.305**	

Date prepared 1/Mar/24 **Date immerse**	8/Mar/24 **Date tested**		15/Mar/24
Mould No.			
Factor(f)	**2.305**		
(h)Wet Soil to fill mould c x f x %comp	**9,006.2**		
(j) Wt of air dried soil	**6,000**		
Air dry M/c	**14.2**		
(k) soil dry wt (100j/100+b)	**5,254.5**		
Stabliser	**6% LIME & 1.5% FIBRE**		
(m)Stablisers content %	**6.0**		
(n) Stabliser to add k x(m/100)	**315.3**		
Water Addition((j+n)x(d-b))/(100+b)	**730.7**		
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**	
Stabliser	**6% LIME & 1.5% FIBRE**	**6% LIME & 1.5% FIBRE**	
Content %	**6.0**	**6.0**	
Mould g	**A**	**B**	
Wet Soil g	**4,513.0**	**4,596.0**	
Compaction M/c %	**29.6**	**29.6**	
Dry density kg/m3	**1.511**	**1.539**	
%Compaction	**105.9**	**107.9**	
FORCE	**10.9**	**10.5**	
UCS	**0.597**	**0.574**	**0.59**

STIRLING CIVIL ENGINEERING LTD P.O. BOX 755, KAMPALA (U)

INSTITUTION	STUDENTS NAMES	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	ASIIMWE CALEB & MANANA MARK	Stirling
PROJECT	ASSESSING THE USE OF POLYETHYLINE TEREPHTHALATE FIBRE AND LIME FOR STABILISATION OF EXPANSIVE SOILS	

STABLISED CBR

(BS 1924 PART 2 1)

EXPANSIVE SOIL STABILISED WITH 6% LIME & 2.0% FIBRE

M/c of air dried sample				M/c After Mixing			
Tin No		MJR		Stabliser	6% LIME & 2.0% FIBRE		
Tin + Wet soil	gm	2118		Content	6 0		
Tin + Dry Soil	gm	1958		Tin No	YY		
Tin	gm	790		Tin + Wet Soil	1630		
Water	gm	160.0		Tin + Dry Soil	1443		
Dry Soil	gm	1,168.0		Tin	783		
M/c	%	13.7		Water	187.0		
Av. M/c	%	13.7		Dry Soil	660.0		
				M/c	28.3		

(a)MDD	1.492	kg/m3	(b)Air Dry M/c	13.7	%
(c)WD	4,102	kg/m3	(e)M/c to add	13.8	%
(d)OMC	27.5	%	(F) volume	2.305	

Date prepared 1/Mar/24	Date immerse 8/Mar/24	Date tested	15/Mar/24
Mould No.			
Factor(f)	2.305		
(h)Wet Soil to fill mould c x f x %comp	9,454.2		
(j) Wt of air dried soil	6,000		
Air dry M/c	13.7		
(k) soil dry wt (100j/100+b)	5,277.1		
Stabliser	6% LIME & 2.0% FIBRE		
(m)Stablisers content %	6.0		
(n) Stabliser to add k x(m/100)	316.6		
Water Addition((j+n)x(d-b))/(100+b)	766.7		
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	
Stabliser	6% LIME & 2.0% FIBRE	6% LIME & 2.0% FIBRE	
Content %	6.0	6.0	
Mould g	A	B	
Wet Soil g	4,462.0	4,502.0	
Compaction M/c %	28.3	28.3	
Dry density kg/m3	1.508	1.522	
%Compaction	101.1	102.0	
FORCE	4.5	4.5	
UCS	0.248	0.248	0.25

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

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EXCELLENCE THROUGH PRECISION AND INTEGRITY

DETERMINATION OF FREE SWELL

Project:	ASSESSING THE USE OF POLYETHYLENE TEREPHATHALATE FIBRE AND LIME IN THE STABILISATION OF EXPANSIVE SOILS		
Client:	MANANA MARK & ASIIMWE CALEB		
Location:	MUYEMBE-NAKAPIRIPIRIT ROAD	Sampling Date:	4-Apr-24
Project ref:	NEAT SOIL SAMPLE	Testing Date:	8-Apr-24
Test standard:	IS:2720 (Part 40) 1977		

Sample Identification	Depth (m)	Measuring Cylinder No		Measuring Cylinder No (After 24Hrs)		Swell (%)
		Kerosene	Distilled Water	Kerosene	Distilled Water	
TBH1	0.5-0.9	100.0	10.0	10	14.4	**44**
TBH2	1.0-1.5	10.0	10.0	10	15	**50**
Average (%)						**47**

Technician*(Signature)*:	Computed by *(Signature)*:	Checked by *(Signature)*:

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EXCELLENCE THROUGH PRECISION AND INTEGRITY

DETERMINATION OF FREE SWELL

Project:	**ASSESSING THE USE OF POLYETHYLENE TEREPHATHALATE FIBRE AND LIME IN THE STABILISATION OF EXPANSIVE SOILS**		
Client:	**MANANA MARK & ASIIMWE CALEB**		
Location:	**MUYEMBE-NAKAPIRIPIRIT ROAD**	**Sampling Date:**	**4-Apr-24**
Project ref:	**SOIL STABILISED WITH 6% LIME**	**Testing Date:**	**8-Apr-24**
Test standard:	**IS:2720 (Part 40) 1977**		

Sample Identification	Depth (m)	Measuring Cylinder No		Measuring Cylinder No (After 24Hrs)		Swell (%)
		Kerosene	Distilled Water	Kerosene	Distilled Water	
TBH1	0.5-0.9	100.0	10.0	10	13.0	**30**
TBH2	1.0-1.5	10.0	10.0	10	13.4	**34**
Average (%)						**32**

Technician*(Signature)* :	Computed by *(Signature)* :	Checked by *(Signature)* :
[signature]	[signature]	[signature]

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EXCELLENCE THROUGH PRECISION AND INTEGRITY

DETERMINATION OF FREE SWELL			
Project:	ASSESSING THE USE OF POLYETHYLENE TEREPHATHALATE FIBRE AND LIME IN THE STABILISATION OF EXPANSIVE SOILS		
Client:	MANANA MARK & ASHMWE CALEB		
Location:	MUYEMBE-NAKAPIRIPIRIT ROAD	Sampling Date:	4-Apr-24
Project ref:	SOIL STABILISED WITH 6% LIME AND 1.5% PET FIBRE	Testing Date:	8-Apr-24
Test standard:	IS:2720 (Part 40) 1977		

Sample Identification	Depth (m)	Measuring Cylinder No		Measuring Cylinder No (After 24Hrs)		Swell (%)
		Kerosene	Distilled Water	Kerosene	Distilled Water	
TBH1	0.5-0.9	100.0	10.0	10	11.8	**18**
TBH2	0.5-1.0	10.0	10.0	10	12.5	**25**
Average (%)						**22**

Technician *(Signature)*:	Computed by *(Signature)*:	Checked by *(Signature)*:
[signature]	[signature]	[signature]

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