

**GEOTECHNICAL PROPERTIES IMPROVEMENT OF EROSION SUSCEPTIBLE SOIL
WITH CAUSTIC SODA (A CASE STUDY OF EKOSODIN, BENIN CITY)**

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DEPARTMENT OF STRUCTURAL ENGINEERING

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UNIVERSITY OF BENIN

BENIN CITY

SEPTEMBER 2023

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**A PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE AWARD OF BACHELOR OF ENGINEERING (B. Eng.) DEGREE IN THE
DEPARTMENT OF STRUCTURAL ENGINEERING, FACULTY OF ENGINEERING,
UNIVERSITY OF BENIN, BENIN CITY, NIGERIA**

SEPTEMBER 2023

CERTIFICATION

This is to certify that this work was carried out by **Ubah, Samuel Uche**, with Matriculation number **ENG1805018** under the supervisor of Dr. **Ngozi Kayode - Ojo** of the Department of Structural Engineering, Faculty of Engineering, University of Benin, Benin City, Edo state, Nigeria.

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DEDICATION

This project work is dedicated to Almighty God for his infinite mercy and kindness over my life. I equally dedicate this work to my lovely mum Mrs. Chigozie Ubah who serve as a real source of inspiration towards my academic pursuit.

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Special thanks go to Almighty God for giving me the strength to complete this work and for His guidance and protection throughout my stay in the University of Benin.

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.

ABSTRACT

A good road network of a developing area such as Ekosodin community to major cities leads to rapid urban development. However, the erosion susceptible soil in the area has tasked highway and geotechnical engineers into research on improvement techniques on such problematic soil and still produce satisfactory pavement or foundation bases. Therefore, this study was focused on testing the effect of caustic soda additives on erosion susceptible soil in Ekosodin, Benin city, to improve its geotechnical properties.

This study was achieved by collecting four soil samples from the study area, analysing the soil specific gravity, particle size distribution, Atterberg limits, optimum moisture content, maximum dry density, cohesion, angle of internal friction, and California bearing ratio. Also, the effect of the caustic soda addition in 2%, 4%, 6%, 8% and 10% on these geotechnical properties were investigated and compared. Afterwards, the optimum percentage of caustic soda to give the highest soil strength based on the load bearing and subgrade capacity was determined.

The final soil results, based on its index and engineering properties in its unstabilized form, showed an AASHTO class of A-6 and A-7-6 class soil which usual types of significant constituent materials are Clayey soil of more than 35% fine passing BS sieve No 200, with fair to poor subgrade rating in pavement design and a significant level of plasticity. However, the addition of caustic soda was analysed to a maximum percentage of 10 on the Soil Atterberg limits, Compaction and California Bearing Ratio (CBR) test results, and the following was observed. A decrease in the liquid limit from 50.38% to 25.44% in soil samples at point 1; 39.66% to 25.49% in point 2; 50.59% to 26.20% in point 3; and 41.99% to 28.22% in point 4. Similarly, the plastic limit reduced from 25.53% to 11.47%, 20.12% to 10.96%, 21.18% to 14.22%, and 20.77% to 16.04% for soil samples at points 1, 2, 3, and 4 respectively. While the optimum moisture content decreased from their original values of 15.7%, 14.8%, 15.9%, and 14.8% to 13.30%,

13.80%, 11.20%, and 10.30% for soil in points 1, 2, 3, and 4 respectively. Similarly, the angle of internal friction from their original values of 5.45° , 7.02° , 8.14° , and 6.49° to 3.75° , 5.54° , 7.06° , and 5.17° for soil in points 1, 2, 3, and 4 respectively. However, an increase in the maximum dry density from 1.63 g/cm³, 1.65 g/cm³, 1.63 g/cm³, 1.66g/cm³ to 1.79 g/cm³, 1.77 g/cm³, 1.80 g/cm³, and 1.79 g/cm³ respectively at the addition of the 10% caustic soda. Similarly, increased the cohesion from their original values of 32.0 kN/m², 27.0 kN/m², 31.0 kN/m², and 32.0 kN/m² to 38.60 kN/m², 32.00

kN/m², 38.04 kN/m², and 37.86 kN/m² for soil in points 1, 2, 3, and 4 respectively. Also, an increase in the California Bearing Ratio (CBR) was observed both in the unsoaked and soaked state to 23.45%, 22.99%, 26.00%, and 20.50% for soil in points 1, 2, 3 and 4 respectively. The highest soaked soil CBR value of 26.0% was achieved at an optimum value of 10% caustic soda stabilization. Therefore, the chemical stabilization of caustic soda was recommended for erosion susceptible soil in Ekosodin as it improved the soil sample of the area from poor subgrade or foundation soil to a good load bearing and subgrade capacity soil for building and road construction.

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ACRONYMS

AASHTO – American Association of State Highway and Transportation Officials
CBR – California

Bearing Ratio test.

LL – Liquid limit
PL – Plastic limit

PI – Plasticity Index

OMC – optimum moisture content
MDD – Maximum dry density

c – Cohesion

ϕ – Angle of internal friction

FMWH – Federal ministry of works and housing

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Soil erosion is the term for the separation and movement of soil by natural factors such as gravity, ice, wind, or flowing water. This erosion typically takes the following three forms: sheet, rill, and gully erosion (Okengwo, et al., 2015). The soil in Ekosodin, Benin city Nigeria, was investigated to be highly susceptible to erosion caused by flowing water due to its geotechnical properties such as poor graded soil with low clay content, low erodibility index, and high precipitation (Ojeaga and Afolabi, 2022). Other factors include sloppy terrain, improper drain termination, lack of erosion control structure, low vegetation cover and bad land use (Ehiz and Omougbo, 2013). The erosion in Ekosodin caused by flowing water on the ground surface over time generated a big gully which disrupted the wildlife ecology and destroyed road construction projects in addition to destroying agricultural lands and natural vegetation, and residential buildings (Okengwo, *et al.*, 2015). While the water that infiltrated into the soil and the pore-water pressure build-up within the soil creates foundational and slope instability for both roads, buildings, and the existing gully (Egbueri, *et al.*, 2021).

All naturally existing, loose, uncemented, weakly cemented, or comparatively unconsolidated mineral particles, whether organic or inorganic in nature, that are found on top of bed rock, which is created when rocks weather (disintegrate), can be referred to as soil. Due to the easy wash-off of the soil fine particles during the rainy season, soil with a high fine content has poor resisting power, resulting in a weakly bound or loose soil. When exposed to water in high quantity, soil with high clay tends to soften and liquefy, and this property of soil makes construction difficult due to its low strength and stiffness. This has posed serious challenges in geotechnical engineering because weak

soil may cause damage to the foundation of buildings and cause cracks to buildings and along road pavement. Improvement of the soil is essential in this case to minimize the negative effect of the water content in the soil to a safe level.

The soil improvement involves a process of changing one or more soil characteristics mechanically or chemically to produce an improved soil material with the intended engineering properties. The purpose of soil stabilization not only limited to enhance the loadbearing of the soil capacity but also improve the shear strength, filter, drainage system permeability, enhance soil resistance to the weathering process and traffic usage. Improvement of the soil through mechanical or physical means include the reduction of the void ratio through physical alteration of the grain size fractions and adjustment of the soil's particle size composition. While the chemical methods involve the reaction of chemical additives with soil particles, which then results in the formation of a strong structure that binds the soil grains. By comparing the two methods of soil improvement, the chemical method was most recommended for erosion susceptible soil as it yields soil of higher quality and greater strength and durability than mechanical and physical methods (Olaniyan, *et al.*, 2011).

Caustic soda also known as sodium hydroxide is a non-volatile, whitish substance with no odour. Its principal advantages are that it can easily react with water which results into a powerful compaction aid giving a higher density for the same compactive effort (Olaniyan, *et al.*, 2011).

1.2 Statement of the Problem

The economic importance of Ekosodin community in Benin City, Nigeria, is significant as it is the home to the University of Benin (UNIBEN), one of the foremost universities in Nigeria. The local economy benefits from the influx of staff and students' spending on goods and services.

Firstly, Ekosodin community is predominantly agrarian, with a significant portion of the population engaged in farming activities. Improving erosion-susceptible soil is essential for enhancing agricultural productivity. Erosion can lead to soil degradation, loss of topsoil, and reduced fertility, negatively impacting crop yields. By implementing erosion control measures and soil conservation practices, farmers can protect their land, maintain soil fertility, and increase agricultural output. This, in turn, contributes to food security, income

Secondly, addressing erosion-susceptible soil in Ekosodin is crucial for environmental conservation. Erosion not only affects agricultural land but also leads to sedimentation in

degrade water quality, and impede water flow, resulting in adverse effects on fisheries, biodiversity, and other ecosystem services. By mitigating erosion, the community can protect the natural environment, preserve water resources, and maintain ecological balance, ultimately supporting sustainable economic activities such as fishing, tourism, and rivers, streams, and other water bodies. Sedimentation can disrupt aquatic ecosystems, recreational activities.

Thirdly, Erosion-susceptible soil can pose a threat to infrastructure development in Ekosodin. Also, Erosion poses a significant risk to the community's resilience and exacerbates vulnerability to natural disasters. During heavy rainfall events, erosion-prone areas are more susceptible to flash floods, landslides, and other related hazards.

In summary, addressing the issue of erosion-susceptible soil in Ekosodin community is vital due to its economic implications. By improving soil conservation practices, the community can enhance agricultural productivity, promote environmental conservation, support infrastructure development, tap into tourism potential, and enhance resilience to natural disasters. These efforts will contribute to sustainable economic growth, improved livelihoods, and the overall well-being of the community. Therefore, this study was focused on testing the effect of caustic soda additives on erosion susceptible soil in Ekosodin, Benin city, to improve its geotechnical properties.

1.3 Aim and Objectives

The aim of this study is to analyse the effect of caustic soda additives on erosion susceptible soil in Ekosodin, Benin city, to improve its geotechnical properties.

The Objectives are to:

1. Determine the index and engineering properties of soil in Ekosodin, Benin City.
2. Determine the effect of caustic soda on the soil strength using the compaction characteristics and California Bearing Ratio (CBR) results.
3. Determine which percentage combination by caustic soda will give the optimum soil strength based on the maximum dry density and CBR value.

1.4 Scope of the Study

The scope of work of this study involves:

- 1.4.1 Collection of soil samples at various locations in Ekosodin, Benin City.
- 1.4.2 Specific gravity test to evaluate the mineralogy and history of weathering of the soil.
- 1.4.3 Sieve analysis and hydrometer test to evaluate the particle size distribution parameters of the recovered samples.
- 1.4.4 Atterberg limits test to evaluate the consistency of the recovered soil.
- 1.4.5 Compaction test to obtain the maximum dry density and optimum moisture content of soil.
- 1.4.6 California Bearing Ratio (CBR) test to evaluate the strength of the soil as a pavement foundation.
- 1.4.7 Compaction and CBR test on a Caustic soda stabilized soil to analyse any possible improvement.

1.5 Justification of the Study

This study is required to examine the engineering characteristics of the soil in Ekosodin and how they can be enhanced by caustic soda additives. The success of this research will redirect individuals and government agencies, involved in research, environmental impact assessment (EIA), building design, highway construction, and many more to an economical and affordable chemical additive that improves problematic soil with a higher density.

CHAPTER TWO

LITERATURE REVIEW

2.1 Soil

Soil is described as an uncemented mixture of mineral grains and organic matter that has decomposed, with water and air filling the spaces between the solid particles (Hartemink, 2016). Civil engineers investigate the geotechnical properties of soil, such as its origin, grain size distribution, ability to drain water, compressibility, shear strength, and load-bearing capability, as soil is a frequently used construction material for supporting structural foundations.

The soil existing at Ekosodin, Benin City Nigeria, was described as a laterite soil due to its history of weathering and formation (Doyne and Watson, 2009). The Laterite soil profile was formed over igneous rocks under alternating conditions of percolation and evaporation. The soil profile consists of reddish or brownish coarse (gravel and sand) and fine (silt and clay) particles (Kayode-Ojo and Odemerho, 2023) due to its main mineral composition of silica (quartz) and ferric oxide (Schwertmann, 2023). Depending on the proportion of the different soil particle sizes and the quantity of water present in the voids between the particles, the laterite soil can either be a stable or unstable foundation material to any civil engineering structures. The soil composition with more of coarse particles than fine particles have more strength and stability to support load or resist pressure due to water movement. Gravelly or sandy soil with little or insignificant fine content could infiltrate and pass out water through them easily. However, the little fine content acting as binders or void fillers could be washed off, leaving the soil composition prone to sliding failure or erosion (Ojeaga and Afolabi, 2022). For silty or clayey soil with less coarse content, water takes a long time to infiltrate and flow out from them. Their moisture content is more absorb within them leading to swelling or volume expansion. The quantity of water absorb within the soil layer can

exceed its water retaining ability, leading to a soil liquefaction. After the water flows out, some fine particles mixed in the water could also flows out with it, leading to shrinkage or volume reduction. To avoid possible soil stability problems due to high compressibility, low shear strength and poor load bearing capacity, it is crucial to understand the geotechnical properties through field or laboratory investigation before construction (BS 1377: Part 1, 1990). The geotechnical properties of a laterite soil commonly investigated, include the natural water content, specific gravity, particle size distribution, Atterberg limits, compaction characteristics, compressive and shear strength (Amadi, 2010; Bowles, 2012; Roy and Bhalla, 2017); and these various geotechnical properties has different influence on civil engineering structures.

2.1.1 Natural Water Content

The natural water content is the amount of water that can be extracted from soil in its natural state, usually by heating at 105 °C. It is generally given as a percentage of the dry mass (BS 1377: Part 2, 1990). Unlike permeability which shows the movement of water in soil, the water content shows the moisture absorb within the soil particles. In problematic soil such as highly clayey soil, the water within the soil causes the swell-shrink effect which in a long term, causes foundation or earth retaining structural failure (Ehigiator, 2014). While for coarse soil such as gravelly or sandy soil, a large water content can disassociate the individual particles by washing off their binding grains and consequently, reduces their load bearing capacity (Ehiz and Omougbo, 2013).

2.1.2 Specific Gravity

Specific gravity is determined through laboratory analysis by dividing the mass of soil solids by the mass of an equivalent volume of water (BS 1377: Part 2, 1990). It is an important soil index property that is directly related to its mineralogy or chemical composition, gives information of the soil weathering history as shown in Table 2.1, and its suitability as construction material (Roy and Bhalla, 2017).

Table 2.1: Typical Values of Specific Gravity (Bowles, 2012)

Types of soil	Specific gravity
Sand	2.65-2.67
Silty sand	2.67-2.70
Inorganic clay	2.70-2.80
Soil with mica or iron	2.75-3.00
Organic soil	1.00-2.60

Based on minerals and chemical composition, iron containing soil have a higher specific gravity value than silica containing soil. While based on soil weathering, fine grained soil have higher specific gravity value than coarse grained soil. Soil with higher specific gravity value has stronger pressure resistance or shear strength for pavement (Roy and Dass, 2014) or foundation design (Roy, 2016).

2.1.3 Particle Size Distribution

Particle size distribution is the index property linked to the percentages of the various grain sizes present in a soil as determined by sieve and hydrometer analysis (BS 1377: Part 1, 1990). The sieving method involves the percentage of different sizes of soil particles coarser than 75 μ m, while hydrometer analysis determines the percentage of grain sizes lesser than 75 μ m. After the different grain size analyses, a particle size distribution curve is plotted, and coefficient of uniformity (Cu) and curvature (Cc) is measured as seen respectively in equation 2.1 and 2.2 below, to identify the gradation of the soil i.e., whether the soil grain composition is well or poorly graded.

$$C_u = \frac{D_{60}}{D_{10}} \quad (2.1)$$

$$C_c = \frac{D_{30}^2}{D_{10} \times D_{60}} \quad (2.2)$$

$$C_c = \frac{D_{30}^2}{D_{10} \times D_{60}}$$

Where

D₁₀ = the effective size of a soil at which 10% of the total soil mass is finer and 90% of the particles are coarser than D₁₀.

D₃₀ = the size at which 30% is finer by weight and remaining 70% particles are coarser than D₃₀ size

D₆₀ is the particle size at which 60% of the particles are finer and 40% of the particles are coarser than D₆₀ size.

C_u greater than 6 classifies the soil as well graded, and otherwise is classified as poorly graded or uniformly graded soil. While C_c between 1 and 3 is well graded if the C_u is also greater than 6. For instances where the C_c value is less than 1 or greater than 3, the soil is

gap graded (BS 1377: Part 2, 1990). The gradation of the soil is a very important information to predict soil water movement and the shear strength characteristics in foundation, roads, dam, and embankment construction (Bowles, 2012).

2.1.4 Atterberg Limits

Atterberg limits is the soil index property that provides information on the consistency of fine-grained soil based on the water content of the soil (BS 1377: Part 2, 1990). As the amount of water in a fine-grained soil slurry gradually decreases, the state of the soil changes through the following limits, from liquid to plastic (liquid limit), from the plastic to semi-solid (plastic limit) and finally from semi-solid to solid (shrinkage limit). The difference between the liquid and plastic limits is the plasticity index. Based on the plasticity index, different soil type was classified by Atterberg as seen in Table 2.2 below.

Table 2.2: Types of Soils Based on Plasticity Index Value (Roy & Bhalla, 2017)

Plasticity index (%)	Soil type	Degree of plasticity	Degree of cohesiveness
0	Sand	Non-plastic	Non-cohesive
<7	Silt	Low plastic	Partly cohesive
7-17	Silt clay	Medium plastic	Cohesive
>17	Clay	High plastic	Cohesive

2.1.5 Compaction Characteristics

Compaction is a process in which the soil grains are more closely put together by applying compactive energy to the soil (BS 1377: Part 2, 1990). The two soil characteristics obtained from a compaction process is the maximum dry density and the optimum dry density. At a soil maximum dry density, its shear strength is increased, its permeability decreased, its settlement rate decreased, and its bearing capacity is increased (Roy & Bhalla, 2017). The value of the optimum moisture

content obtained by the laboratory proctor compaction test controls the moisture content at which the soils are compacted in the field or at the laboratory to determine its California bearing ratio (BS 1377: Part 4, 1990).

California bearing ratio is a soil engineering property that determines the strength of a foundation soil material for pavement design. At the laboratory, it is evaluated as the ratio of the applied force at certain values of penetration to a standard force (BS 1377 : Part 4, 1990). Depending on the value of the California bearing ratio, the laterite soil can be characterized as a base, sub-base, or subgrade material (Roy, 2016).

2.1.6 Compressive Strength

The compressive strength of a soil is its ability to resist compressive stress due to external forces (BS 1377: Part 5, 1990). A soil layer undergoes compression when it experiences compressive stress because of construction activities. The compression could be caused by a variety of processes, including particle crushing, water seepage, particle rearrangement, and elastic distortions. The most common form of soil compression investigated before any civil engineering construction is the soil settlement due to structural load (Roy and Bhalla, 2017). Soil uneven settlement can tilt the structural foundation or generate cracks on the overlaying structure, hence ruin its aesthetic view. At critical level, the soil settlement can lead to building collapse or pavement failure (Bowles, 2012).

2.1.7 Shear Strength

The shear strength of soil is the result of the interlocking of particles (friction) and bonding at the particles contact (cohesion). Shear strength is influenced by the soil's consistency, mineralogy, grain size distribution, form, initial void ratio, and structural characteristics like layers, joints, fissures, and cementation (BS 1377: Part 7, 1990). The shear strength is the capability of a soil to support a loading from a structure, or to support its overburden, or to sustain a slope in equilibrium (Roy and

Bhalla, 2017). The shear strength parameter of a coarse particle is because of the frictional forces of the particles as they slide and interlock during shearing, while that of a fine soil is as a result of the cohesion bond between the particles (Roy and Dass, 2014).

2.2 Erosion

Soil erosion is the process by which soil particles are dispersed from parent materials and transferred from one place to another by a force such as wind, water, or a landslide. Erosion is a natural occurrence, but because of human interference with natural processes, it has a faster rate of occurrence than the typical geological erosion rate (Abdulfatai, *et al.*, 2014).

In Ekosodin, gully is the highly noticeable type of soil erosion that has reduced land use, lowered soil production, and posed a hazard to roads, fences, and structures (Ehigiator, 2014). In addition to the gully disruption of the ecological balance of plants and animals, the deep steep walls at capitol, University of Benin, which are prone to landslides at times of heavy rainfall, pose a serious threat to student and staff (Ojeaga and Afolabi, 2022). Some researchers have unequivocally stated that the underlying geology plays a significant part in the gully development and that, often, the process of gully formation is reliant on the type of soil because some soils are more prone to erosion than others (Abdulfatai, *et al.*, 2014; Egbueri, *et al.*, 2021; Ehiz and Omougbo, 2013; Ehigiator, 2014; Ojeaga and Afolabi, 2022). Hence, a need to improve the soil by reinforcing it against any possible agent of erosion.

2.3 Caustic Soda

Caustic soda is a non-volatile, whitish, and odourless substance, which can easily react with the water in soil to generate a powerful compaction aid giving a higher density for the same compactive effort (Olaniyan, *et al.*, 2011). Wang, *et al.* (2021) studied the effect of caustic soda on the unconfined compressive strength and plasticity of a soft soil and observed an increasing

strength and a better ductility of the soft soil. A caustic soda stabilized mud soil was introduced to reinforce an acidic sandy soil to increase its load bearing capacity (Summers, *et al.*, 2001). Despite this positive effect caustic soda has on soil properties, the quantity introduced must be moderated, as a negative effect can be observed at higher concentration of this alkali interaction due its ability to form new compounds or mineralogical changes in behaviour of some soils (Rao and Chittaranjan, 2010).

Caustic soda as shown in Figure 2.1, is a crystalline ionic compound consisting of sodium cations Na^+ and hydroxide anions OH^- (Wang, *et al.*, 2021).

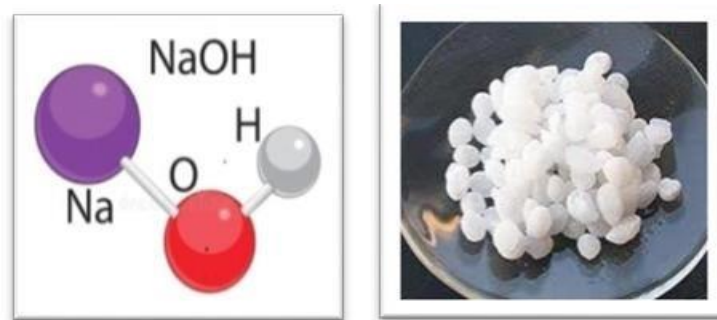


Figure 2.1: Sodium Hydroxide or Caustic Soda (Hussain, 2019)

The hydrogen atoms of the hydroxyls firmly connect to the oxygen atoms within each O (oxygen) layer. Adjacent O layers are held together by hydrogen bonds between water molecules. At average ambient temperatures without safety precautions, sodium hydroxide, a highly corrosive alkali, breaks down proteins and can result in severe chemical burns. It is highly soluble in water but less soluble in polar solvents like ethanol and methanol (Olaniyan, *et al.*, 2011). The dissolution of solid Caustic soda in water often leads to a colourless and odourless alkaline solution which feels slippery with skin contact due to the process of saponification that occurs between NaOH and natural skin oils. Caustic- soda/sodium-hydroxide forms a series of hydrates, of which the commercially available sodium hydroxide is the monohydrate $\text{NaOH}\cdot\text{H}_2\text{O}$. As one of the

simplest hydroxides, sodium hydroxide is frequently used alongside neutral water and acidic hydrochloric acid to demonstrate the pH scale in chemistry. It is also used in the production of paper, sodium salt, soap, detergents, alumina, petroleum, chemicals, artificial textiles fibers, degreasing metals, water treatment, acid neutralization, drain cleaner, mining, glassmaking, metalworking and so on (Olaniyan, *et al.*, 2011; Wang, *et al.*, 2021).

2.4 Stabilization

Stabilization of a soil is any physical, chemical, or combined process of improving soil not suitable for construction by modifying its properties to meet an engineering purpose (Ayininuola and Abidoye, 2018; Joel and Agbede, 2011; Maaitah, 2012). The most challenging issue for civil engineers when constructing on an expanding clay, for example of an unsuitable soil, is the volume change that occurs with or without moisture. Improvement/stabilization of such soil can lower its permeability, reduce pavement thickness, boost its shear strength, manage its shrink-swell characteristics, and increases its load bearing capacity for building or road pavements constructions (Amadi, 2010). Some of the stabilizing additive already introduced over the years include enzymes, surfactants, biopolymers, synthetic polymers, co-polymer-based goods, cross-linking styrene acrylic polymers, bitumen, tree resins, ionic stabilizers, fibre reinforcement, sodium hydroxide, calcium chloride, calcite, sodium chloride, magnesium chloride, and more (Amadi and Okeiyi, 2017; Sakr, *et al.*, 2008; Joel and Agbede, 2011; Oluyemi-Ayibiowu, 2019; Ayininuola and Abidoye, 2018; Saing, *et al.*, 2017; Hussain, 2019). The process of applying the aboved stabilizing agents to improve soil properties mainly falls under physical or chemical stabilization (Hussain, 2019).

2.4.1 Physical Stabilization

The physical stabilization involves a mechanical process of altering soil particle size distribution (i.e., modifying its porosity and particle interlocking friction) and its plasticity to yield better result

(Ayininuola and Abidoye, 2018). The mechanical techniques include compaction, wetting-drying cycles, soil reinforcement with agricultural, industrial, or physical solid wastes/materials, etc. A physical stabilization process can include an injection of an impermeable materials into a cohesionless soil by grouting to boost its permeability and cohesiveness (Kazemain and Barghchi, 2012). A properly embedded geotextiles, fabrics, fibres, and plastics in soil are mechanical ways of reinforcing the soil with physical solid waste to increase its stability and strength in road construction (Kayode-Ojo and Eteure, 2023). The addition of some agricultural waste such as rice husk ash, periwinkle shells, corn husk ash, etc to unstable soil also resulted in high strength and stability (Rahgozar, *et al.*, 2018). Industrial materials such as polymers, mining waste, bentonite and bitumen have been introduced as binders to sandy soil to reduce its permeability (i.e., filling the voids between particles in contact) and increase its strength through an increase in the particles cohesive bond (Wayal, *et al.*, 2012).

2.4.2 Chemical Stabilization

Chemical stabilization entails adding to a soil an ideal percentage of a chemical compound of opposite ion polarity to produce a mixture with greater strength (Ayininuola and Abidoye, 2018). Just like physical stabilization, the chemical techniques seal the voids between particles in contact, preventing water penetration. However, the chemical additives applied to the soil do react with the soil to form new soil chemical compound. For example, in a caustic soda stabilization of an acidic soil for agricultural use, the sodium hydroxide reaction increases the pH of the soil to an acceptable alkaline level for good plants growth by neutralizing any acidic property in the soil (Hussain, 2019). Also, the exothermic reaction of sodium hydroxide, expels excess water from soil, resulting to higher dry density, stability, and strength (Wang, *et al.*, 2021).

2.5 Review of Related Works

Over the years, several agricultural, industrial, chemical, and physical materials have been used in

stabilizing soil naturally unsuitable to support civil engineering structures. Sakr, *et al.* (2008) used lime in the following proportion 1%, 3%, 5%, and 7% by weight to stabilize a soft clay soil of high organic content. The mineralogical and microstructural examinations, grain size analysis, plasticity limits, unconfined compressive tests, vane shear tests and oedometer tests were conducted on the stabilized soil and compared with the unstabilized soil. The results demonstrated improvement on the soil plasticity, strength, and compressibility.

Amadi and Okeiyi (2017) compared the use of quick and hydrated lime in the following proportion 0%, 2.5%, 5%, 7.5% and 10% by weight to stabilize a lateritic soil. Atterberg limits, compaction, unconfined compression tests, California bearing ratio (CBR), swelling potential using CBR instrument and hydraulic conductivity were conducted on the stabilized soil and compared with the unstabilized soil. It was found from the foregoing results that the quick lime stabilized soil exhibited a superior engineering property than the hydrated lime stabilized soil.

Saing, *et al.* (2017) used cement in the following proportion 3%, 5%, 7%, and 10% to stabilize laterite soil. The moisture content, particle size distribution, specific gravity, Atterberg limits, compaction test, and unconfined compressive strength were conducted on the stabilized soil and compared with the unstabilized soil. The result showed that the cement addition increased the compressive strength of the soil and boost the soil potential from a subgrade material to a good road base material.

Joel and Agbede (2011) mixed sand and cement in a ratio of 5:1 to stabilize lateritic soil. Classification, compaction, California bearing ratio (CBR), and unconfined compressive strength tests were conducted on the stabilized soil and compared with the unstabilized soil. It was concluded that sand enhanced the effective stabilization of laterite soil with cement within the maximum cement content specified by the Nigerian code.

Oluyemi-Ayibiowu (2019) studied the stabilization of laterite soil with asphalt- emulsion in the following 0%, 2%, 4%, 6%, and 8%. Classification, compaction, California bearing ratio (CBR), and unconfined compressive strength tests were conducted on the stabilized soil and compared with the unstabilized soil. The results show that lateritic soils respond favourably with the addition of asphalt-emulsion, but materials containing excessive amounts of clay are not found suitable for stabilizing with asphalt-emulsion due to difficulty in mixing and a prolonged curing period needed to obtain desired strength.

Ayininuola and Abidoye (2018) examined the effect of stabilizing lateritic soil with a combination of bitumen emulsion and cement. Unconfined Compressive Strength (UCS) test and California Bearing Ratio (CBR) test were conducted on the stabilized soil and compared with the unstabilized soil. It was observed that both the UCS and CBR values increased as the cement component increased for both soil samples. Stabilising laterite with mixture of bitumen emulsion and cement improved the strength of the soil.

Maaitah (2012) investigated the effect of chemical stabilization on an expansive soil. The chemical stabilizing agents were sodium silicate and lime at different percentages. The results showed that the geotechnical properties improved when soil was treated by the combination of lime and sodium silicate.

Zaliha, *et al.* (2013) examined the effect of soil stabilization with each of the following additives: sodium hydroxide, fly ash geopolymeric binder, ashes, and cementitious binders. All stabilizing agents except fly ash geopolymeric binder increased the soil strength with increase in their percentage.

However, the chemical additive, Caustic soda has not been explored to improve the erosion susceptible laterite soil present in Ekosodin, Benin City, Nigeria. Hence, this study is proposed.

CHAPTER THREE

METHODOLOGY

3.1 Study Area

Ekosodin as shown in Figure 3.1, is a community located at the east of Isihor in Ovia Northeast Local Government Area of Edo state Benin City. It is bounded by the University of Benin on the south, Evbhomhore community in the West, Isihor in the North and the Ovia River in the East. It is located along longitude $5^{\circ}45'$ and $6^{\circ}15'$ East and latitude $5^{\circ}15'$ and $6^{\circ}45'$ North (Rawlings and Seghosime, 2022).

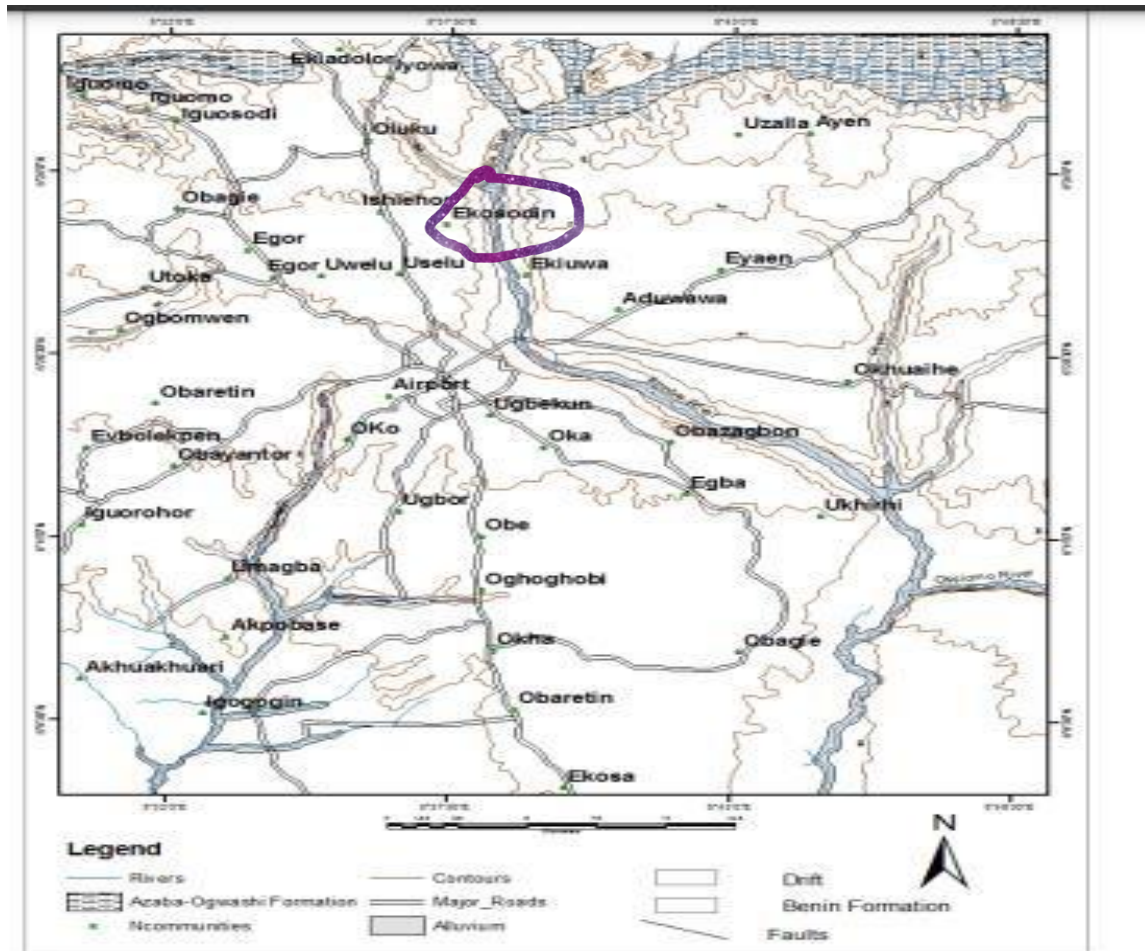


Figure 3.1 Map of Benin City showing Ekosodin (Source: Ikhile, 2016)

The Benin Region is underlain by sedimentary formation of the South Sedimentary Basin. The geology is generally marked by top reddish earth, composed of ferruginized or literalized clay sand. It constitutes part of the Benin formation which is made up of over 90% massive, porous, coarse sand with thick clay/shale interbeds having high groundwater retention capacity. The geology is generally marked by top reddish earth, composed of ferruginized or literalized clay sand. Geologically, the Benin Region comprises of the Benin formation; alluvium; drift/topsoil and Azagba-Ogwashi (Asaba-Ogwashi) formation (Ihkile,2016).

3.1.1 Research Procedures

To achieve the aim of this study which is to analyse the effect of caustic soda additives on erosion susceptible soil in Ekosodin, Benin city, the following procedures that will be applied to the study are.

1. Reconnaissance survey of the study areas,
2. Collection of samples for the needed tests,
3. Preparation of the additive solution,
4. Carrying out the classification and the engineering tests on the samples.

3.2 Materials

The materials that were used for this study include soils and caustic soda.

3.2.1 Caustic Soda

Caustic soda, which is an inorganic alkali with strong alkaline properties, is typically available in solid form as white, translucent pellets or flakes and this will be bought from a chemical store in Benin – City. The caustic soda solution is dissolved in water per litre of the mass of the soil samples.

3.2.2. Collection and Preparation of Soil Samples

To this study, about 300kg each of disturbed soil samples is collected from four points in Ekosodin at a depth of 1.0m from the ground surface by means of a hand auger. Some quantities of the samples were placed in an airtight polythene sheet to prevent the escape of moisture for the determination of the natural moisture content of the soils. The samples were then taken to the geotechnical laboratory and allowed to dry, while the larger lumps of soils are pulverized to smaller crumbs.

3.3. Laboratory Test Conducted

Preliminary tests were conducted on the natural soils to be able to classify the soils and the California Bearing Ratio (CBR) of the control were conducted. The classification tests that were conducted on the samples are specific gravity test, particle size distribution tests; Atterberg's limits tests which are the liquid limit and plastic limit test, and compaction tests to determine the optimum moisture content and maximum dry density of the natural soils.

3.3.1 Specific Gravity Test

The specific gravity of a soil mass refers to the mass of solids in the soil in comparison with an equal volume of water. The specific gravity provides us with the knowledge of how porous the soil is and the voids that is present in the soil mass. It is a classification property that is linked with the mineralogy or chemical composition and reflects the history of weathering. The method used in the determination of the specific gravity in the laboratory was the density bottle method as shown in Figure 3.2. This method was performed in accordance with BS 1377; Part 2 1990.



Figure 3.2: Apparatus for Specific Gravity Test

3.3.2 Particle Size Distribution

Particle size distribution, also known as gradation, refers to the proportions by dry mass of a soil distributed over detailed particle-size ranges. The particle size distribution test gives the information of the different sizes that are present in the soil, these particulate sizes are gravel, sand, silt, and clay. These sizes control the engineering properties of the soil. The particle size distribution is performed by sieving the loosed soil through a mesh of sieves as shown in Figure 3.3. The soil is passed through different sieve mesh starting from 4.75mm (IS no 4), 2.36mm (IS no 8), 1.18mm (IS no 16), 600 μ m (IS no 30), 425 μ m (IS no 40), 300 μ m (IS no 50), 212 μ m (IS no 70), 150 μ m (IS no 100), 75 μ m (IS no 200) and the receiver. The test procedure is stated in BS 1377; Part 2: 1990. From the result the sieve sizes are plotted against the percentage passing and the graph is then interpreted.



Figure 3.3: Apparatus for Particle Size Distribution

3.3.3 Atterberg's Limit Test

The consistency and behaviour of cohesive soils is different as are the engineering properties at fluctuating degrees of moisture content. Thus, the boundary between each state can be defined based on a change in the behaviour of the cohesive soil. The limits are based on the premise that fine grained soils exist in four states in respect to the moisture content. These states are the solid, semi-solid, plastic, and liquid states. These states are defined by the Atterberg's limits. The limits that were considered in this study were the liquid and plastic limits. The liquid limit is the water content which causes the fine-grained soil slurry to pass from the liquid state to a plastic state. While the plastic limit is the water content which causes the fine-grained soil to pass from plastic state to a semi-solid, and finally to the solid state. The difference between liquid limit and plastic limit is defined as the plasticity index (PI). The test procedures as shown in Figure 3.4 are as given by BS 1377; Part 2 1990.

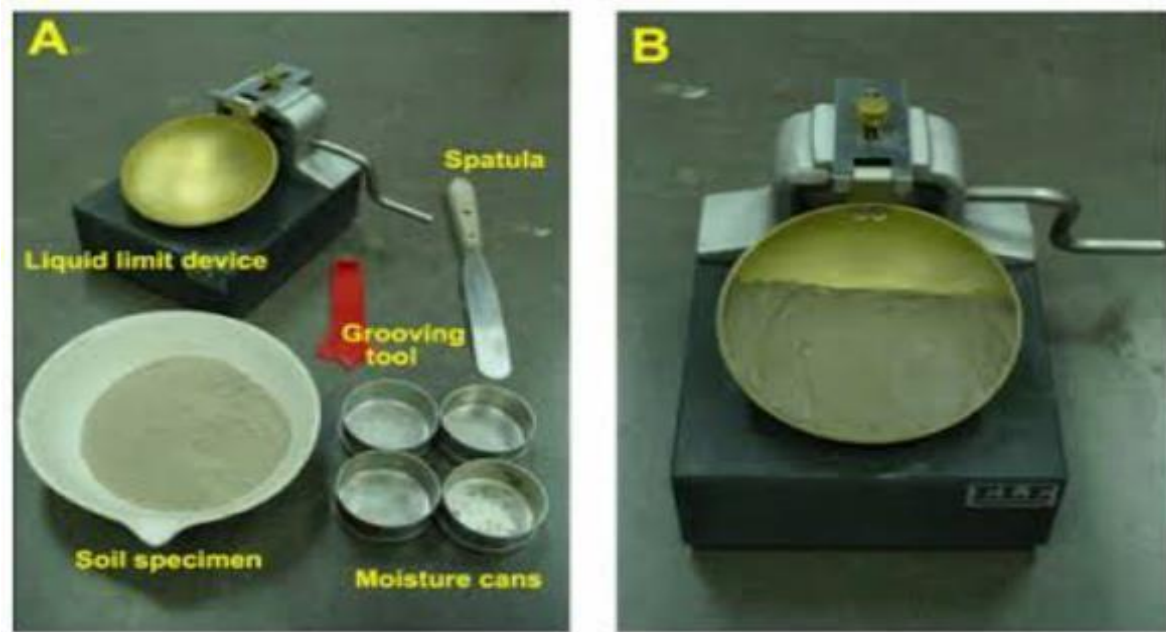


Figure 3.4: Apparatus for Atterberg Limit Test

3.3.4 Compaction Test

Compaction deals with the process of increasing the bulk density of the soil sample by the expulsion of air from the voids. For a given soil, at any compaction effort, the density is as a result of the moisture present in the soil. The effect of the moisture content can be interpreted based on the fact that at high moisture content, the maximum dry density is gotten when the soil is compacted close to the saturated density, such that the majority of the air has been expelled from the voids. But at lower moisture content, there is an interaction between the particles of the soil leading to an increase in the bulk density. The procedure for the conduction of the compaction test as shown in Figure 3.5 is as given by BS 1377; Part 4:1990. The test conducted in this study is the standard proctor test, and the optimum moisture and maximum dry density were obtained.

The compaction test was conducted by the use of the standard proctor method, in which the soil sample was compacted in three layers while subjecting each layer to 25 blows. The test was first conducted on the control from the locations, and then additive solutions. The caustic soda is mixed

with the water in this test. The percentage addition of the caustic soda per litre of water used in this study will be 0%, 2%, 4%, 6%, 8% and 10% by mass of the soil sample dissolved in water.



Figure 3.5: Apparatus for Compaction Test

3.3.5 Unconsolidated Undrained Triaxial Test

The unconsolidated undrained triaxial test (UU test) is a laboratory test commonly conducted to determine the shear strength parameters of soils. It is particularly useful for cohesive soils, such as clays, where pore water pressure generation during shearing is significant. In the UU test, a cylindrical soil specimen is confined within a rubber membrane and placed in a triaxial cell. The specimen is initially saturated, but no consolidation or drainage is allowed before shearing. This means that the pore water pressure within the specimen remains undrained during the test. The test proceeds in three stages: the initial consolidation, the shearing, and the measurement of pore pressure. During the initial consolidation stage, an isotropic cell pressure is applied to the specimen, allowing excess pore water pressures to dissipate. This stage ensures that the specimen is uniformly stressed before shearing begins. Next, shearing is induced by applying an axial load while maintaining the confining pressure constant. The specimen deforms and shears along a predetermined failure plane. The axial load and the corresponding axial strain are recorded throughout the shearing process. Simultaneously, the excess pore water pressure is measured using

pore pressure transducers. The undrained condition prevents any drainage of pore water during shearing, resulting in the development of high pore-water pressures within the specimen. These pressures are measured and used to determine the soil's undrained shear strength. The UU test provides valuable information about a soil's strength characteristics, including the cohesion (c) and the angle of internal friction (ϕ). These parameters are essential for geotechnical engineering analyses such as slope stability, foundation design, and retaining wall design. It is important to note that the UU test assumes that the soil sample is fully saturated, and the pore water pressure is the primary factor influencing shear strength. It may not accurately represent the soil's behavior under drained conditions or in situations where drainage occurs during loading. Overall, the unconsolidated undrained triaxial test as shown Figure 3.6 is a widely used laboratory test to assess the undrained shear strength of cohesive soils. It provides valuable data for engineering analysis and helps in understanding the soil's behavior under different loading conditions. The test was carried out in accordance with BS 1377:75 Test 13 and BS EN 1997-2-200



Figure 3.6: Apparatus for UU Triaxial Test

3.3.6 California Bearing Ratio Test

The California Bearing Ratio (CBR) is a measure used to evaluate the strength and load-bearing capacity of soils. It is commonly used in geotechnical engineering to assess the suitability of soils for road construction and pavement design. The CBR test provides an indication of the soil's ability to resist deformation under applied load. The CBR value is determined by comparing the penetration resistance of the soil sample to that of a standard crushed stone material. The ratio of the measured load to the standard load is multiplied by 100 to obtain the CBR value as a percentage. A higher CBR value indicates a stronger and more resilient soil, capable of supporting heavier loads without excessive deformation. The test procedures as shown in Figure 3.7 are as given by BS 1377; Part 7: 1990.

This test is conducted at the optimum moisture content of the compaction tests carried on the samples as in the compaction tests.



Figure 3.7: Apparatus for CBR Test

3.4 Sample Preparation Methods

The classification tests are prepared in accordance with the procedures as stated by their respective standard of practice. The soil samples used in the laboratory for the CBR test are disturbed samples that are compacted at their optimum moisture content and maximum dry density as obtained from the compaction tests conducted on the soil samples.

The caustic soda is dissolved in water as per the percentage mass to be added to the soil. The caustic soda solution is prepared 24 hours before carrying out the tests in the laboratory as the reaction between caustic soda and water is very high and hence care must be taken to avoid chemical accident.

Table 3.1 shows the batching method in relation to the weight of the soil samples and the percentage caustic soda to be dissolved in the determination of the optimum moisture content of the respective soil samples.

Table 3.1 Percentage Composition of Soil + Caustic Soda Solution

Description	Soil (%)	Caustic Soda (%)
CS1	100	0
CS2	98	2
CS3	96	4
CS4	94	6
CS5	92	8
CS6	90	10

CHAPTER FOUR

RESULTS AND DISCUSSION

The test parameters as stated in chapter three were investigated to achieve the objectives of this study. The parameters include the Specific gravity, Particle size distribution, Atterberg limits, Compaction, California bearing ratio (CBR) and Shear Strength values of the soil samples and the effect of a caustic soda stabilization on the soil geotechnical properties in the proportion of 2%, 4%, 6%, 8% and 10%.

4.1 The Classification of the Soil Based on its Index and Engineering Properties

The soil properties investigated in this study in its non-stabilized state, were the specific gravity, particle size distribution, liquid limit, plastic limit, plasticity index, optimum moisture content, maximum dry density, cohesion, angle of internal friction and California Bearing Ratio; and they are presented in Table 4.1.

Table 4.1 The Soil Index and Engineering Properties

Soil Properties		Point 1	Point 2	Point 3	Point 4
Specific Gravity		2.25	2.37	2.20	2.36
Percentage Passing British Standard	No. 10	97.74	98.12	98.23	98.47
(BS) Sieve Size	No. 40	76.83	72.16	75.39	78.99
	No. 200	43.39	35.59	42.35	42.68
Liquid Limit (%)		50.38	39.66	50.59	41.99
Plastic Limit (%)		25.53	20.12	21.18	20.77
Plasticity Index (%)		24.85	19.53	29.41	21.22
Optimum Moisture Content (%)		15.7	14.8	15.9	14.8
Maximum Dry Density (g/cm ³)		1.63	1.65	1.63	1.66
Cohesion (kN/m ²)		32.0	27.0	31.0	32.0
Angle of Friction (°)		5.45	7.02	8.14	6.49
California Bearing Ratio (%)	Unsoaked	8.30	17.26	6.48	12.92
	Soaked	5.12	8.42	0.99	8.09
AASHTO Classification		A-7-6	A-6	A-7-6	A-7-6

4.1.1 The Specific Gravity

The range of specific gravity values of the different test samples was 2.20 to 2.37. This result depicts a soil with more of inorganic granular grain, silica and/or iron mineral, and a significant fine content (Bowles, 2012; DD ENV 1997-2, 2000; AASHTO M145-91, 2012).

4.1.2 The Soil Particle Size Distribution based on the BS Sieve Analysis

Particle size distribution represents the relative proportions of different grain sizes in the soil composition. Table 4.1 above present the percentage of the total soil mass that passing through the BS sieve No 10, 40 and 200 respectively. According to AASHTO M145-91 (2012), soil grains that are retained on each of these three sieve sizes represent the gravel, sand (coarse and medium) and fine sand respectively. While the percentage that passes through the BS sieve No. 200, represents the silt and clay content of the soil. As observed from the sieve analysis at point 1, the proportion of gravel in the soil was 2.26%, coarse and medium size sand 20.91%, fine sand 33.44%, silt and clay 43.39%. Similarly, point 2 has 1.88% gravel, 25.96% coarse and medium sand, 36.57% fine sand, 35.59% silt and clay. Point 3 has 1.77% gravel, 22.84% coarse and medium sand, 33.04% fine sand, 42.35% silt and clay. While point 4 has 1.53% gravel, 19.48% coarse and medium sand, 36.31% fine sand, 42.68% silt and clay.

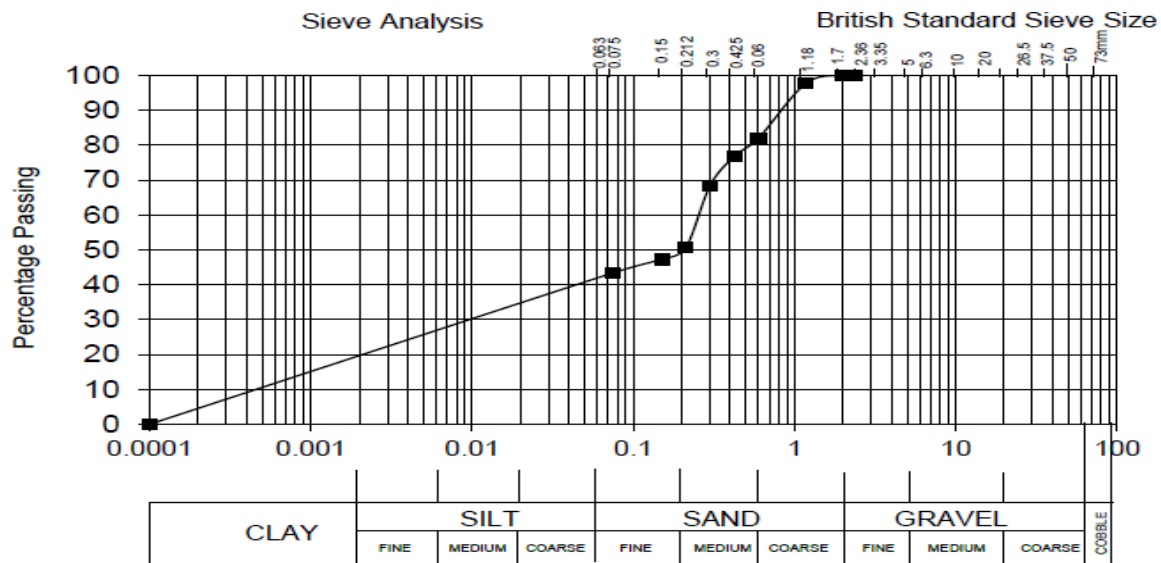


Figure 4.1: Sieve Analysis Graph of Soil Samples at Point 1

According to BS 1377: Part 2 (1990), the soil gradation can be determined by evaluating the coefficient of uniformity CU and coefficient of curvature CC through the equations 1.0 and 2.0 below. The average effective size of the soil, D_{10} , which is the corresponding particle size at 10% fine passing, was approximately evaluated from Figure 4.1 as 0.00045mm. Similarly, D_{30} and D_{60} were evaluated as 0.009mm and 0.25mm respectively.

$$u = \frac{D_{60}}{D_{10}} = \frac{0.25 \text{ mm}}{0.00045 \text{ mm}} = 555 \quad (1.0)$$

$$c = \frac{D_{30}^2}{D_{10} \times D_{60}} = \frac{0.009^2}{0.00045 \times 0.25 \text{ mm}^2} = 0.72 \quad (2.0)$$

The resulting CU value was greater than 6.0 which indicates that the soil does not contain uniform size particles. However, the CC value did not fall within the range of 1.0 and 3.0 which represents a well graded soil. Therefore, the soil samples at point 1 was evaluated to be poorly graded with some soil grain fractions either missing or in very small or excess quantity compared to the others (BS 1377: Part 2, 1990).

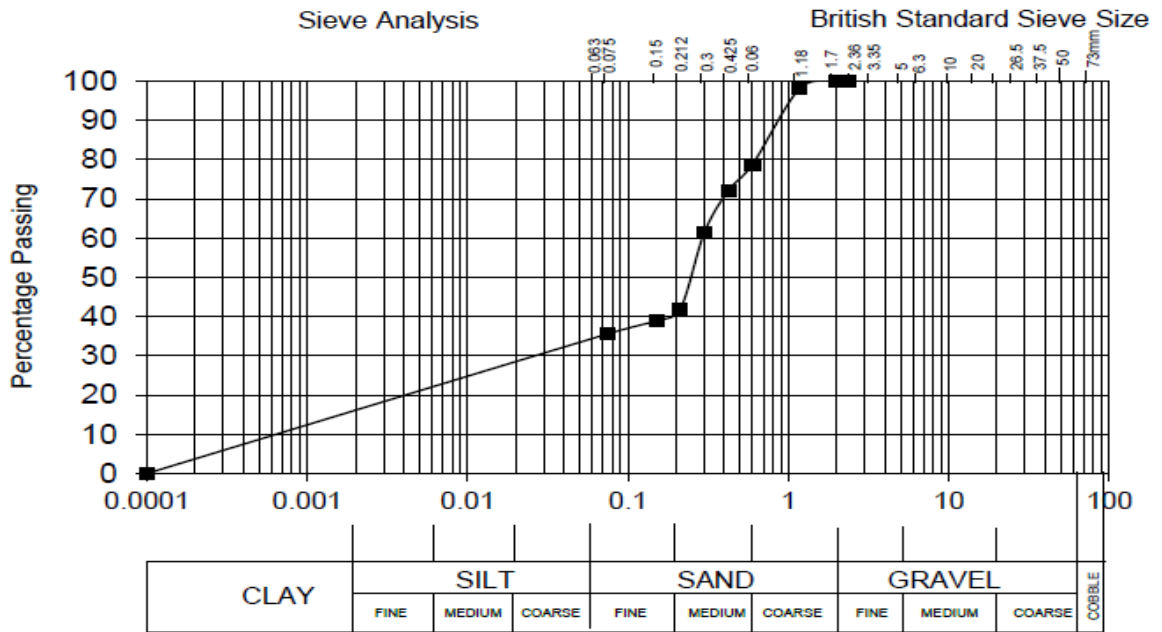


Figure 4.2: Sieve Analysis Graph of Soil Samples at Point 2

Similarly, from Figure 4.2, D10, D30 and D60 were evaluated as 0.0006, 0.025mm and 0.28mm respectively. The resulting CU and CC values were 467 and 3.72 respectively, which depicts a poorly graded soil with voids due to some missing intermediate soil particles.

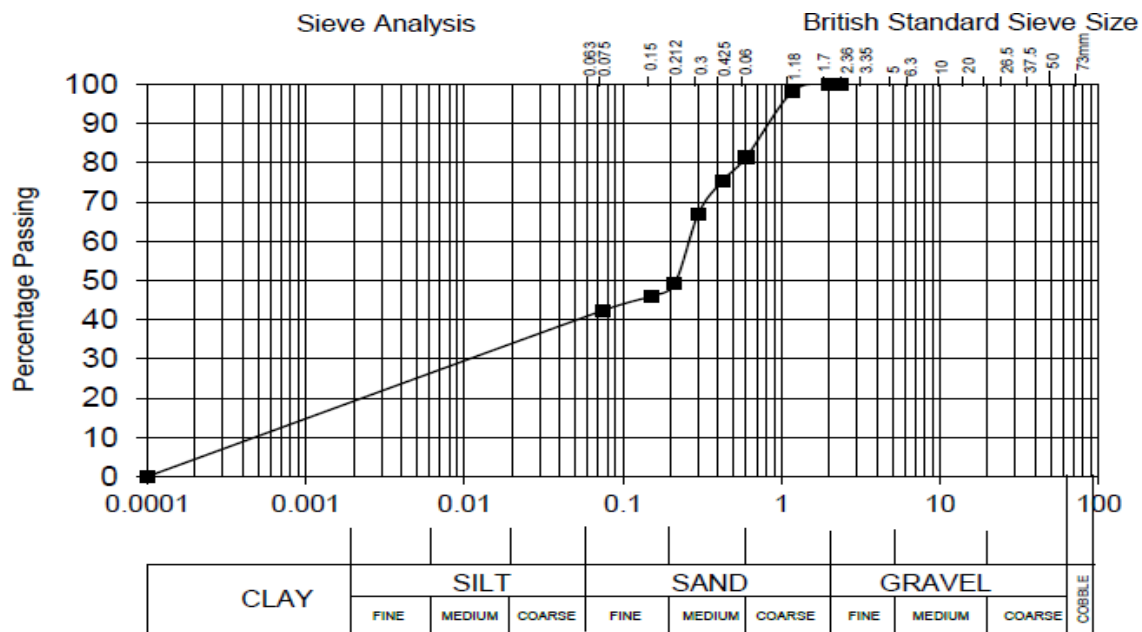


Figure 4.3: Sieve Analysis Graph of Soil Samples at Point 3

Figure 4.3 showed a D10, D30 and D60 of 0.00047, 0.01mm and 0.26mm respectively. The resulting CU and CC values were 553 and 0.82 respectively, which depicts a poorly graded soil with voids due to some missing intermediate soil particles.

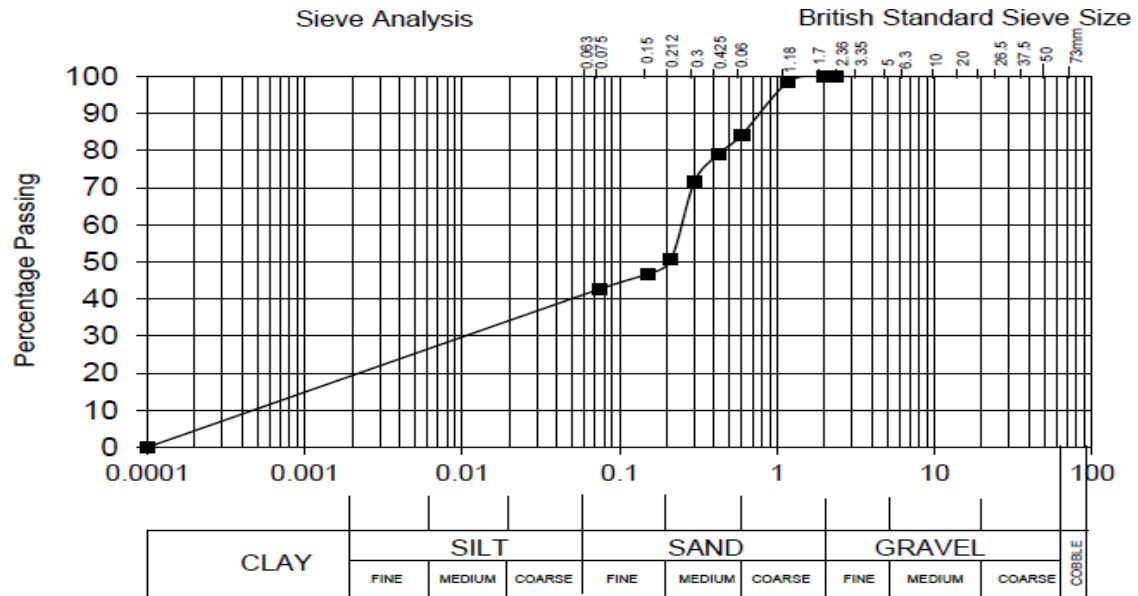


Figure 4.4: Sieve Analysis Graph of Soil Samples at Point 4

Figure 4.4 showed a D10, D30 and D60 of 0.00047, 0.01mm and 0.26mm respectively. The resulting CU and CC values were 553 and 0.82 respectively, which depicts a poorly graded soil with voids due to some missing intermediate soil particles.

4.1.3 Atterberg Limits

The Atterberg limits which showed the consistency of the fine grain in the soil composition based on the influenced of the soil water content was determined through the evaluation of the Liquid limit (LL) and Plastic limit (PL). Also, the soil plasticity was determined by evaluating the difference between the LL and PL to obtain the plasticity index.

The LL values at Point 1, Point 2, Point 3 and Point 4 respectively, were presented in Table

4.1 above as 50.38%, 39.66%, 50.59%, and 41.99%. While the PL values at Point 1, Point 2, Point 3 and Point 4 respectively, were 25.53%, 20.12%, 21.18%, and 41.99%. The PI were evaluated as 24.85%, 19.53%, 29.41%, and 21.22% for Point 1, Point 2, Point 3 and Point 4 respectively. According to the Unified Soil Classification System, the plasticity level of the soil samples based on their liquid limits and plasticity index is CH, CI, CH, and CI at point1, 2, 3, and 4 respectively. CI and CH represent soil with intermediate and high plasticity respectively (DD ENV 1997-2, 2000; Bowles, 2012). Also, they are very susceptible to a high level of compressibility (BS 1377: Part 2, 1990; AASHTO M145-91, 2012).

4.1.4 Compaction

The compaction test results of soil samples obtained at point 1, 2, 3, and 4 respectively, were obtained from the dry density versus average moisture content relationship of the B.S 2.5kg rammer compaction method as seen in Figure 4.5 below.

From the compaction graph below, the values of the Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) were 1.63g/cm³, 1.65g/cm³, 1.63g/cm³, 1.66g/cm³ and 15.7%, 14.8%, 15.9%, 14.8% for point 1, point 2, point 3 and point 4 respectively. The range of MDD, and OMC values depict an inorganic clayey soil (BS 1377: Part 2; Bowles, 2012)

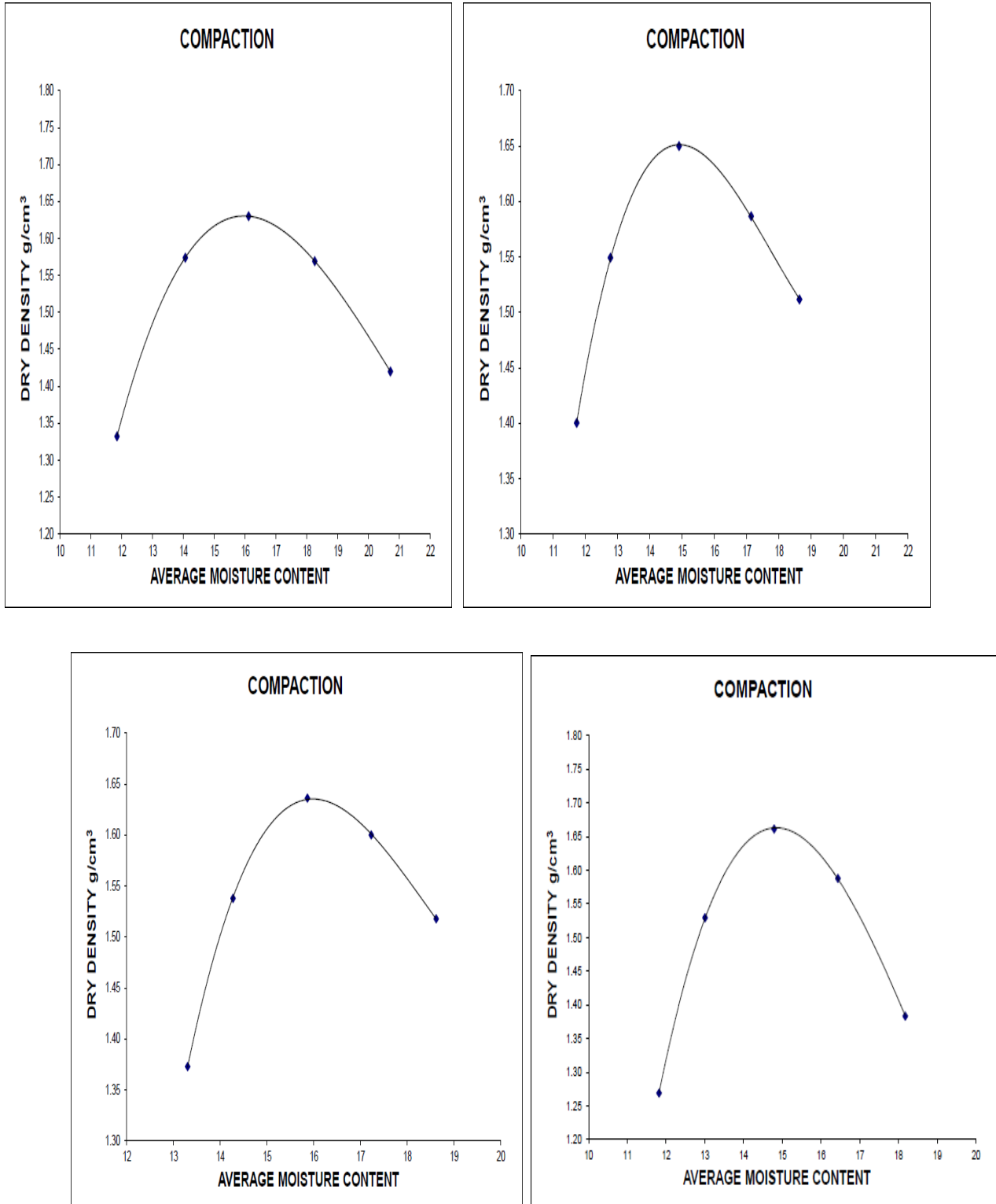


Figure 4.5: Compaction Graph of Soil Samples at Points 1, 2, 3, and 4

4.1.5 California Bearing Ratio Test

The California bearing ratio (CBR) is a standardized penetration test used to evaluate the mechanical strength of soil subgrades and base courses. The CBR of the soil samples at 2.5mm and 5.0mm penetration of the standard plunger in the soaked and unsoaked state, was evaluated through the given equations 3.0 and 4.0 below and the average CBR values were presented in table 4.1 above.

$$CBR_{2.5mm} = \frac{\text{Measured Load at 2.5mm Penetration}}{136 \text{ kN}} \times 100\% \quad (3.0)$$

$$CBR_{5.0mm} = \frac{\text{Measured Load at 5.0mm Penetration}}{205 \text{ kN}} \times 100\% \quad (4.0)$$

According to the Federal Ministry of Works and Housing, FMWH (2013), the critical CBR value for pavement design is the soaked CBR value and the minimum soaked CBR value for a good subgrade material is 5%. Soil samples from points 1, 2 and 4 had a soaked CBR values of 5.12%, 8.42% and 8.09% respectively, which do satisfy the FMWH minimum specification for a good subgrade. However, soil sample at points 3 had a CBR value of 0.99% which do not satisfy the FMWH specification of a subgrade material.

4.1.6 Shear Strength Parameters from U-U Triaxial Test

The U-U Triaxial test determines the maximum shearing resistance of the soil under pressure before failure occurs. Under the normal pressures of 100 kN/m^2 , 205 kN/m^2 and 310 kN/m^2 , the relationship between measured shear stress at failure and normal applied stress was obtained for soil samples at points 1, 2, 3, and 4 through the Mohr's circle graphs presented in Figure 4.6 below. The cohesion (c) and (ϕ) values were then taken as the intercept and slope of the straight-line graph respectively (BS 1377: Part 7, 1990).

At Point 1, the soil cohesion and angle of internal friction were 32.0 kN/m^2 and 5.45° respectively. Likewise, Points 2, 3, and 4 had a soil cohesion of 27.0 kN/m^2 , 31.0 kN/m^2 , and 32.0 kN/m^2 respectively; and angle of internal friction of 7.02° , 8.14° , and 6.49° respectively. This depicts a clayey soil with high clay content (BS 1377: Part 2; Bowles, 2012).

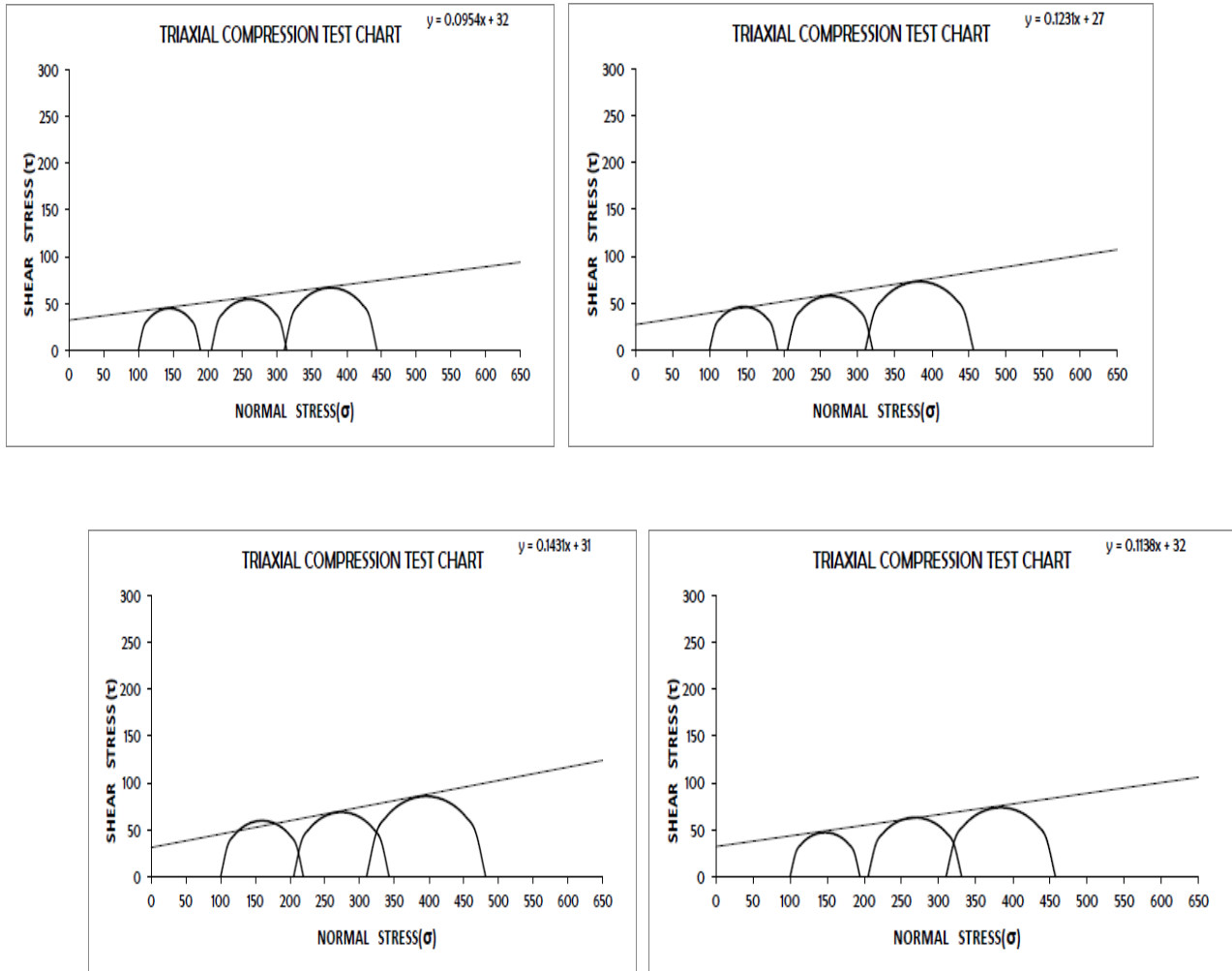


Figure 4.6: Triaxial Mohr's Circle Graphs of Soil Samples at Points 1, 2, 3, and 4

4.1.7 AASHTO Soil Classification System

The American Association of State Highway and Transportation Officials (AASHTO) soil classification is based on the particle size distribution, Liquid limit, and the Plasticity index of the soil. As seen in Figure 4.7 below, the soil samples at point 1, 3, and 4 were classified as A-7-6, while soil samples at point 2 was classified as A-6.

A-6 and A-7-6 soil class represent soils with significant constituent materials of clayey soil and more than 35 percent of the total soil sample passing BS sieve No. 200. They are generally rated as fair to poor subgrade materials.

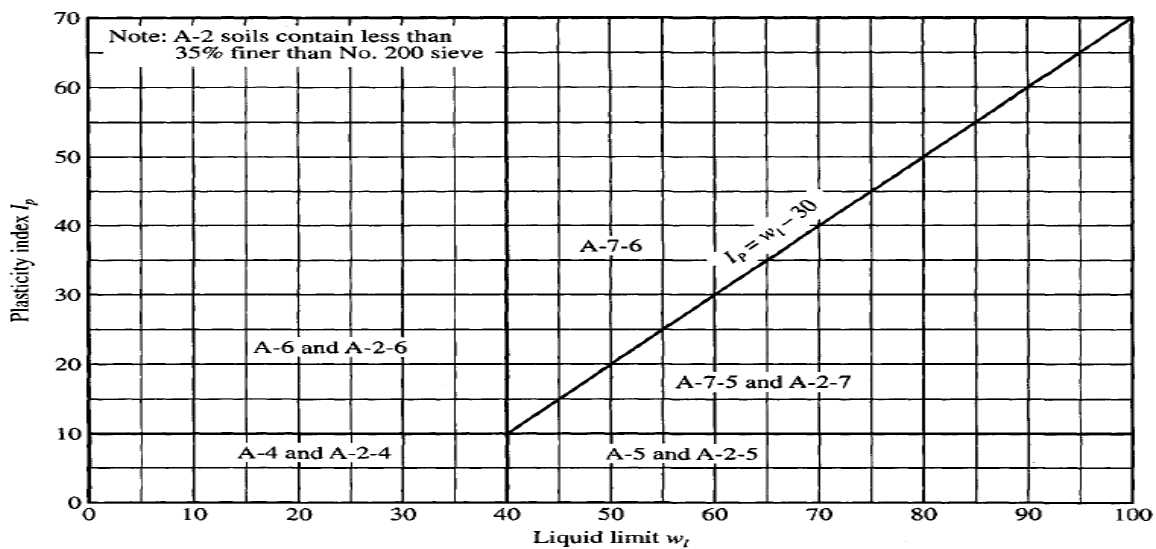


Figure 4.7: AASHTO Soil Classification

4.2 The Effect of Caustic Soda Stabilization on the Soil Properties

The effect of the caustic soda addition to the soil at a proportion of 2%, 4%, 6%, 8% and 10% respectively was determine by analysing the data variation in the soil liquid limit, plastic limit, plasticity index, maximum dry density (MDD), optimum moisture content (OMC), cohesion, angle of internal friction, and California bearing ratio. The Table 4.2 below present the summary of the Laboratory results on the stabilization, while more details can be found in the APPENDIXs.

Table 4.2 The Properties of a Caustic Soda Stabilized Soil.

S/N	ID	Atterberg Limits	2%	4%	6%	8%	10%
1	Point 1	Liquid limit (%)	39.19	37.60	35.57	32.62	25.44
2		Plastic limit (%)	20.48	19.44	18.15	15.72	11.47
3		Plasticity index (%)	18.71	18.16	17.42	16.90	13.97
4		OMC (%)	15.40	15.00	14.80	14.10	13.30
5		MDD (g/cm ³)	1.64	1.68	1.71	1.73	1.79
6		Cohesion (kN/m ²)	32.02	33.50	33.90	34.60	38.60
7		Angle of Friction (°)	5.00	4.57	4.32	4.01	3.75
8		Soaked CBR (%)	11.61	15.18	16.17	21.63	23.45
9	Point 2	Liquid limit (%)	38.43	35.37	31.29	27.31	25.49

S/N	ID	Atterberg Limits	2%	4%	6%	8%	10%
10		Plastic limit (%)	19.42	16.99	13.79	11.90	10.96
11		Plasticity index (%)	19.01	18.38	17.50	15.40	14.53
12		OMC (%)	14.70	14.60	14.50	14.30	13.80
14		MDD (g/cm ³)	1.66	1.67	1.74	1.76	1.77
15		Cohesion (kN/m ²)	27.60	29.50	31.40	31.88	32.00
16		Angle of Friction (°)	7.00	6.74	6.22	6.07	5.54
17		California Bearing Ratio (%)	12.33	14.50	17.65	21.00	22.99
18	Point 3	Liquid limit (%)	40.42	38.06	37.07	32.56	26.20
19		Plastic limit (%)	18.55	18.03	17.35	16.73	14.22
20		Plasticity index (%)	21.87	20.03	19.72	15.83	11.98
21		OMC (%)	13.10	12.90	12.50	11.40	11.20
22		MDD (g/cm ³)	1.69	1.72	1.73	1.76	1.80
23		Cohesion (kN/m ²)	32.41	32.99	34.00	35.60	38.04
24		Angle of Friction (°)	7.86	7.55	7.24	7.11	7.06
25		California Bearing Ratio (%)	12.99	15.60	19.00	23.50	26.00
26	Point 4	Liquid limit (%)	38.52	36.11	35.11	31.36	28.22
27		Plastic limit (%)	18.70	18.45	17.83	16.20	16.04
28		Plasticity index (%)	19.82	17.66	17.28	15.16	12.18
29		OMC (%)	12.60	12.50	12.20	11.20	10.30
30		MDD (g/cm ³)	1.67	1.68	1.69	1.71	1.79
31		Cohesion (kN/m ²)	32.90	35.11	37.10	37.56	37.86
32		Angle of Friction (°)	6.22	6.14	5.74	5.44	5.17
33		California Bearing Ratio (%)	10.68	13.28	15.69	18.34	20.50

The addition of the caustic soda to the soil to a maximum percentage of 10 reduced the liquid limit from 50.38% to 25.44% in soil samples at point 1; 39.66% to 25.49% in point 2; 50.59% to 26.20% in point 3; and 41.99% to 28.22% in point 4. Similarly, the plastic limit reduced from 25.53% to 11.47%, 20.12% to 10.96%, 21.18% to 14.22%, and 20.77% to 16.04% for soil samples at points 1, 2, 3, and 4 respectively. The plasticity index of the soil from

the four sampling points were decreased from their original values of 24.85%, 19.53%, 29.41% and 21.22% to 13.97%, 14.53%, 11.98% and 12.18% respectively at the addition of the 10% Caustic soda. These observations of a decreasing pattern in the Atterberg limits based on the addition of caustic soda to the soil was also confirmed by Zangana (2012).

The maximum dry density of the soil from the four sampling points were increased from their original values of 1.63 g/cm³, 1.65 g/cm³, 1.63 g/cm³, 1.66 g/cm³ to 1.79 g/cm³, 1.77 g/cm³, 1.80 g/cm³, and 1.79 g/cm³ respectively at the addition of the 10% caustic soda. While the optimum moisture content decreased from their original values of 15.7%, 14.8%, 15.9%, and 14.8% to 13.30%, 13.80%, 11.20%, and 10.30% for soil in points 1, 2, 3, and 4 respectively. These observations of an increasing and decreasing pattern in the MDD and OMC respectively, based on the addition of caustic soda to a soil was also confirmed by Zangana (2012).

The addition of the caustic soda to a maximum percentage of 10 decreased the angle of internal friction from their original values of 5.45°, 7.02°, 8.14°, and 6.49° to 3.75°, 5.54°, 7.06°, and 5.17° for soil in points 1, 2, 3, and 4 respectively. While caustic soda stabilization to a maximum percentage of 10 increased the cohesion from their original values of 32.0 kN/m², 27.0 kN/m², 31.0 kN/m², and 32.0 kN/m² to 38.60 kN/m², 32.00 kN/m², 38.04 kN/m², and 37.86 kN/m² for soil in points 1, 2, 3, and 4 respectively. Similarly, an increase in the California bearing ratio values was observed both in the unsoaked and soaked state at all sampling points. Comparing the soaked CBR values at 10% caustic soda stabilization of 23.45%, 22.99%, 26.00%, and 20.50% for soil in points 1, 2, 3, and 4 respectively as seen in Table 4.2 above, with the general specifications of sub-grade materials for roads by the Federal Ministry of Works (FMWH, 2013), which stated that soil with CBR soaked values greater than five percent (5%) are suitable subgrade material for road pavement; the soil in all investigated areas are therefore fit as a good subgrade material.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The study was focused on the improvement of erosion susceptible soil at Ekosodin, Benin City with caustic soda stabilization. This aim was achieved by collecting four soil samples collected from the study area, analysing the soil index and engineering properties, and reporting the effect of the caustic soda on its geotechnical properties.

The soil, based on its index and engineering properties, was categorized as A-6 and A-7-6 class soil. The usual types of significant constituent materials in an A-6 and A-7-6 soil class are Clayey soil which have more than 35% fine passing BS sieve No 200, with fair to poor subgrade rating in pavement design and a significant level of plasticity.

The addition of caustic soda was analysed to a maximum percentage of 10 on the Soil Atterberg limits, a reduction was observed in the liquid limit from 50.38% to 25.44% in soil samples at point 1; 39.66% to 25.49% in point 2; 50.59% to 26.20% in point 3; and 41.99% to 28.22% in point 4. Similarly, the plastic limit reduced from 25.53% to 11.47%, 20.12% to 10.96%, 21.18% to 14.22%, and 20.77% to 16.04% for soil samples at points 1, 2, 3, and 4 respectively. The plasticity index of the soil from the four sampling points were decreased from their original values of 24.85%, 19.53%, 29.41% and 21.22% to 13.97%, 14.53%, 11.98% and 12.18% respectively at the addition of the 10% Caustic soda.

The effect of caustic soda addition on the soil compaction parameters (maximum dry density and optimum moisture content) were also analysed. The maximum dry density of the soil from the four sampling points were increased from their original values of 1.63 g/cm³, 1.65 g/cm³, 1.63 g/cm³,

1.66 g/cm³ to 1.79 g/cm³, 1.77 g/cm³, 1.80 g/cm³, and 1.79 g/cm³ respectively at the addition of the 10% caustic soda. While the optimum moisture content decreased from their original values of 15.7%, 14.8%, 15.9%, and 14.8% to 13.30%, 13.80%, 11.20%, and 10.30% for soil in points 1, 2, 3, and 4 respectively.

The addition of the caustic soda to a maximum percentage of 10 decreased the angle of internal friction from their original values of 5.45°, 7.02°, 8.14°, and 6.49° to 3.75°, 5.54°, 7.06°, and 5.17° for soil in points 1, 2, 3, and 4 respectively. While caustic soda stabilization

to a maximum percentage of 10 increased the cohesion from their original values of 32.0 kN/m², 27.0 kN/m², 31.0 kN/m², and 32.0 kN/m² to 38.60 kN/m², 32.00 kN/m², 38.04 kN/m², and 37.86 kN/m² for soil in points 1, 2, 3, and 4 respectively. Similarly, an increase in the California bearing ratio values was observed both in the unsoaked and soaked state at all sampling points. Comparing the soaked CBR values at 10% caustic soda stabilization of 23.45%, 22.99%, 26.00%, and 20.50% for soil in points 1, 2, 3, and 4, with the general FMWH specifications of sub-grade materials for roads design, which stated that soil with CBR soaked values greater than five percent (5%) are suitable subgrade material for road pavement; the soil in all investigated areas is therefore fit as a good subgrade material.

5.2 Recommendation

From the investigation, the addition of caustic soda stabilization on erosion susceptible soil at Ekosodin improved the load bearing and subgrade capacity of the soil for building and road construction. Therefore, the chemical stabilization of caustic soda is recommended for erosion susceptible soil and as further research application at other study areas.

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APPENDIX

APPENDIX A

PLATE A - 1



SIEVING SOIL SAMPLE

PLATE A - 2



WEIGHING OF COMPACTED SOIL

PLATE A - 3



ALTERBERG LIMIT TEST

PLATE A - 4



ALTERBERG LIMIT TEST

PLATE A - 5



SIEVE ANALYSIS

PLATE A – 6



SIEVE ANALYSIS

PLATE A - 7



C.B.R TEST

PLATE A - 8



C.B.R CPMPACTION WIT CAUTIC SODA

PLATE A - 9



COLLECTION OF SOIL SAMPLE FROM SITE

PLATE A - 10:



COLLECTION OF SOIL SAMPLE FROM SITE

PLATE A - 11



COLLECTION OF SOIL SAMPLE FROM THE SITE

PLATE A - 12



COLLECTION OF SOIL SAMPLE FROM SITE

APPENDICE B

Table B - 1

LIQUID AND PLASTIC LIMITS, LINEAR SHRINKAGE

Sample No.: **POINT 1 (2% Caustic Soda Stabilization)** Liquid Limit: **39.19%** Plastic Limit: **20.48%**

Date: **19/08/2023**

Plastic Index: **18.71%**

Student: **SAMUEL UCHE UBAH**

Liquid limit marked L.L. plastic limit marked P.L.

Type of Test	LL		LL		LL		LL		LL	
No. of Blows/shrinkage %	43.00		33.00		23.00		17.00		11.00	
Container No.	ZH		TA		NO		BO		ZZ	
Wt of wet soil & container (g)	31.20		37.00		48.80		53.10		57.10	
Wt of dried soil & container (g)	27.90		31.80		40.10		42.70		44.90	
Wt of container (g)	17.70		17.40		18.20		18.10		17.60	
Wt of dry soil (Wd) (g)	10.20		14.40		21.90		24.60		27.30	
Wt of moisture (Wm) (g)	3.30		5.20		8.70		10.40		12.20	
Moisture content 100 (Wm/Wd)	32.35		36.11		39.73		42.28		44.69	
Type of Test		PL		PL		PL				
No. of Blows/shrinkage %										
Container No.		OZ		RT		JA				
Wt of wet soil & container (g)		22.20		23.00		22.10				
Wt of dried soil & container (g)		21.40		22.10		21.40				
Wt of container (g)		17.60		17.80		17.80				
Wt of dry soil (Wd) (g)		3.80		4.30		3.60				
Wt of moisture (Wm) (g)		0.80		0.90		0.70				
Moisture content 100 (Wm/Wd)		21.05		20.93		19.44				

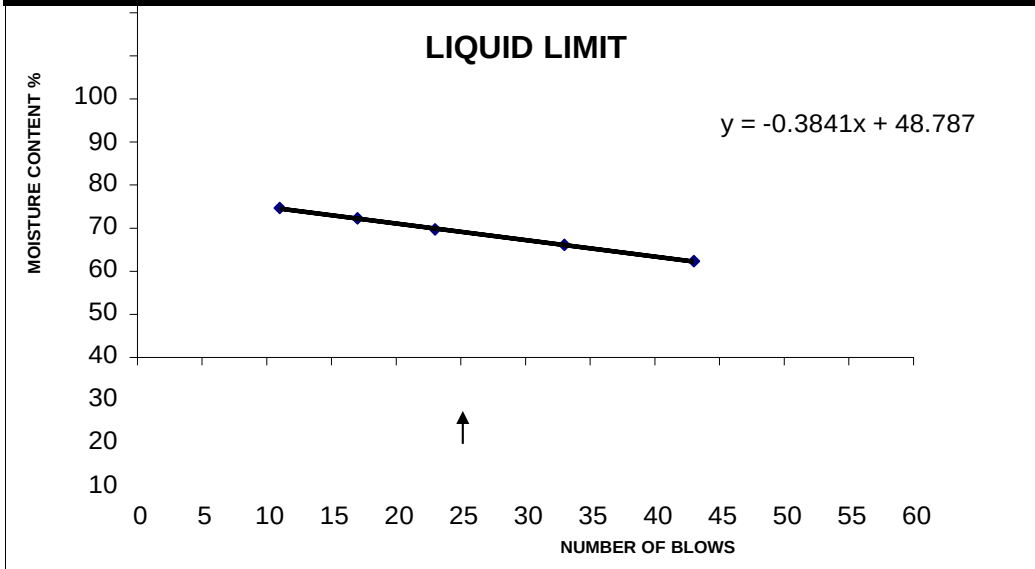


Table B - 2**LIQUID AND PLASTIC LIMITS, LINEAR SHRINKAGE**Sample No.: **POINT 1 (4% Caustic Soda Stabilization)** Liquid Limit: **37.60%** Plastic Limit: **19.44%**Date: **19/08/2023**Plastic Index: **18.16%**Student: **SAMUEL UCHE UBAH**

Liquid limit marked L.L. plastic limit marked P.L.

Type of Test	LL		LL		LL		LL		LL	
No. of Blows/shrinkage %	45.00		34.00		25.00		18.00		14.00	
Container No.	OH		PA		JA		OB		MZ	
Wt of wet soil & container (g)	36.80		35.83		32.66		34.65		28.32	
Wt of dried soil & container (g)	32.20		31.10		28.50		29.90		24.50	
Wt of container (g)	17.16		17.22		17.38		18.04		15.38	
Wt of dry soil (Wd) (g)	15.04		13.88		11.12		11.86		9.12	
Wt of moisture (Wm) (g)	4.60		4.73		4.16		4.75		3.82	
Moisture contain 100 (Wm/Wd)	30.59		34.08		37.41		40.05		41.89	
Type of Test		PL		PL		PL				
No. of Blows/shrinkage %										
Container No.		OS		NO		AS				
Wt of wet soil & container (g)		25.23		25.13		30.22				
Wt of dried soil & container (g)		24.40		24.00		28.80				
Wt of container (g)		20.05		18.36		21.40				
Wt of dry soil (Wd) (g)		4.35		5.64		7.40				
Wt of moisture (Wm) (g)		0.83		1.13		1.42				
Moisture contain 100 (Wm/Wd)		19.08		20.04		19.19				

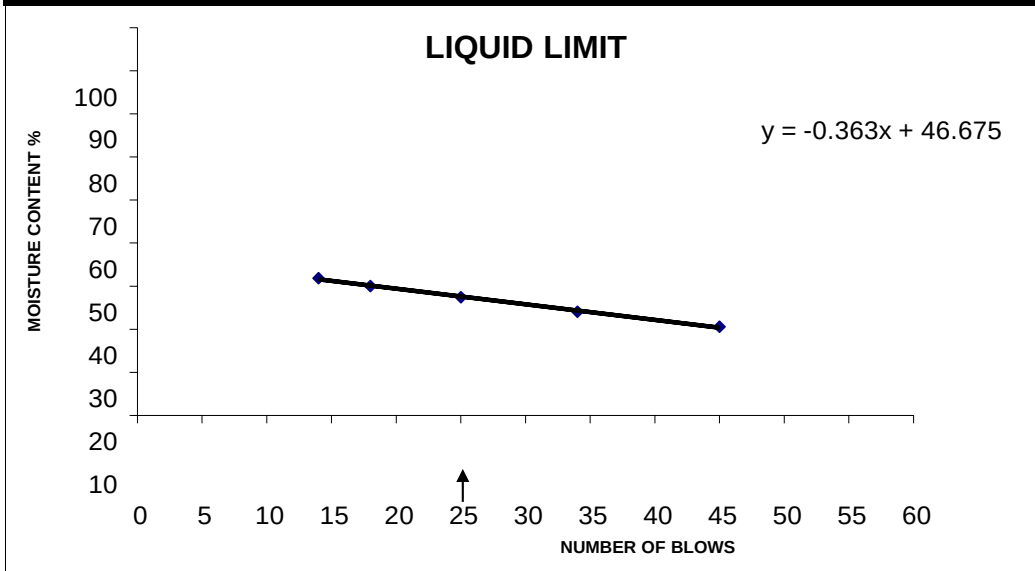


Table B - 3

LIQUID AND PLASTIC LIMITS, LINEAR SHRINKAGESample No.: **POINT 1 (6% Caustic Soda Stabilization)** Liquid Limit: **35.57%** Plastic Limit: **18.15%**Date: **19/08/2023**Plastic Index: **17.42%**Student: **SAMUEL UCHE UBAH**

Liquid limit marked L.L. plastic limit marked P.L.

Type of Test	LL		LL		LL		LL		LL	
No. of Blows/shrinkage %	45.00		31.00		24.00		18.00		13.00	
Container No.	RT		NP		OO		RZ		OB	
Wt of wet soil & container (g)	34.27		32.06		35.32		33.36		35.33	
Wt of dried soil & container (g)	29.90		27.40		30.70		28.80		30.40	
Wt of container (g)	16.73		13.91		17.78		16.27		17.15	
Wt of dry soil (Wd) (g)	13.17		13.49		12.92		12.53		13.25	
Wt of moisture (Wm) (g)	4.37		4.66		4.62		4.56		4.93	
Moisture content 100 (Wm/Wd)	33.18		34.54		35.76		36.39		37.21	
Type of Test		PL		PL		PL				
No. of Blows/shrinkage %										
Container No.		OB		TO		PO				
Wt of wet soil & container (g)		26.33		24.54		24.75				
Wt of dried soil & container (g)		25.00		23.50		23.50				
Wt of container (g)		17.77		17.70		16.60				
Wt of dry soil (Wd) (g)		7.23		5.80		6.90				
Wt of moisture (Wm) (g)		1.33		1.04		1.25				
Moisture content 100 (Wm/Wd)		18.40		17.93		18.12				

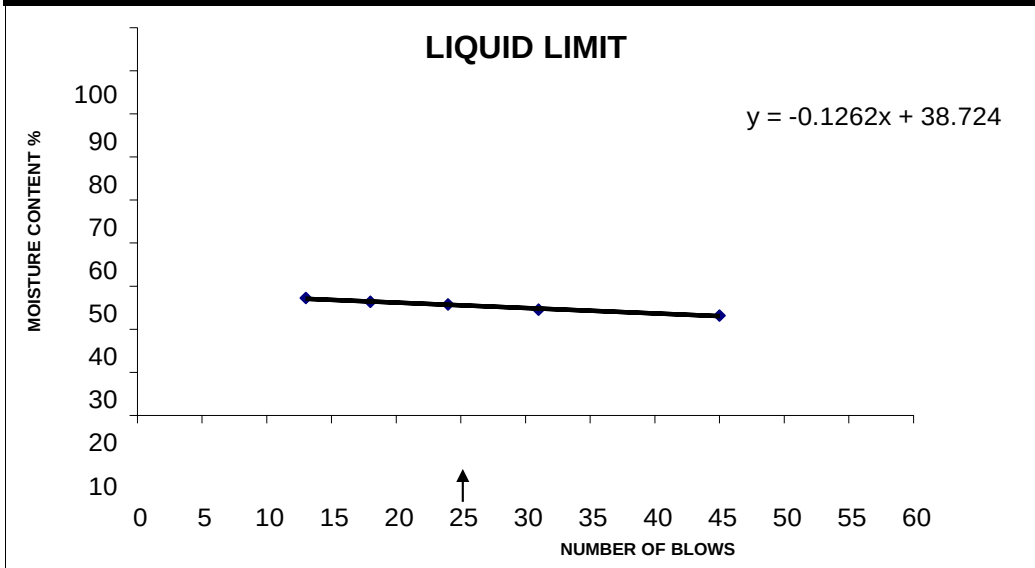


Table B - 4

LIQUID AND PLASTIC LIMITS, LINEAR SHRINKAGE

Sample No.: **POINT 1 (8% Caustic Soda Stabilization)** Liquid Limit: **32.62%** Plastic Limit: **15.72%**

Date: **19/08/2023**

Plastic Index: **16.90%**

Student: **SAMUEL UCHE UBAH**

Liquid limit marked L.L. plastic limit marked P.L.

Type of Test	LL		LL		LL		LL		LL	
No. of Blows/shrinkage %	48.00		36.00		26.00		19.00		13.00	
Container No.	JA		EM		UU		FU		IY	
Wt of wet soil & container (g)	33.07		36.73		37.00		32.81		33.47	
Wt of dried soil & container (g)	28.90		32.50		32.80		28.60		29.40	
Wt of container (g)	14.72		18.58		19.79		15.97		17.77	
Wt of dry soil (Wd) (g)	14.18		13.92		13.01		12.63		11.63	
Wt of moisture (Wm) (g)	4.17		4.23		4.20		4.21		4.07	
Moisture content 100 (Wm/Wd)	29.41		30.39		32.28		33.33		35.00	
Type of Test		PL		PL		PL				
No. of Blows/shrinkage %										
Container No.		AY		DR		BB				
Wt of wet soil & container (g)		21.51		25.53		25.72				
Wt of dried soil & container (g)		20.50		24.50		24.70				
Wt of container (g)		13.81		18.20		18.21				
Wt of dry soil (Wd) (g)		6.69		6.30		6.49				
Wt of moisture (Wm) (g)		1.01		1.03		1.02				
Moisture content 100 (Wm/Wd)		15.10		16.35		15.72				

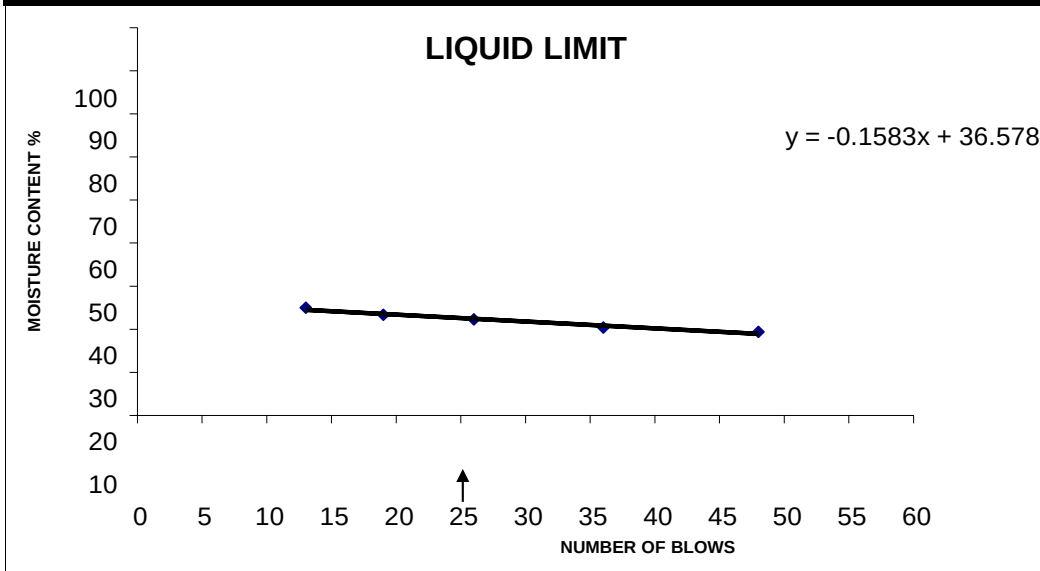


Table B - 5

LIQUID AND PLASTIC LIMITS, LINEAR SHRINKAGE

Sample No.: **POINT 1 (10% Caustic Soda Stabilization)** Liquid Limit: **25.44%** Plastic Limit: **11.47%**Date: **19/08/2023**Plastic Index: **13.97%**Student: **SAMUEL UCHE UBAH**

Liquid limit marked L.L. plastic limit marked P.L.

Type of Test	LL		LL		LL		LL		LL	
No. of Blows/shrinkage %	45.00		36.00		26.00		19.00		13.00	
Container No.	NO		AB		RT		JA		TH	
Wt of wet soil & container (g)	38.70		44.70		46.30		48.20		65.00	
Wt of dried soil & container (g)	35.40		39.50		40.50		40.70		54.30	
Wt of container (g)	20.30		17.30		17.60		12.40		15.50	
Wt of dry soil (Wd) (g)	15.10		22.20		22.90		28.30		38.80	
Wt of moisture (Wm) (g)	3.30		5.20		5.80		7.50		10.70	
Moisture content 100 (Wm/Wd)	21.85		23.42		25.33		26.50		27.58	
Type of Test		PL		PL		PL				
No. of Blows/shrinkage %										
Container No.		OH		IX		AB				
Wt of wet soil & container (g)		20.40		22.50		23.70				
Wt of dried soil & container (g)		19.90		22.00		23.20				
Wt of container (g)		15.70		17.70		18.60				
Wt of dry soil (Wd) (g)		4.20		4.30		4.60				
Wt of moisture (Wm) (g)		0.50		0.50		0.50				
Moisture content 100 (Wm/Wd)		11.90		11.63		10.87				

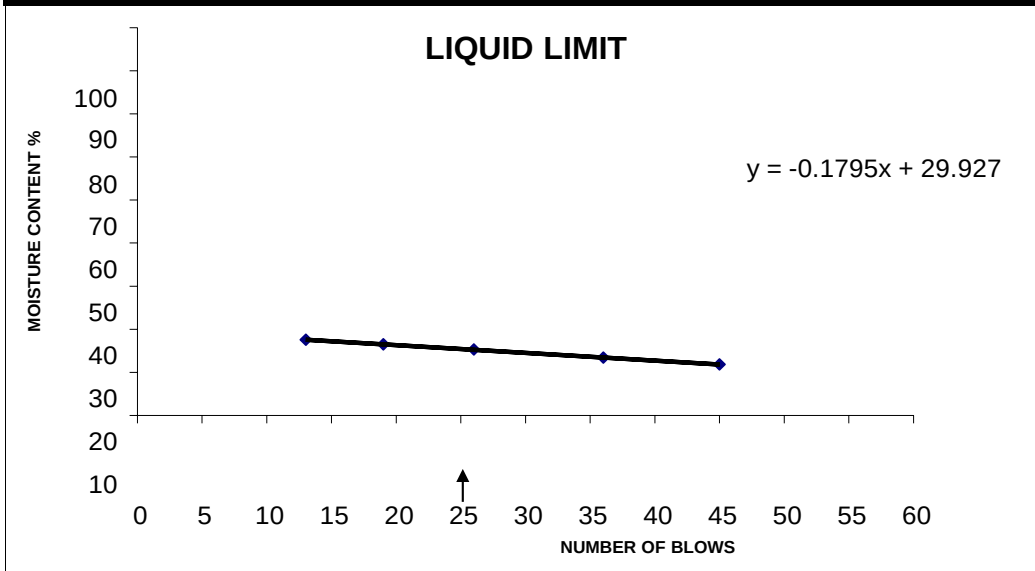


Table B - 6

LIQUID AND PLASTIC LIMITS, LINEAR SHRINKAGE

Sample No.: **POINT 1**Liquid Limit: **50.38%**Plastic Limit: **25.53%**Date: **19/08/2023**Plastic Index: **24.85%**Student: **SAMUEL UCHE UBAH**

Liquid limit marked L.L. plastic limit marked P.L.

Type of Test	LL		LL		LL		LL		LL	
No. of Blows/shrinkage %	42.00		32.00		28.00		18.00		12.00	
Container No.	OZ		LA		RT		TA		PA	
Wt of wet soil & container (g)	26.50		33.10		43.80		48.90		53.30	
Wt of dried soil & container (g)	23.70		28.10		35.10		37.90		40.40	
Wt of container (g)	17.20		17.50		17.60		17.30		17.20	
Wt of dry soil (Wd) (g)	6.50		10.60		17.50		20.60		23.20	
Wt of moisture (Wm) (g)	2.80		5.00		8.70		11.00		12.90	
Moisture content 100 (Wm/Wd)	43.08		47.17		49.71		53.40		55.60	
Type of Test		PL		PL		PL				
No. of Blows/shrinkage %										
Container No.		OB		YA		BB				
Wt of wet soil & container (g)		25.60		25.10		25.30				
Wt of dried soil & container (g)		24.00		23.50		23.70				
Wt of container (g)		17.80		17.20		17.40				
Wt of dry soil (Wd) (g)		6.20		6.30		6.30				
Wt of moisture (Wm) (g)		1.60		1.60		1.60				
Moisture content 100 (Wm/Wd)		25.81		25.40		25.40				

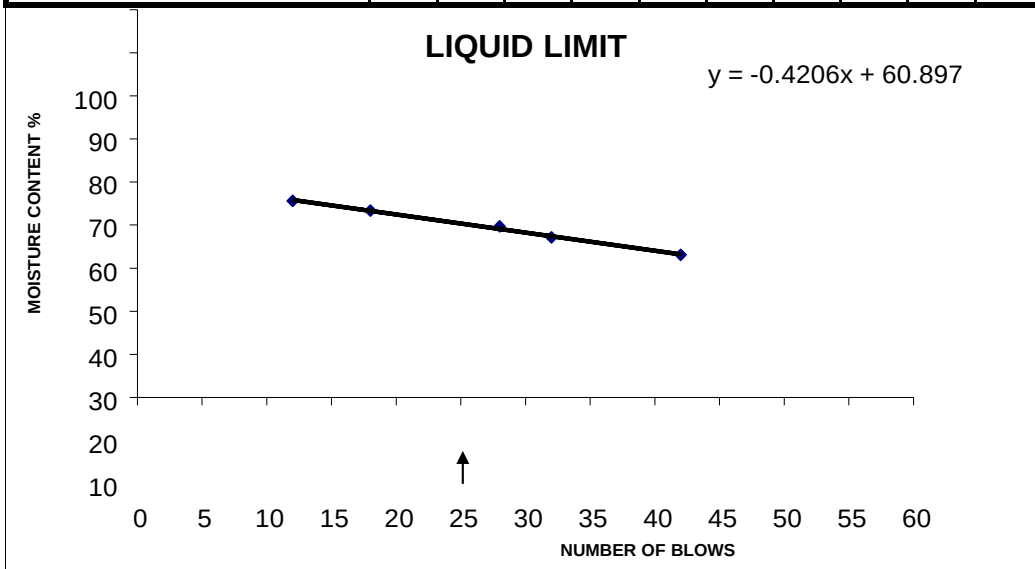


Table B - 7

LIQUID AND PLASTIC LIMITS, LINEAR SHRINKAGE

Sample No.: **POINT 2 (2% Caustic Soda Stabilization)** Liquid Limit: **38.43%** Plastic Limit: **19.42%**

Date: **19/08/2023**

Plastic Index: **19.01%**

Student: **SAMUEL UCHE UBAH**

Liquid limit marked L.L. plastic limit marked P.L.

Type of Test	LL		LL		LL		LL		LL	
No. of Blows/shrinkage %	47.00		35.00		23.00		17.00		12.00	
Container No.	TB		PO		HZ		OZ		VO	
Wt of wet soil & container (g)	33.39		32.89		36.17		33.15		28.47	
Wt of dried soil & container (g)	29.50		28.10		31.20		28.50		24.80	
Wt of container (g)	17.25		14.34		18.48		17.13		16.22	
Wt of dry soil (Wd) (g)	12.25		13.76		12.72		11.37		8.58	
Wt of moisture (Wm) (g)	3.89		4.79		4.97		4.65		3.67	
Moisture contain 100 (Wm/Wd)	31.76		34.81		39.07		40.90		42.77	
Type of Test		PL		PL		PL				
No. of Blows/shrinkage %										
Container No.		BO		EK		U				
Wt of wet soil & container (g)		32.84		24.88		26.45				
Wt of dried soil & container (g)		31.00		23.70		24.90				
Wt of container (g)		21.46		17.48		17.15				
Wt of dry soil (Wd) (g)		9.54		6.22		7.75				
Wt of moisture (Wm) (g)		1.84		1.18		1.55				
Moisture contain 100 (Wm/Wd)		19.29		18.97		20.00				

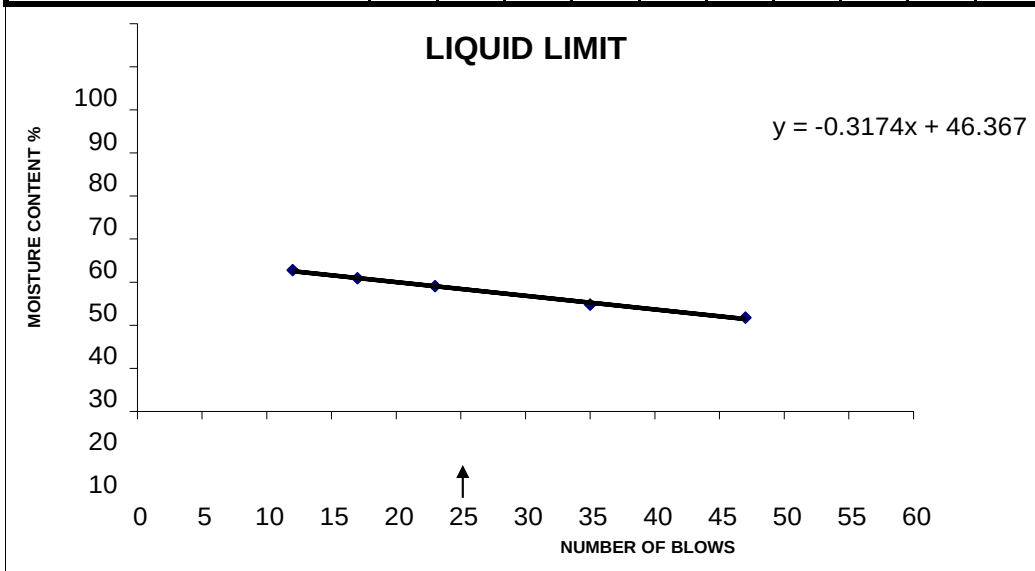


Table B - 8

LIQUID AND PLASTIC LIMITS, LINEAR SHRINKAGE

Sample No.: POINT 2 (4% Caustic Soda Stabilization) Liquid Limit: 35.37% Plastic Limit: 16.99%

Date: 19/08/2023

Plastic Index: 18.38%

Student: SAMUEL UCHE UBAH

Liquid limit marked L.L. plastic limit marked P.L.

Type of Test	LL		LL		LL		LL		LL	
No. of Blows/shrinkage %	45.00		35.00		26.00		18.00		12.00	
Container No.	ET		OH		LO		OB		ZH	
Wt of wet soil & container (g)	30.20		35.20		42.10		48.70		56.20	
Wt of dried soil & container (g)	27.30		31.10		36.00		40.10		45.40	
Wt of container (g)	17.50		18.50		18.50		17.20		17.80	
Wt of dry soil (Wd) (g)	9.80		12.60		17.50		22.90		27.60	
Wt of moisture (Wm) (g)	2.90		4.10		6.10		8.60		10.80	
Moisture contain 100 (Wm/Wd)	29.59		32.54		34.86		37.55		39.13	
Type of Test		PL		PL		PL				
No. of Blows/shrinkage %										
Container No.		WO		VI		BO				
Wt of wet soil & container (g)		22.60		22.50		23.40				
Wt of dried soil & container (g)		21.70		21.60		22.70				
Wt of container (g)		16.30		16.50		18.50				
Wt of dry soil (Wd) (g)		5.40		5.10		4.20				
Wt of moisture (Wm) (g)		0.90		0.90		0.70				
Moisture contain 100 (Wm/Wd)		16.67		17.65		16.67				

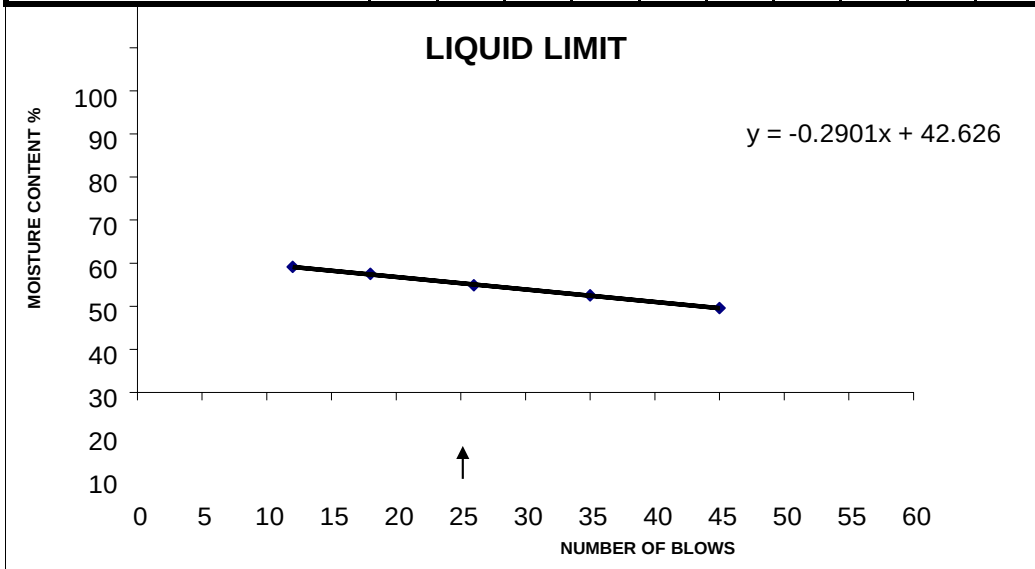


Table B - 9

LIQUID AND PLASTIC LIMITS, LINEAR SHRINKAGE

Sample No.: **POINT 2 (6% Caustic Soda Stabilization)** Liquid Limit: **31.29%** Plastic Limit: **13.79%**Date: **19/08/2023**Plastic Index: **17.50%**Student: **SAMUEL UCHE UBAH**

Liquid limit marked L.L. plastic limit marked P.L.

Type of Test	LL		LL		LL		LL		LL
No. of Blows/shrinkage %	47.00		37.00		27.00		19.00		13.00
Container No.	BZ		PA		QQ		FL		UT
Wt of wet soil & container (g)	36.17		37.01		33.99		31.37		35.30
Wt of dried soil & container (g)	32.40		32.50		29.50		27.50		31.40
Wt of container (g)	17.41		17.14		15.06		15.59		19.92
Wt of dry soil (Wd) (g)	14.99		15.36		14.44		11.91		11.48
Wt of moisture (Wm) (g)	3.77		4.51		4.49		3.87		3.90
Moisture contain 100 (Wm/Wd)	25.15		29.36		31.09		32.49		33.97
Type of Test		PL		PL		PL			
No. of Blows/shrinkage %									
Container No.		OB		OG		IZ			
Wt of wet soil & container (g)		22.76		29.24		30.71			
Wt of dried soil & container (g)		21.90		28.00		29.40			
Wt of container (g)		15.74		19.10		19.67			
Wt of dry soil (Wd) (g)		6.16		8.90		9.73			
Wt of moisture (Wm) (g)		0.86		1.24		1.31			
Moisture contain 100 (Wm/Wd)		13.96		13.93		13.46			

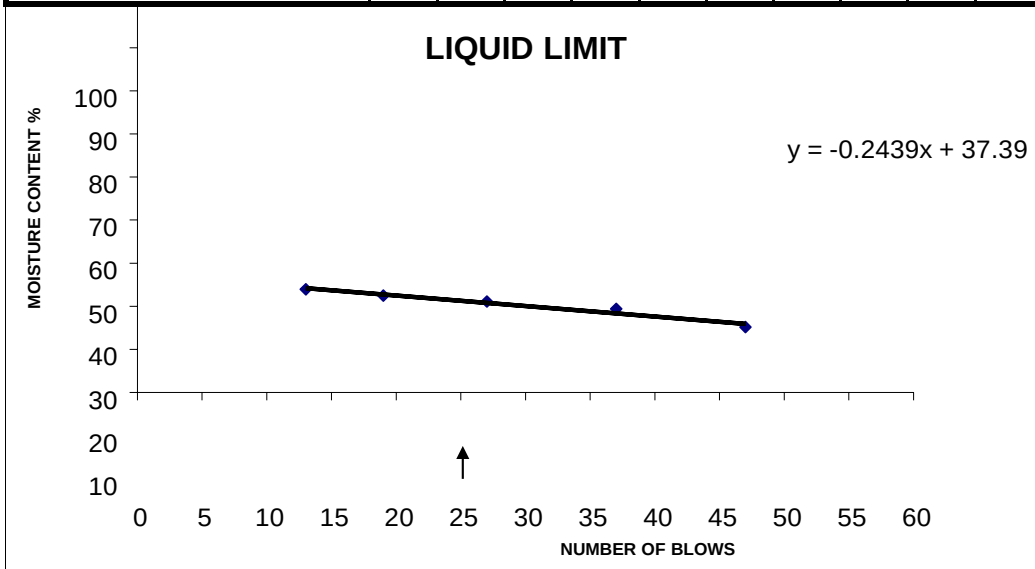


Table B - 10

LIQUID AND PLASTIC LIMITS, LINEAR SHRINKAGE

Sample No.: **POINT 2 (8% Caustic Soda Stabilization)** Liquid Limit: **27.31%** Plastic Limit: **11.90%**Date: **19/08/2023**Plastic Index: **15.40%**Student: **SAMUEL UCHE UBAH**

Liquid limit marked L.L. plastic limit marked P.L.

Type of Test	LL		LL		LL		LL		LL
No. of Blows/shrinkage %	43.00		35.00		23.00		16.00		11.00
Container No.	RT		LA		PA		IP		AE
Wt of wet soil & container (g)	51.80		31.20		35.50		41.60		47.40
Wt of dried soil & container (g)	45.00		28.40		31.70		36.30		41.00
Wt of container (g)	17.60		17.40		17.70		17.40		18.90
Wt of dry soil (Wd) (g)	27.40		11.00		14.00		18.90		22.10
Wt of moisture (Wm) (g)	6.80		2.80		3.80		5.30		6.40
Moisture contain 100 (Wm/Wd)	24.82		25.45		27.14		28.04		28.96
Type of Test		PL		PL		PL			
No. of Blows/shrinkage %									
Container No.		PA		TA		DC			
Wt of wet soil & container (g)		25.10		23.60		24.40			
Wt of dried soil & container (g)		24.30		22.90		23.80			
Wt of container (g)		17.30		17.50		18.50			
Wt of dry soil (Wd) (g)		7.00		5.40		5.30			
Wt of moisture (Wm) (g)		0.80		0.70		0.60			
Moisture contain 100 (Wm/Wd)		11.43		12.96		11.32			

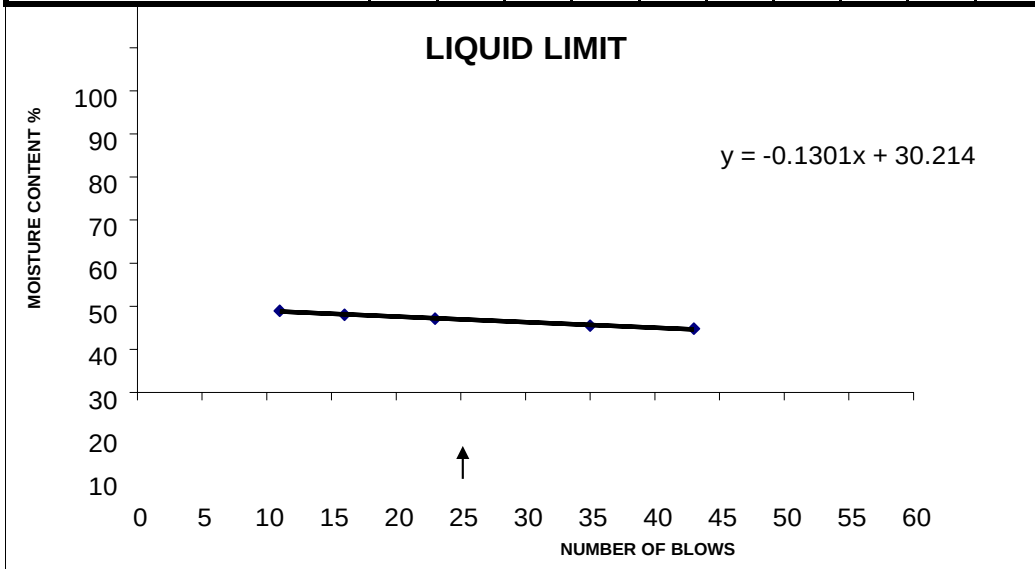


Table B - 11

LIQUID AND PLASTIC LIMITS, LINEAR SHRINKAGE

Sample No.: **POINT 2 (10% Caustic Soda Stabilization)** Liquid Limit: **25.49%** Plastic Limit: **10.96%**

Date: **19/08/2023**

Plastic Index: **14.53%**

Student: **SAMUEL UCHE UBAH**

Liquid limit marked L.L. plastic limit marked P.L.

Type of Test	LL		LL		LL		LL		LL	
No. of Blows/shrinkage %	45.00		35.00		24.00		19.00		14.00	
Container No.	OH		ET		PI		AI		AQ	
Wt of wet soil & container (g)	35.33		37.97		38.42		38.88		34.08	
Wt of dried soil & container (g)	32.00		34.20		34.30		35.00		31.00	
Wt of container (g)	15.71		17.81		18.22		20.43		20.26	
Wt of dry soil (Wd) (g)	16.29		16.39		16.08		14.57		10.74	
Wt of moisture (Wm) (g)	3.33		3.77		4.12		3.88		3.08	
Moisture contain 100 (Wm/Wd)	20.44		23.00		25.62		26.63		28.68	
Type of Test		PL		PL		PL				
No. of Blows/shrinkage %										
Container No.		OH		PP		GI				
Wt of wet soil & container (g)		27.31		32.14		31.29				
Wt of dried soil & container (g)		26.40		30.80		29.90				
Wt of container (g)		18.02		18.48		17.44				
Wt of dry soil (Wd) (g)		8.38		12.32		12.46				
Wt of moisture (Wm) (g)		0.91		1.34		1.39				
Moisture contain 100 (Wm/Wd)		10.86		10.88		11.16				

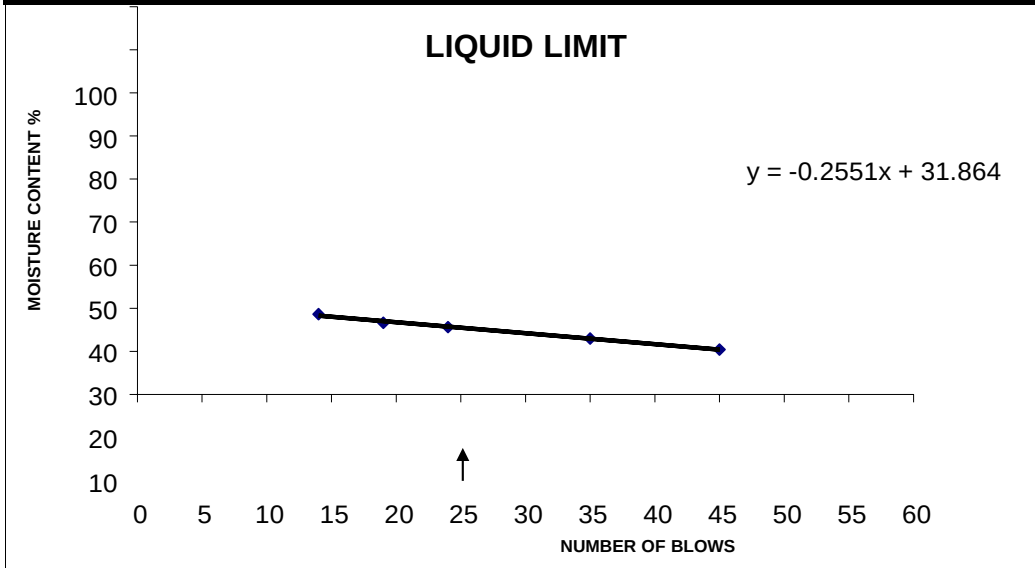


Table B - 12

LIQUID AND PLASTIC LIMITS, LINEAR SHRINKAGE

Sample No.: **POINT 2**Liquid Limit: **39.66%**Plastic Limit: **20.12%**Date: **19/08/2023**Plastic Index: **19.53%**Student: **SAMUEL UCHE UBAH**

Liquid limit marked L.L. plastic limit marked P.L.

Type of Test	LL		LL		LL		LL		LL	
No. of Blows/shrinkage %	50.00		34.00		22.00		16.00		10.00	
Container No.	RT		BM		NO		TA		OZ	
Wt of wet soil & container (g)	29.00		34.60		40.30		48.70		57.30	
Wt of dried soil & container (g)	25.90		30.10		34.20		39.70		45.40	
Wt of container (g)	17.40		18.40		18.90		17.40		17.20	
Wt of dry soil (Wd) (g)	8.50		11.70		15.30		22.30		28.20	
Wt of moisture (Wm) (g)	3.10		4.50		6.10		9.00		11.90	
Moisture content 100 (Wm/Wd)	36.47		38.46		39.87		40.36		42.20	
Type of Test		PL		PL		PL				
No. of Blows/shrinkage %										
Container No.		EN		EO		CX				
Wt of wet soil & container (g)		23.40		22.50		24.30				
Wt of dried soil & container (g)		22.60		21.40		23.30				
Wt of container (g)		18.60		16.00		18.30				
Wt of dry soil (Wd) (g)		4.00		5.40		5.00				
Wt of moisture (Wm) (g)		0.80		1.10		1.00				
Moisture content 100 (Wm/Wd)		20.00		20.37		20.00				

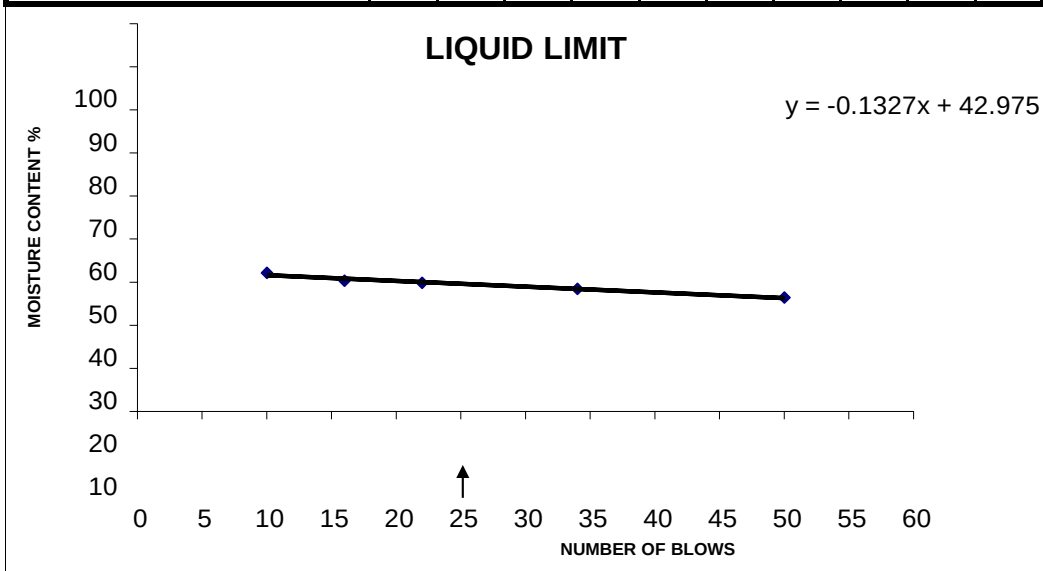


Table B - 13

LIQUID AND PLASTIC LIMITS, LINEAR SHRINKAGE

Sample No.: **POINT 3 (2% Caustic Soda Stabilization)** Liquid Limit: **40.42%** Plastic Limit: **18.55%**

Date: **19/08/2023**

Plastic Index: **21.87%**

Student: **SAMUEL UCHE UBAH**

Liquid limit marked L.L. plastic limit marked P.L.

Type of Test	LL		LL		LL		LL		LL	
No. of Blows/shrinkage %	44.00		36.00		24.00		18.00		12.00	
Container No.	GS		DR		JA		AC		XB	
Wt of wet soil & container (g)	35.40		42.60		55.50		52.20		59.70	
Wt of dried soil & container (g)	31.20		36.20		43.30		42.30		46.00	
Wt of container (g)	18.10		18.00		13.40		19.40		16.70	
Wt of dry soil (Wd) (g)	13.10		18.20		29.90		22.90		29.30	
Wt of moisture (Wm) (g)	4.20		6.40		12.20		9.90		13.70	
Moisture content 100 (Wm/Wd)	32.06		35.16		40.80		43.23		46.76	
Type of Test		PL		PL		PL				
No. of Blows/shrinkage %										
Container No.		JA		RZ		PP				
Wt of wet soil & container (g)		24.30		20.70		21.10				
Wt of dried soil & container (g)		23.20		19.90		20.63				
Wt of container (g)		17.10		15.70		18.10				
Wt of dry soil (Wd) (g)		6.10		4.20		2.53				
Wt of moisture (Wm) (g)		1.10		0.80		0.47				
Moisture content 100 (Wm/Wd)		18.03		19.05		18.58				

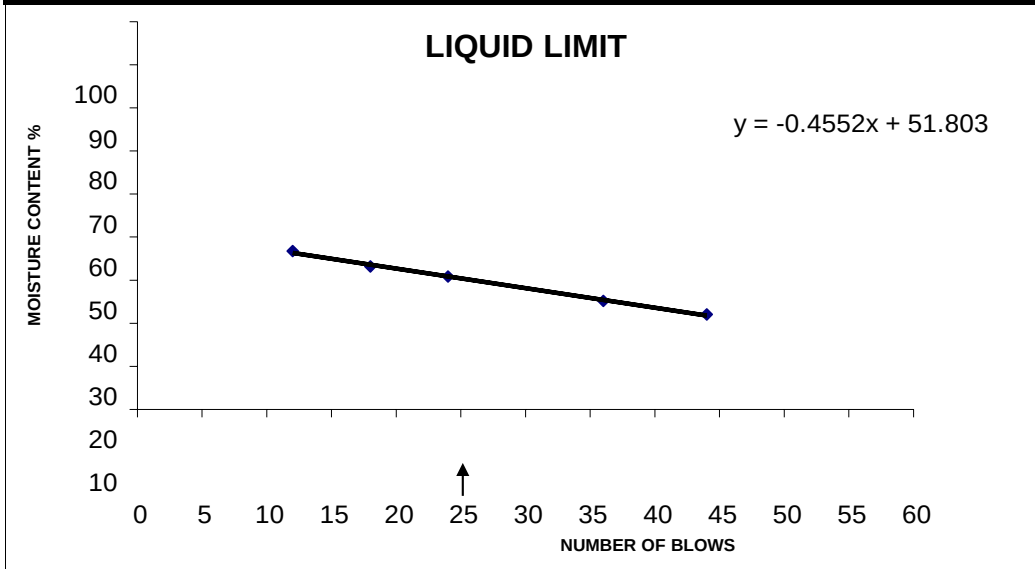


Table B - 14

LIQUID AND PLASTIC LIMITS, LINEAR SHRINKAGE

Sample No.: **POINT 3 (4% Caustic Soda Stabilization)** Liquid Limit: **38.06%** Plastic Limit: **18.03%**Date: **19/08/2023**Plastic Index: **20.03%**Student: **SAMUEL UCHE UBAH**

Liquid limit marked L.L. plastic limit marked P.L.

Type of Test	LL		LL		LL		LL		LL	
No. of Blows/shrinkage %	45.00		37.00		25.00		18.00		12.00	
Container No.	AM		UR		CX		RB		TA	
Wt of wet soil & container (g)	35.80		34.32		30.72		31.48		31.02	
Wt of dried soil & container (g)	31.10		30.00		26.20		27.40		27.00	
Wt of container (g)	17.66		18.05		14.17		16.94		17.11	
Wt of dry soil (Wd) (g)	13.44		11.95		12.03		10.46		9.89	
Wt of moisture (Wm) (g)	4.70		4.32		4.52		4.08		4.02	
Moisture content 100 (Wm/Wd)	34.97		36.15		37.57		39.01		40.65	
Type of Test		PL		PL		PL				
No. of Blows/shrinkage %										
Container No.		GH		WO		EN				
Wt of wet soil & container (g)		25.53		26.97		29.46				
Wt of dried soil & container (g)		23.80		25.30		27.80				
Wt of container (g)		14.49		15.96		18.38				
Wt of dry soil (Wd) (g)		9.31		9.34		9.42				
Wt of moisture (Wm) (g)		1.73		1.67		1.66				
Moisture content 100 (Wm/Wd)		18.58		17.88		17.62				

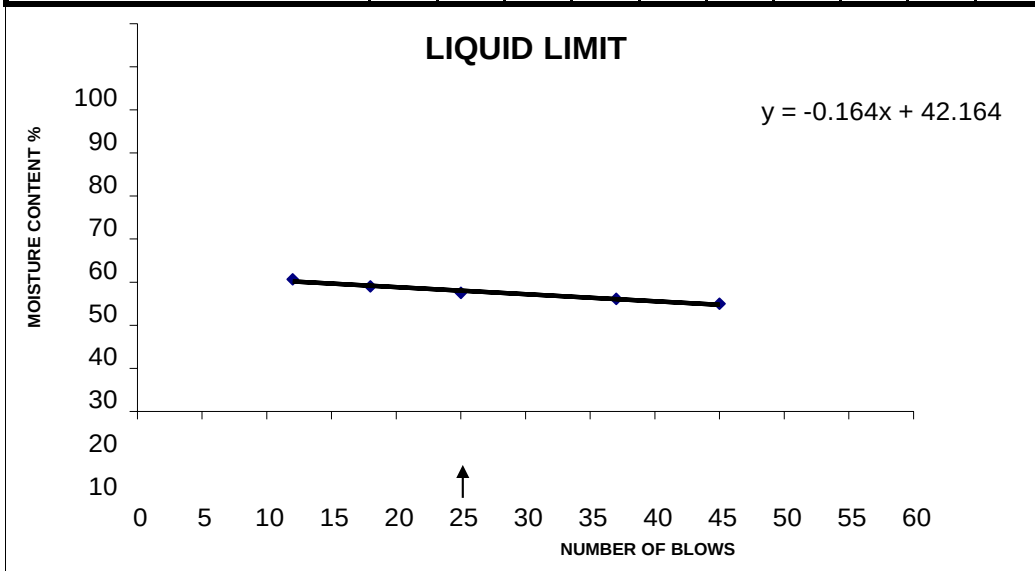


Table B - 15

LIQUID AND PLASTIC LIMITS, LINEAR SHRINKAGE

Sample No.: **POINT 3 (6% Caustic Soda Stabilization)** Liquid Limit: **37.07%** Plastic Limit: **17.35%**Date: **19/08/2023**Plastic Index: **19.72%**Student: **SAMUEL UCHE UBAH**

Liquid limit marked L.L. plastic limit marked P.L.

Type of Test	LL		LL		LL		LL		LL	
No. of Blows/shrinkage %	46.00		37.00		27.00		18.00		12.00	
Container No.	NP		MU		PC		BL		TA	
Wt of wet soil & container (g)	28.40		36.30		48.60		57.20		61.70	
Wt of dried soil & container (g)	24.70		31.30		40.20		46.10		49.30	
Wt of container (g)	13.90		17.30		17.20		16.80		17.50	
Wt of dry soil (Wd) (g)	10.80		14.00		23.00		29.30		31.80	
Wt of moisture (Wm) (g)	3.70		5.00		8.40		11.10		12.40	
Moisture contain 100 (Wm/Wd)	34.26		35.71		36.52		37.88		38.99	
Type of Test		PL		PL		PL				
No. of Blows/shrinkage %										
Container No.		UO		TW		OB				
Wt of wet soil & container (g)		23.80		23.80		23.40				
Wt of dried soil & container (g)		23.00		22.90		22.60				
Wt of container (g)		18.20		17.90		18.00				
Wt of dry soil (Wd) (g)		4.80		5.00		4.60				
Wt of moisture (Wm) (g)		0.80		0.90		0.80				
Moisture contain 100 (Wm/Wd)		16.67		18.00		17.39				

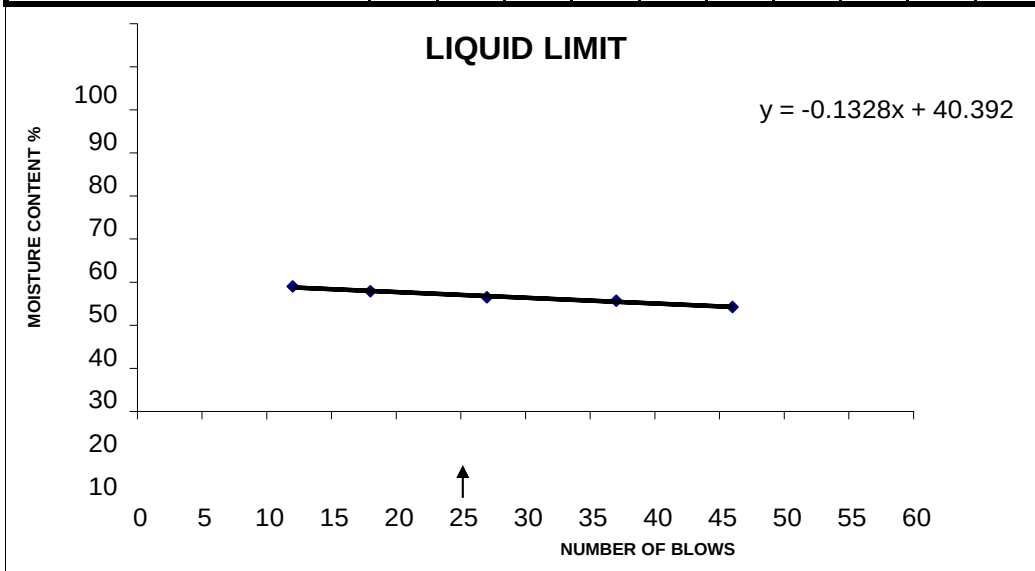


Table B - 16

LIQUID AND PLASTIC LIMITS, LINEAR SHRINKAGE

Sample No.: **POINT 3 (8% Caustic Soda Stabilization)**Liquid Limit: **32.56%**Plastic Limit: **16.73%**Date: **19/08/2023**Plastic Index: **15.83%**Student: **SAMUEL UCHE UBAH**

Liquid limit marked L.L. plastic limit marked P.L.

Type of Test	LL		LL		LL		LL		LL	
No. of Blows/shrinkage %	48.00		35.00		25.00		19.00		14.00	
Container No.	FF		OH		PP		CO		OB	
Wt of wet soil & container (g)	37.40		36.80		35.90		36.50		30.20	
Wt of dried soil & container (g)	32.80		32.30		31.40		31.60		26.80	
Wt of container (g)	17.20		17.90		17.50		17.00		16.80	
Wt of dry soil (Wd) (g)	15.60		14.40		13.90		14.60		10.00	
Wt of moisture (Wm) (g)	4.60		4.50		4.50		4.90		3.40	
Moisture content 100 (Wm/Wd)	29.49		31.25		32.37		33.56		34.00	
Type of Test		PL		PL		PL				
No. of Blows/shrinkage %										
Container No.		UR		IP		LE				
Wt of wet soil & container (g)		27.40		26.00		23.70				
Wt of dried soil & container (g)		26.00		24.70		22.60				
Wt of container (g)		17.70		16.90		16.00				
Wt of dry soil (Wd) (g)		8.30		7.80		6.60				
Wt of moisture (Wm) (g)		1.40		1.30		1.10				
Moisture content 100 (Wm/Wd)		16.87		16.67		16.67				

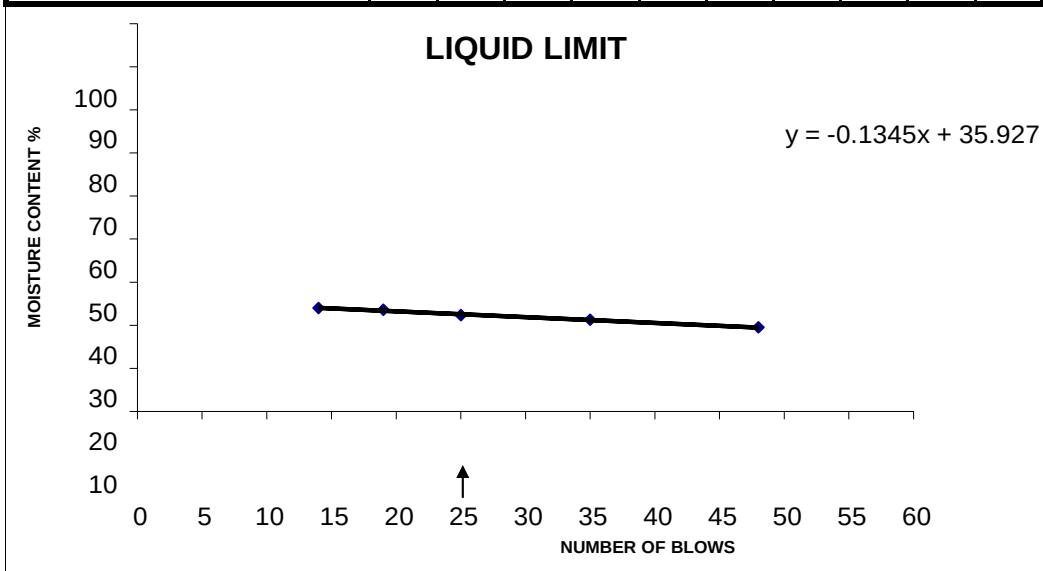


Table B - 17

LIQUID AND PLASTIC LIMITS, LINEAR SHRINKAGE

Sample No.: **POINT 3 (10% Caustic Soda Stabilization)** Liquid Limit: **26.20%** Plastic Limit: **14.22%**

Date: **19/08/2023**

Plastic Index: **11.98%**

Student: **SAMUEL UCHE UBAH**

Liquid limit marked L.L. plastic limit marked P.L.

Type of Test	LL		LL		LL		LL		LL	
No. of Blows/shrinkage %	43.00		33.00		24.00		17.00		11.00	
Container No.	BB		HO		AC		BH		JA	
Wt of wet soil & container (g)	31.96		34.77		34.01		27.69		31.93	
Wt of dried soil & container (g)	29.20		31.50		30.60		24.70		28.60	
Wt of container (g)	17.23		18.25		17.83		13.67		17.08	
Wt of dry soil (Wd) (g)	11.97		13.25		12.77		11.03		11.52	
Wt of moisture (Wm) (g)	2.76		3.27		3.41		2.99		3.33	
Moisture content 100 (Wm/Wd)	23.06		24.68		26.70		27.11		28.91	
Type of Test		PL		PL		PL				
No. of Blows/shrinkage %										
Container No.		OZ		OP		MD				
Wt of wet soil & container (g)		25.94		25.41		29.06				
Wt of dried soil & container (g)		24.80		24.40		28.00				
Wt of container (g)		16.88		17.14		20.61				
Wt of dry soil (Wd) (g)		7.92		7.26		7.39				
Wt of moisture (Wm) (g)		1.14		1.01		1.06				
Moisture content 100 (Wm/Wd)		14.39		13.91		14.34				

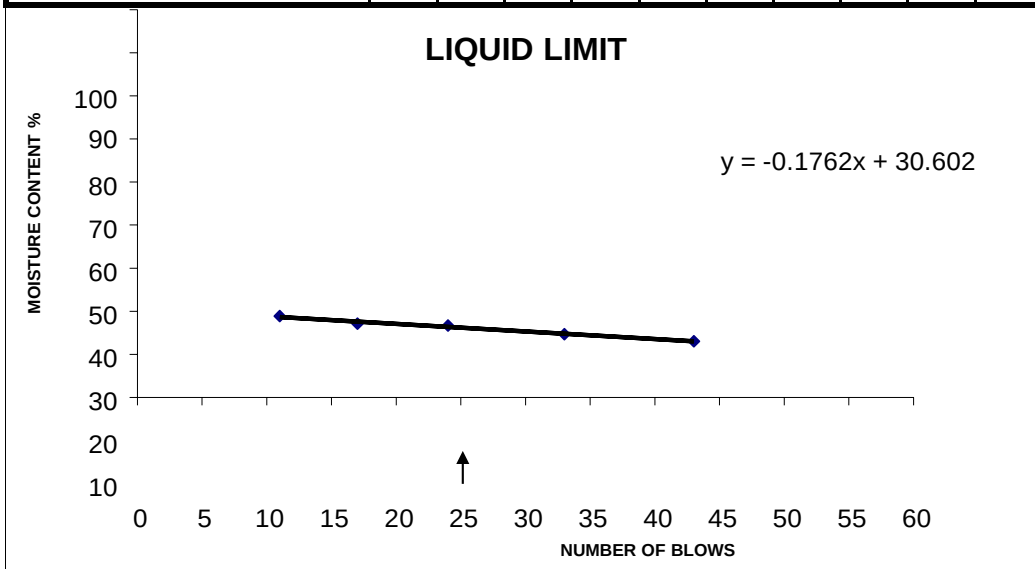


Table B - 18

LIQUID AND PLASTIC LIMITS, LINEAR SHRINKAGE

Sample No.: **POINT 3**Liquid Limit: **50.59%**Plastic Limit: **21.18%**Date: **19/08/2023**Plastic Index: **29.41%**Student: **SAMUEL UCHE UBAH**

Liquid limit marked L.L. plastic limit marked P.L.

Type of Test	LL		LL		LL		LL		LL	
No. of Blows/shrinkage %	46.00		34.00		23.00		17.00		11.00	
Container No.	XP		PA		DA		OB		VO	
Wt of wet soil & container (g)	33.00		40.30		46.60		52.30		55.80	
Wt of dried soil & container (g)	27.80		32.80		36.80		39.70		42.00	
Wt of container (g)	16.70		17.30		17.50		15.50		16.30	
Wt of dry soil (Wd) (g)	11.10		15.50		19.30		24.20		25.70	
Wt of moisture (Wm) (g)	5.20		7.50		9.80		12.60		13.80	
Moisture content 100 (Wm/Wd)	46.85		48.39		50.78		52.07		53.70	
Type of Test		PL		PL		PL				
No. of Blows/shrinkage %										
Container No.		ME		OB		OH				
Wt of wet soil & container (g)		23.90		25.30		24.20				
Wt of dried soil & container (g)		22.80		23.90		23.10				
Wt of container (g)		17.80		17.40		17.60				
Wt of dry soil (Wd) (g)		5.00		6.50		5.50				
Wt of moisture (Wm) (g)		1.10		1.40		1.10				
Moisture content 100 (Wm/Wd)		22.00		21.54		20.00				

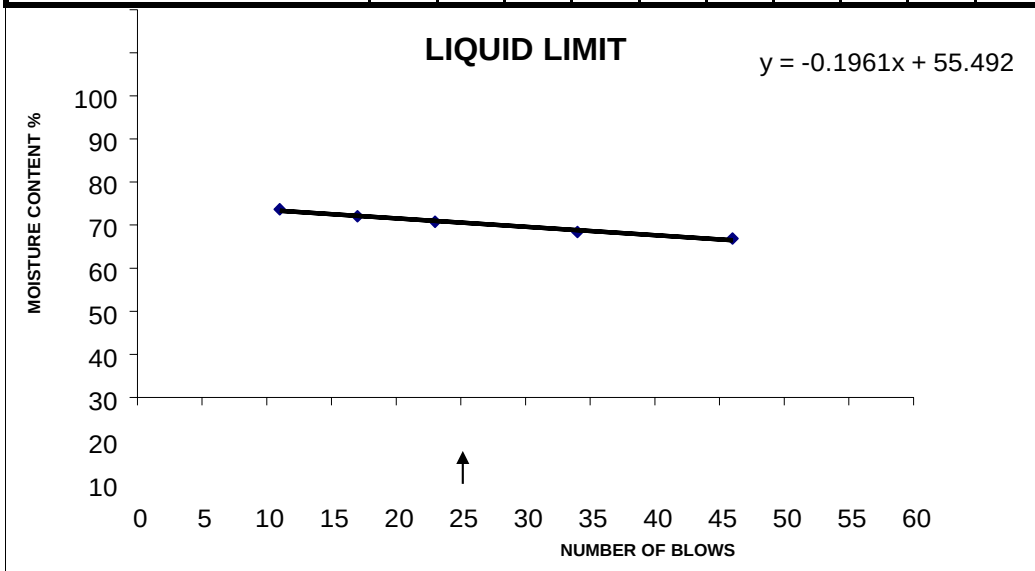


Table B - 19

LIQUID AND PLASTIC LIMITS, LINEAR SHRINKAGESample No.: **POINT 4 (2% Caustic Soda Stabilization)** Liquid Limit: **38.52%** Plastic Limit: **18.70%**Date: **19/08/2023**Plastic Index: **19.82%**Student: **SAMUEL UCHE UBAH**

Liquid limit marked L.L. plastic limit marked P.L.

Type of Test	LL		LL		LL		LL		LL	
No. of Blows/shrinkage %	45.00		33.00		22.00		16.00		12.00	
Container No.	OZ		UI		NI		CO		RT	
Wt of wet soil & container (g)	50.10		52.00		50.70		47.50		48.90	
Wt of dried soil & container (g)	41.30		42.70		42.10		38.80		39.80	
Wt of container (g)	17.10		17.90		19.70		16.90		17.20	
Wt of dry soil (Wd) (g)	24.20		24.80		22.40		21.90		22.60	
Wt of moisture (Wm) (g)	8.80		9.30		8.60		8.70		9.10	
Moisture content 100 (Wm/Wd)	36.36		37.50		38.39		39.73		40.27	
Type of Test		PL		PL		PL				
No. of Blows/shrinkage %										
Container No.		OF		TN		ZG				
Wt of wet soil & container (g)		19.60		17.40		19.50				
Wt of dried soil & container (g)		19.25		17.02		19.05				
Wt of container (g)		17.30		15.10		16.60				
Wt of dry soil (Wd) (g)		1.95		1.92		2.45				
Wt of moisture (Wm) (g)		0.35		0.38		0.45				
Moisture content 100 (Wm/Wd)		17.95		19.79		18.37				

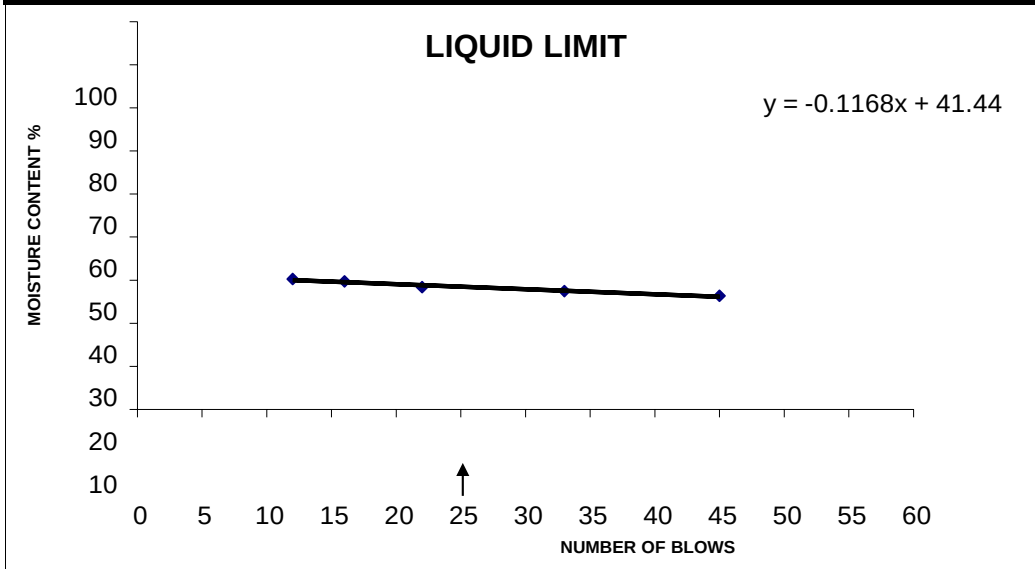


Table B - 20

LIQUID AND PLASTIC LIMITS, LINEAR SHRINKAGE

Sample No.: **POINT 4 (4% Caustic Soda Stabilization)** Liquid Limit: **36.11%** Plastic Limit: **18.45%**Date: **19/08/2023**Plastic Index: **17.66%**Student: **SAMUEL UCHE UBAH**

Liquid limit marked L.L. plastic limit marked P.L.

Type of Test	LL		LL		LL		LL		LL	
No. of Blows/shrinkage %	42.00		32.00		24.00		16.00		10.00	
Container No.	JA		AB		B		TA		OS	
Wt of wet soil & container (g)	30.50		43.40		41.40		58.90		66.10	
Wt of dried soil & container (g)	27.40		37.00		35.30		47.20		51.70	
Wt of container (g)	17.20		17.70		18.40		17.40		17.40	
Wt of dry soil (Wd) (g)	10.20		19.30		16.90		29.80		34.30	
Wt of moisture (Wm) (g)	3.10		6.40		6.10		11.70		14.40	
Moisture content 100 (Wm/Wd)	30.39		33.16		36.09		39.26		41.98	
Type of Test		PL		PL		PL				
No. of Blows/shrinkage %										
Container No.		EN		XY		RT				
Wt of wet soil & container (g)		23.00		25.20		23.80				
Wt of dried soil & container (g)		21.95		24.20		22.80				
Wt of container (g)		16.10		18.80		17.50				
Wt of dry soil (Wd) (g)		5.85		5.40		5.30				
Wt of moisture (Wm) (g)		1.05		1.00		1.00				
Moisture content 100 (Wm/Wd)		17.95		18.52		18.87				

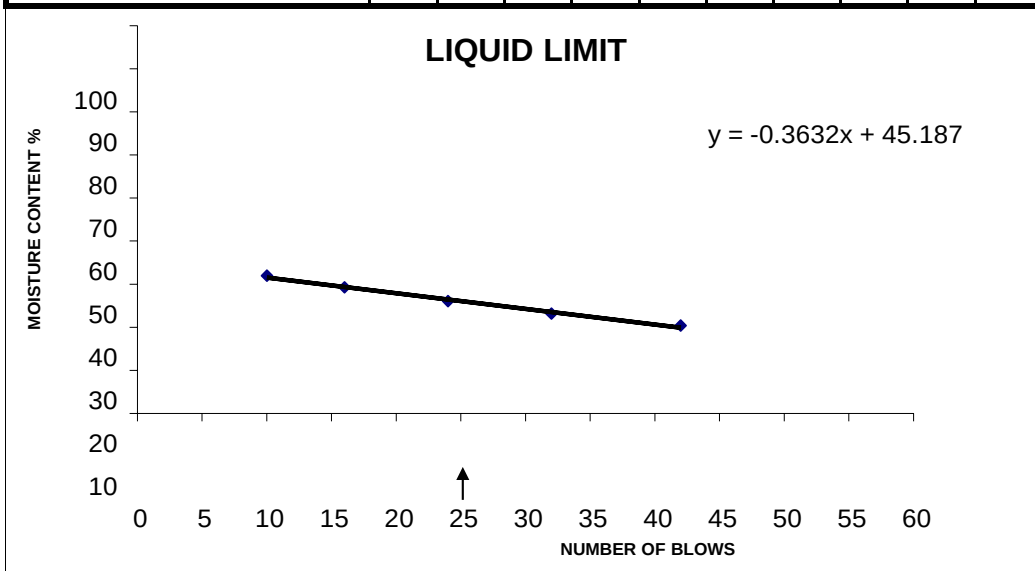


Table B - 21

LIQUID AND PLASTIC LIMITS, LINEAR SHRINKAGE

Sample No.: **POINT 4 (6% Caustic Soda Stabilization)** Liquid Limit: **35.11%** Plastic Limit: **17.83%**Date: **19/08/2023**Plastic Index: **17.28%**Student: **SAMUEL UCHE UBAH**

Liquid limit marked L.L. plastic limit marked P.L.

Type of Test	LL		LL		LL		LL		LL	
No. of Blows/shrinkage %	42.00		32.00		23.00		12.00		8.00	
Container No.	JA		TA		MZ		DR		JT	
Wt of wet soil & container (g)	43.70		46.80		51.20		53.00		51.60	
Wt of dried soil & container (g)	37.20		39.20		41.80		43.60		42.10	
Wt of container (g)	17.00		16.90		15.10		18.20		17.40	
Wt of dry soil (Wd) (g)	20.20		22.30		26.70		25.40		24.70	
Wt of moisture (Wm) (g)	6.50		7.60		9.40		9.40		9.50	
Moisture content 100 (Wm/Wd)	32.18		34.08		35.21		37.01		38.46	
Type of Test		PL		PL		PL				
No. of Blows/shrinkage %										
Container No.		PI		MD		PA				
Wt of wet soil & container (g)		21.10		24.30		20.30				
Wt of dried soil & container (g)		20.45		23.65		19.80				
Wt of container (g)		16.90		19.90		17.00				
Wt of dry soil (Wd) (g)		3.55		3.75		2.80				
Wt of moisture (Wm) (g)		0.65		0.65		0.50				
Moisture content 100 (Wm/Wd)		18.31		17.33		17.86				

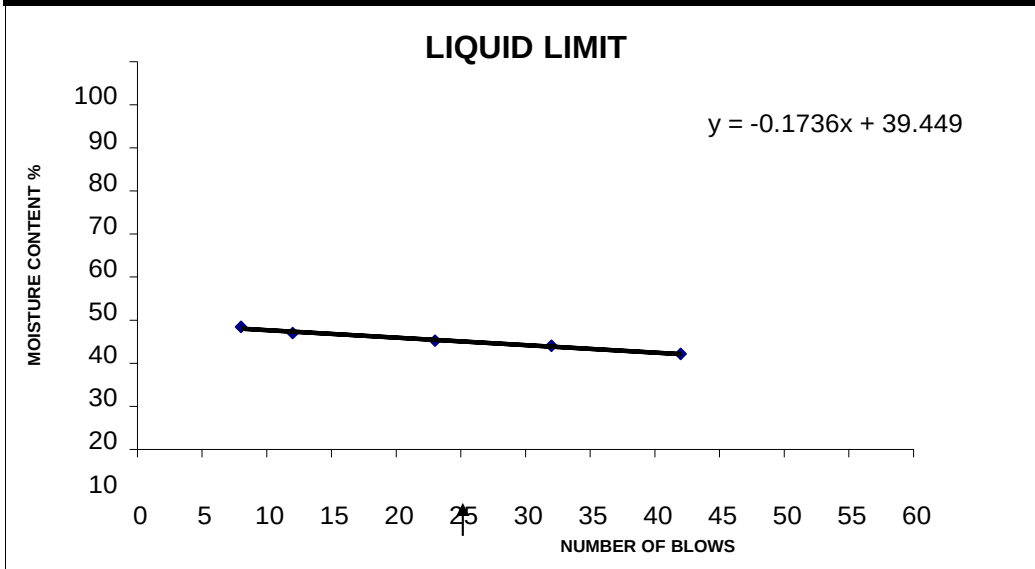


Table B - 22

LIQUID AND PLASTIC LIMITS, LINEAR SHRINKAGE

Sample No.: **POINT 4 (8% Caustic Soda Stabilization)** Liquid Limit: **31.36%** Plastic Limit: **16.20%**Date: **19/08/2023**Plastic Index: **15.16%**Student: **SAMUEL UCHE UBAH**

Liquid limit marked L.L. plastic limit marked P.L.

Type of Test	LL		LL		LL		LL		LL	
No. of Blows/shrinkage %	44.00		34.00		26.00		18.00		12.00	
Container No.	OV		OB		JA		BB		OZ	
Wt of wet soil & container (g)	32.70		38.60		48.10		50.00		53.50	
Wt of dried soil & container (g)	29.50		33.30		40.80		42.20		44.50	
Wt of container (g)	18.00		15.40		17.40		18.50		17.70	
Wt of dry soil (Wd) (g)	11.50		17.90		23.40		23.70		26.80	
Wt of moisture (Wm) (g)	3.20		5.30		7.30		7.80		9.00	
Moisture content 100 (Wm/Wd)	27.83		29.61		31.20		32.91		33.58	
Type of Test		PL		PL		PL				
No. of Blows/shrinkage %										
Container No.		RT		JA		DE				
Wt of wet soil & container (g)		22.00		22.60		23.60				
Wt of dried soil & container (g)		21.35		21.90		22.90				
Wt of container (g)		17.30		17.60		18.60				
Wt of dry soil (Wd) (g)		4.05		4.30		4.30				
Wt of moisture (Wm) (g)		0.65		0.70		0.70				
Moisture content 100 (Wm/Wd)		16.05		16.28		16.28				

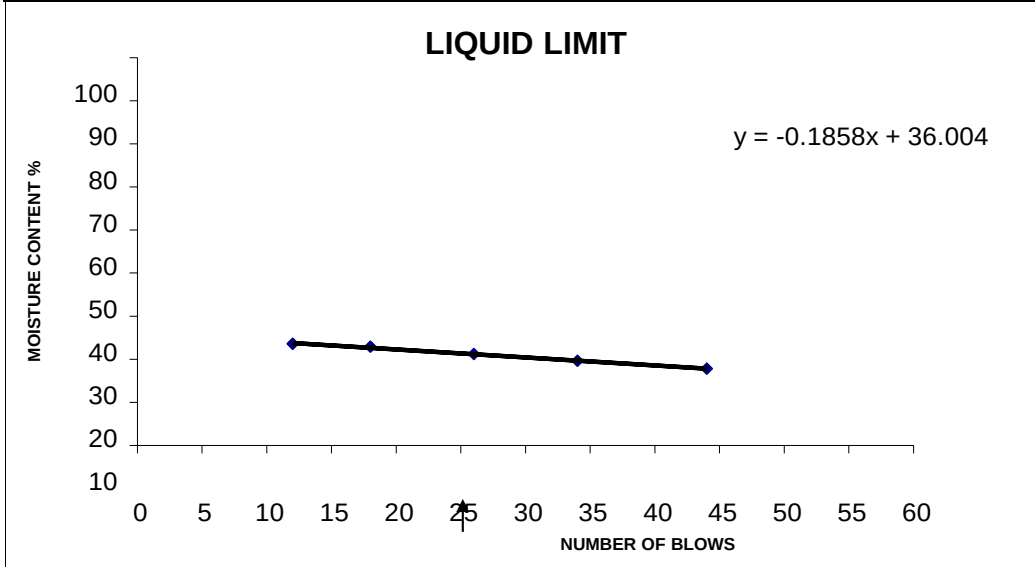


Table B - 23

LIQUID AND PLASTIC LIMITS, LINEAR SHRINKAGE

Sample No.: **POINT 4 (10% Caustic Soda Stabilization)** Liquid Limit: **28.22%** Plastic Limit: **16.04%**

Date: **19/08/2023**

Plastic Index: **12.18%**

Student: **SAMUEL UCHE UBAH**

Liquid limit marked L.L. plastic limit marked P.L.

Type of Test	LL		LL		LL		LL		LL	
No. of Blows/shrinkage %	44.00		32.00		22.00		12.00		8.00	
Container No.	FU		PA		BO		OO		OB	
Wt of wet soil & container (g)	49.40		52.80		45.00		48.70		52.40	
Wt of dried soil & container (g)	43.40		45.50		39.60		41.00		43.70	
Wt of container (g)	18.30		17.90		20.60		16.40		17.10	
Wt of dry soil (Wd) (g)	25.10		27.60		19.00		24.60		26.60	
Wt of moisture (Wm) (g)	6.00		7.30		5.40		7.70		8.70	
Moisture content 100 (Wm/Wd)	23.90		26.45		28.42		31.30		32.71	
Type of Test		PL		PL		PL				
No. of Blows/shrinkage %										
Container No.		CB		TC		OD				
Wt of wet soil & container (g)		22.10		21.70		19.60				
Wt of dried soil & container (g)		21.55		21.19		19.10				
Wt of container (g)		18.10		17.90		16.10				
Wt of dry soil (Wd) (g)		3.45		3.29		3.00				
Wt of moisture (Wm) (g)		0.55		0.51		0.50				
Moisture content 100 (Wm/Wd)		15.94		15.50		16.67				

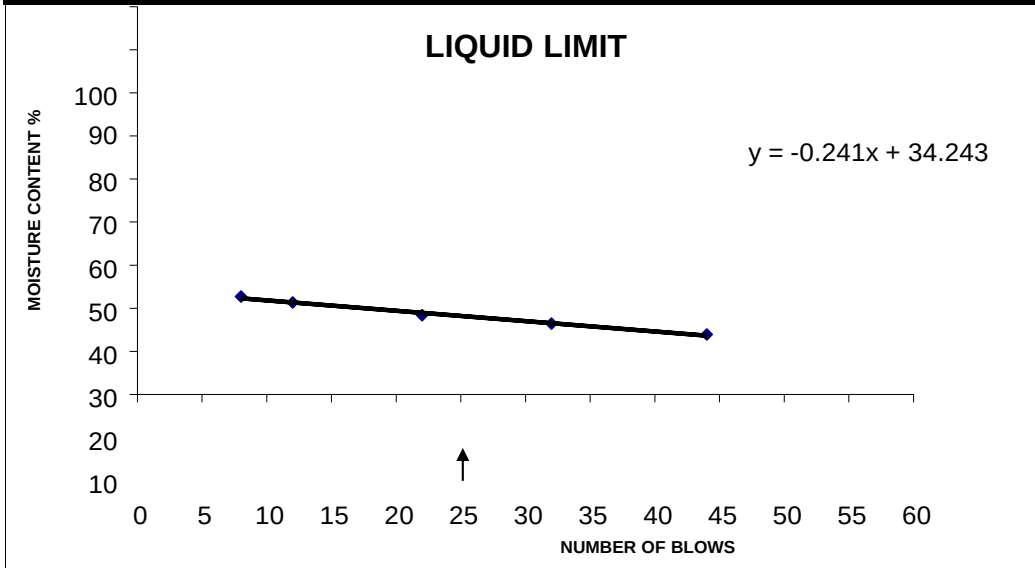


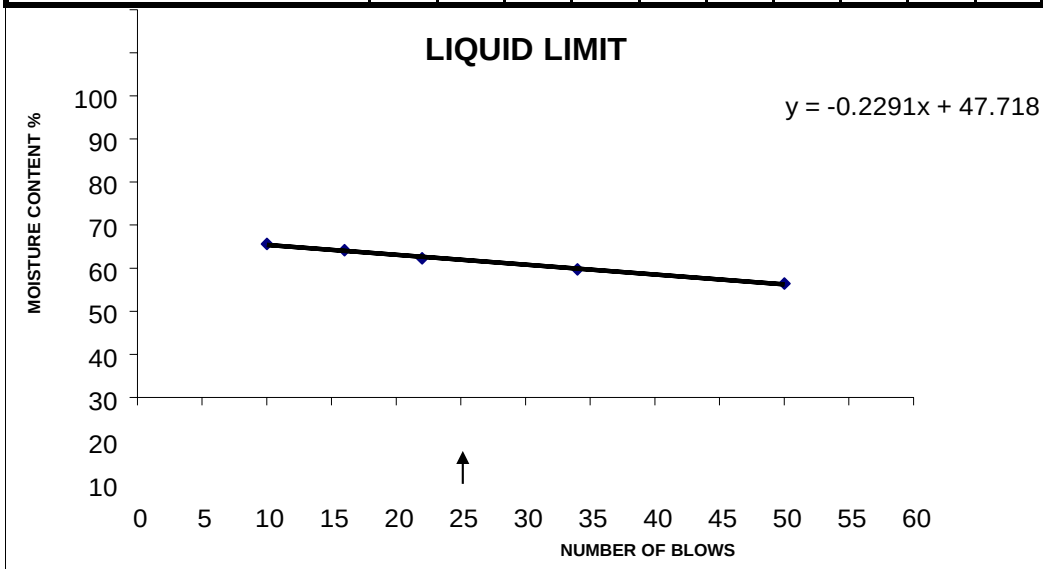
Table B - 24

LIQUID AND PLASTIC LIMITS, LINEAR SHRINKAGE

Sample No.: **POINT 4**Liquid Limit: **41.99%**Plastic Limit: **20.77%**Date: **19/08/2023**Plastic Index: **21.22%**Student: **SAMUEL UCHE UBAH**

Liquid limit marked L.L. plastic limit marked P.L.

Type of Test	LL		LL		LL		LL		LL	
No. of Blows/shrinkage %	50.00		34.00		22.00		16.00		10.00	
Container No.	KE		XX		OB		FD		ZU	
Wt of wet soil & container (g)	26.00		38.60		44.00		49.50		55.10	
Wt of dried soil & container (g)	22.90		32.80		36.30		39.20		43.60	
Wt of container (g)	14.40		18.20		18.10		15.90		18.40	
Wt of dry soil (Wd) (g)	8.50		14.60		18.20		23.30		25.20	
Wt of moisture (Wm) (g)	3.10		5.80		7.70		10.30		11.50	
Moisture content 100 (Wm/Wd)	36.47		39.73		42.31		44.21		45.63	
Type of Test			PL		PL		PL			
No. of Blows/shrinkage %										
Container No.			CB		HO		DE			
Wt of wet soil & container (g)			24.20		22.50		22.70			
Wt of dried soil & container (g)			23.20		21.70		21.90			
Wt of container (g)			18.50		17.80		18.00			
Wt of dry soil (Wd) (g)			4.70		3.90		3.90			
Wt of moisture (Wm) (g)			1.00		0.80		0.80			
Moisture content 100 (Wm/Wd)			21.28		20.51		20.51			



CALIFORNIA BEARING RATIO TEST

SAMPLE ID
DATE

POINT 1 (2% CAUSTIC SODA STABILIZATION)
19/08/2023

UNSOAKED CBR VALUE: 15.78%
SOAKED CBR VALUE: 11.61%

TEST ON BOTTOM (UNSOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	31.00	58	91	124	168	231	267	301	585	699	785
Ditto corrected												
Load (KN)	0	0.33908	0.63441	0.99537	1.35633	1.83761	2.52671	2.92049	3.29238	6.39882	7.64577	8.58645
C. B. R. %												

SURCHARGE

TEST ON TOP (UNSOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	28.00	44	75	120	156	198	231	275	480	532	555
Ditto corrected												
Load (KN)	0	0.30627	0.48128	0.82036	1.31258	1.70635	2.16575	2.52671	3.00799	5.25031	5.8191	6.07067
C. B. R. %												

SURCHARGE

TEST ON BOTTOM (SOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	23.00	37	70	101	134	161	196	234	311	366	385
Ditto corrected												
Load (KN)	0	0.25158	0.40471	0.76567	1.10475	1.46571	1.76104	2.14388	2.55953	3.40176	4.00336	4.21119
C. B. R. %												

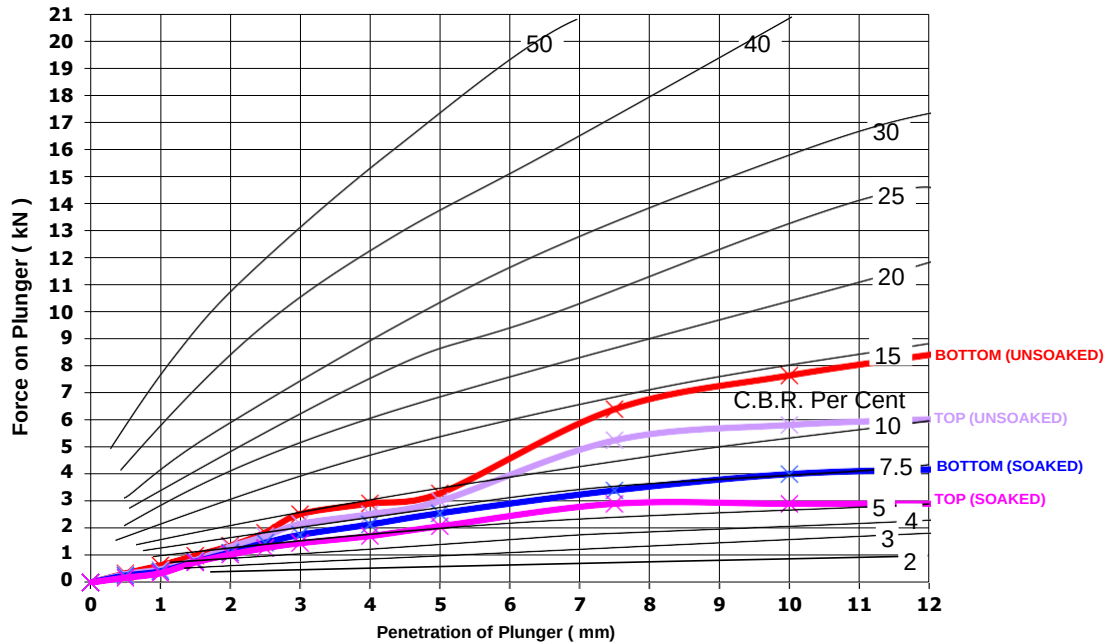
SURCHARGE

TEST ON TOP (SOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	16.00	31	68	94	116	133	157	190	266	266	266
Ditto corrected												
Load (KN)	0	0.17501	0.33908	0.74379	1.02819	1.26883	1.45477	1.71729	2.07825	2.90955	2.90955	2.90955
C. B. R. %												

SURCHARGE

	UNSOAKED		SOAKED	
	2.5mm	5.0mm	2.5mm	5.0mm
BOTTOM	13.87	16.4948	11.0661	12.8232
TOP	12.883	15.07	9.57963	10.412



CALIFORNIA BEARING RATIO TEST

SAMPLE ID
DATE

POINT 1 (4% CAUSTIC SODA STABILIZATION)
19/08/2023

UNSOAKED CBR VALUE: 26.41%
SOAKED CBR VALUE: 15.18%

TEST ON BOTTOM (UNSOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	55.00	67	107	154	325	420	476	514	803	803	803
Ditto corrected												
Load (KN)	0	0.6016	0.73286	1.17038	1.68448	3.5549	4.59402	5.20656	5.62221	8.78333	8.78333	8.78333
C. B. R. %												

SURCHARGE

TEST ON TOP (UNSOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	15.00	50	60	90	275	290	350	450	470	470	470
Ditto corrected												
Load (KN)	0	0.16407	0.54691	0.65629	0.98443	3.00799	3.17206	3.82835	4.92217	5.14093	5.14093	5.14093
C. B. R. %												

SURCHARGE

TEST ON BOTTOM (SOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	11.00	40	79	110	189	213	256	309	375	427	445
Ditto corrected												
Load (KN)	0	0.12032	0.43753	0.86411	1.2032	2.06731	2.32983	2.80017	3.37989	4.10181	4.67059	4.86748
C. B. R. %												

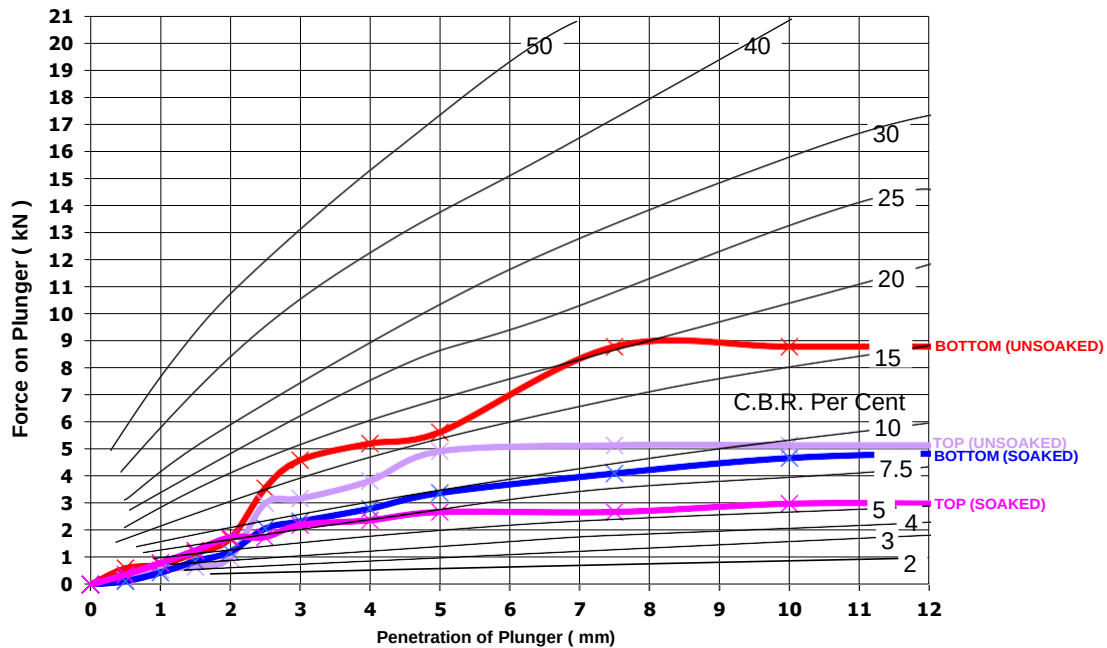
SURCHARGE

TEST ON TOP (SOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	33.00	73	115	160	160	201	217	245	245	273	273
Ditto corrected												
Load (KN)	0	0.36096	0.79848	1.25789	1.7501	1.7501	2.19857	2.37358	2.67985	2.67985	2.98611	2.98611
C. B. R. %												

SURCHARGE

	UNSOAKED		SOAKED	
	2.5mm	5.0mm	2.5mm	5.0mm
BOTTOM	26.84	28.1673	15.6082	16.9332
TOP	22.7103	24.6601	13.2133	13.426



CALIFORNIA BEARING RATIO TEST

SAMPLE ID
DATE

POINT 1 (6% CAUSTIC SODA STABILIZATION)
19/08/2023

UNSOAKED CBR VALUE: 31.83%
SOAKED CBR VALUE: 16.17%

TEST ON BOTTOM (UNSOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	45.00	117	227	265	402	615	722	722	722	722	722
Ditto corrected												
Load (KN)	0	0.49222	1.27976	2.48296	2.89861	4.39714	6.72696	7.89734	7.89734	7.89734	7.89734	7.89734
C. B. R. %												

SURCHARGE

TEST ON TOP (UNSOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	43.00	103	149	210	263	306	382	440	575	653	708
Ditto corrected												
Load (KN)	0	0.47034	1.12663	1.62978	2.29701	2.87673	3.34707	4.17837	4.81279	6.28944	7.14261	7.74421
C. B. R. %												

SURCHARGE

TEST ON BOTTOM (SOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	22.00	83	116	142	182	224	290	345	440	427	445
Ditto corrected												
Load (KN)	0	0.24064	0.90787	1.26883	1.55322	1.99074	2.45015	3.17206	3.77366	4.81279	4.67059	4.86748
C. B. R. %												

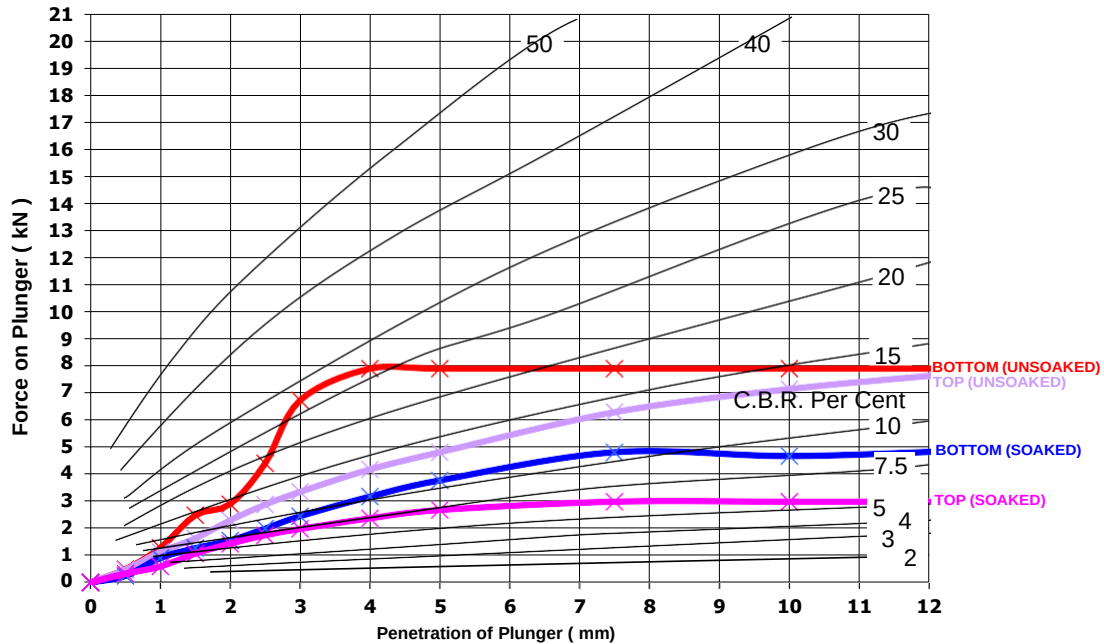
SURCHARGE

TEST ON TOP (SOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	30.00	54	98	131	160	181	217	245	273	273	273
Ditto corrected												
Load (KN)	0	0.32814	0.59066	1.07194	1.4329	1.7501	1.97981	2.37358	2.67985	2.98611	2.98611	2.98611
C. B. R. %												

SURCHARGE

	UNSOAKED		SOAKED	
	2.5mm	5.0mm	2.5mm	5.0mm
BOTTOM	33.20	39.5657	15.0301	18.906
TOP	21.7193	24.1121	13.2133	13.426



CALIFORNIA BEARING RATIO TEST

SAMPLE ID
DATE

POINT 1 (8% CAUSTIC SODA STABILIZATION)
19/08/2023

UNSOAKED CBR VALUE: 47.61%
SOAKED CBR VALUE: 21.63%

TEST ON BOTTOM (UNSOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	635.00	693	717	728	730	730	730	730	730	730	730
Ditto corrected												
Load (KN)	0	6.94573	7.58014	7.84265	7.96297	7.98485	7.98485	7.98485	7.98485	7.98485	7.98485	7.98485
C. B. R. %												

SURCHARGE

TEST ON TOP (UNSOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	249.00	330	354	370	423	455	534	620	707	707	707
Ditto corrected												
Load (KN)	0	2.7236	3.60959	3.87211	4.04712	4.62684	4.97686	5.84097	6.78165	7.73327	7.73327	7.73327
C. B. R. %												

SURCHARGE

TEST ON BOTTOM (SOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	110.00	132	150	232	325	404	435	443	470	515	595
Ditto corrected												
Load (KN)	0	1.2032	1.44384	1.64072	2.53765	3.5549	4.41901	4.7581	4.8456	5.14093	5.63315	6.5082
C. B. R. %												

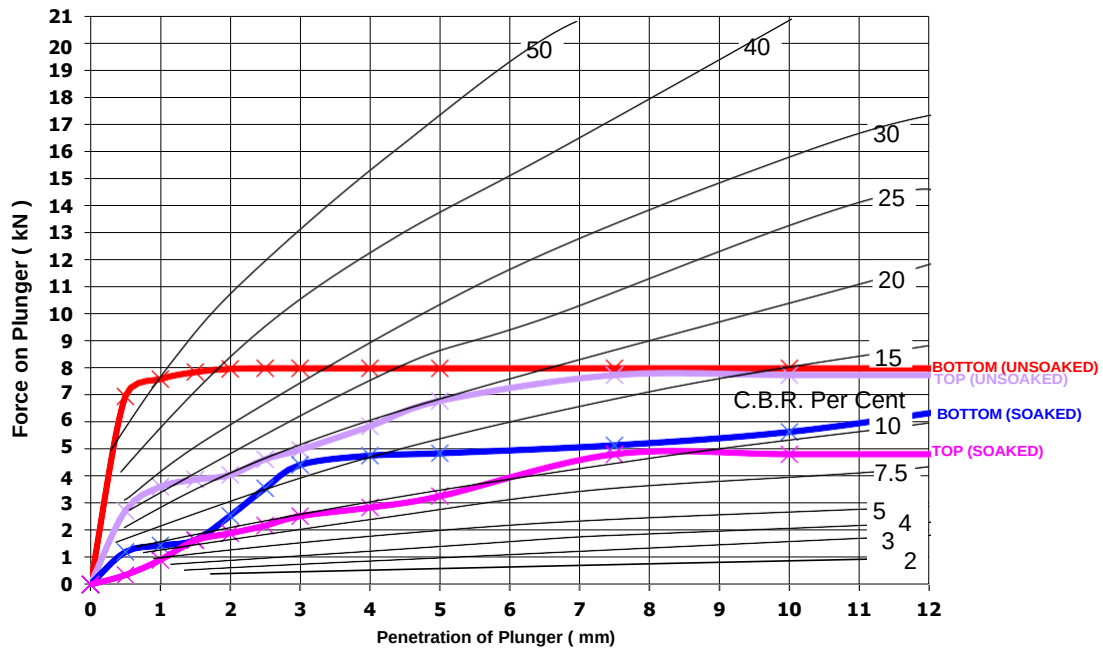
SURCHARGE

TEST ON TOP (SOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	32.00	83	149	173	199	231	260	298	440	440	440
Ditto corrected												
Load (KN)	0	0.35002	0.90787	1.62978	1.8923	2.17669	2.52671	2.84392	3.25957	4.81279	4.81279	4.81279
C. B. R. %												

SURCHARGE

	UNSOAKED		SOAKED	
	2.5mm	5.0mm	2.5mm	5.0mm
BOTTOM	60.29	40.0041	26.8395	24.2765
TOP	34.9326	33.9761	16.434	16.3304



CALIFORNIA BEARING RATIO TEST

SAMPLE ID
DATE

POINT 1 (10% CAUSTIC SODA STABILIZATION)
19/08/2023

UNSOAKED CBR VALUE: 51.90%
SOAKED CBR VALUE: 23.45%

TEST ON BOTTOM (UNSOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	83.00	192	245	412	680	734	812	954	954	954	954
Ditto corrected												
Load (KN)	0	0.90787	2.10012	2.67985	4.50652	7.43794	8.0286	8.88178	10.435	10.435	10.435	10.435
C. B. R. %												

SURCHARGE

TEST ON TOP (UNSOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	57.00	134	220	362	577	651	709	731	777	823	903
Ditto corrected												
Load (KN)	0	0.62347	1.46571	2.40639	3.95961	6.31131	7.12074	7.75515	7.99579	8.49894	9.0021	9.87715
C. B. R. %												

SURCHARGE

TEST ON BOTTOM (SOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	42.00	89	136	198	299	328	378	378	378	378	378
Ditto corrected												
Load (KN)	0	0.4594	0.9735	1.48759	2.16575	3.27051	3.58771	4.13462	4.13462	4.13462	4.13462	4.13462
C. B. R. %												

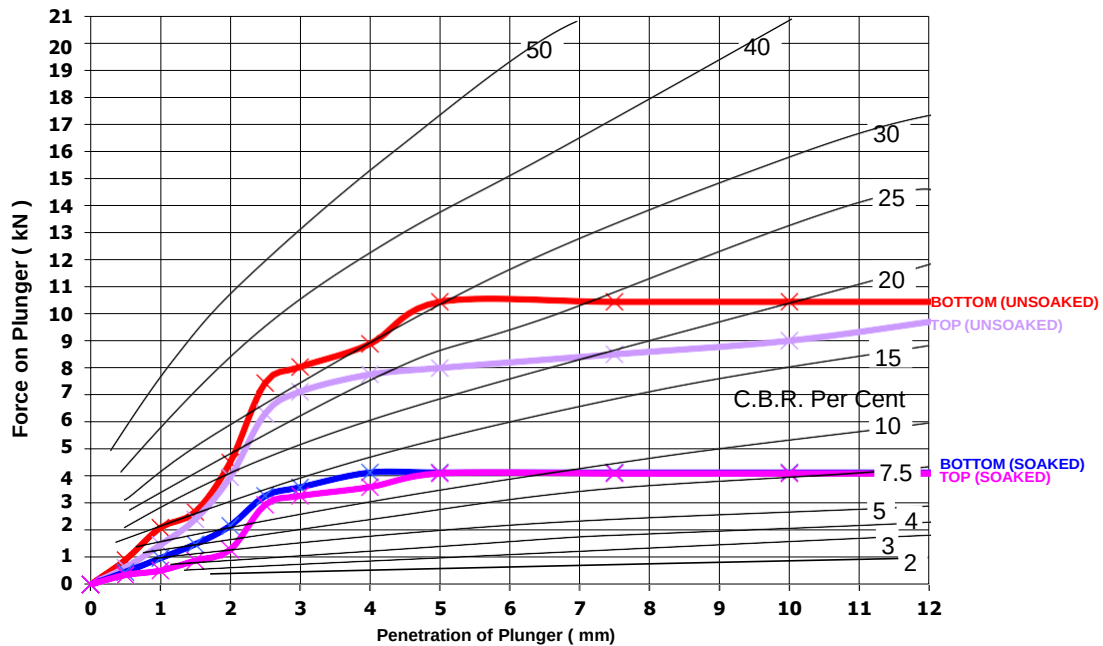
SURCHARGE

TEST ON TOP (SOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	32	47	81	117	269	299	329	375	375	375	375
Ditto corrected												
Load (KN)	0	0.35002	0.51409	0.88599	1.27976	2.94236	3.27051	3.59865	4.10181	4.10181	4.10181	4.10181
C. B. R. %												

SURCHARGE

	UNSOAKED		SOAKED	
	2.5mm	5.0mm	2.5mm	5.0mm
BOTTOM	56.16	52.2793	24.6923	20.7144
TOP	47.6504	40.0589	22.2148	20.55



CALIFORNIA BEARING RATIO TEST

SAMPLE ID POINT 1
DATE 19/08/2023

UNSOAKED CBR VALUE: 8.30%
SOAKED CBR VALUE: 5.12%

TEST ON BOTTOM (UNSOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	23.00	39	43	72	109	113	141	163	216	256	275
Ditto corrected												
Load (KN)	0	0.25158	0.42659	0.47034	0.78755	1.19226	1.23601	1.54228	1.78292	2.36264	2.80017	3.00799
C. B. R. %												

SURCHARGE

TEST ON TOP (UNSOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	32.00	50	85	88	92	106	120	129	167	207	243
Ditto corrected												
Load (KN)	0	0.35002	0.54691	0.92974	0.96256	1.00631	1.15944	1.31258	1.41102	1.82667	2.2642	2.65797
C. B. R. %												

SURCHARGE

TEST ON BOTTOM (SOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	78.00	82	82	82	82	92	98	122	142	157	168
Ditto corrected												
Load (KN)	0	0.85318	0.89693	0.89693	0.89693	0.89693	1.00631	1.07194	1.33445	1.55322	1.71729	1.83761
C. B. R. %												

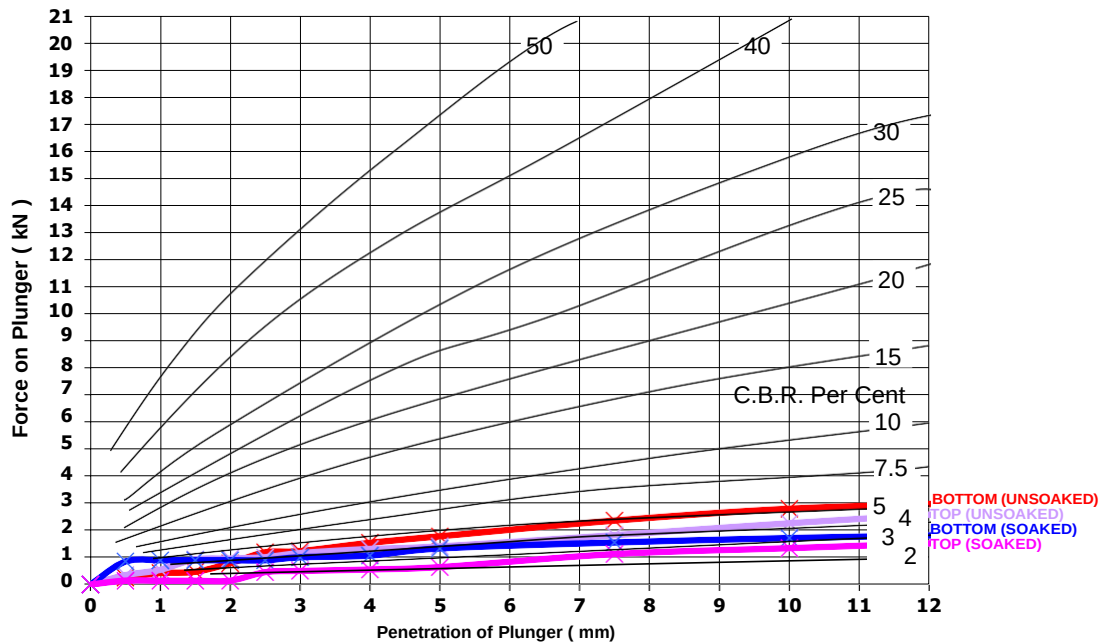
SURCHARGE

TEST ON TOP (SOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	13.00	13	13	13	42	46	51	59	103	123	143
Ditto corrected												
Load (KN)	0	0.1422	0.1422	0.1422	0.1422	0.4594	0.50315	0.55785	0.64535	1.12663	1.34539	1.56416
C. B. R. %												

SURCHARGE

	UNSOAKED		SOAKED	
	2.5mm	5.0mm	2.5mm	5.0mm
BOTTOM	9.00	8.93242	6.77181	6.68562
TOP	7.59764	7.06922	3.46849	3.23321



CALIFORNIA BEARING RATIO TEST

SAMPLE ID POINT 2
DATE 19/08/2023

UNSOAKED CBR VALUE: 17.26%
SOAKED CBR VALUE: 8.42%

TEST ON BOTTOM (UNSOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	140.00	207	212	212	228	274	300	323	330	400	452
Ditto corrected												
Load (KN)	0	1.53134	2.2642	2.31889	2.31889	2.4939	2.99705	3.28145	3.53302	3.60959	4.37526	4.94404
C. B. R. %												

SURCHARGE

TEST ON TOP (UNSOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	58.00	104	146	172	190	212	235	262	309	351	398
Ditto corrected												
Load (KN)	0	0.63441	1.13757	1.59697	1.88136	2.07825	2.31889	2.57047	2.8658	3.37989	3.83929	4.35338
C. B. R. %												

SURCHARGE

TEST ON BOTTOM (SOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	40.00	42	55	77	113	122	142	165	294	344	365
Ditto corrected												
Load (KN)	0	0.43753	0.4594	0.6016	0.84224	1.23601	1.33445	1.55322	1.80479	3.21582	3.76272	3.99242
C. B. R. %												

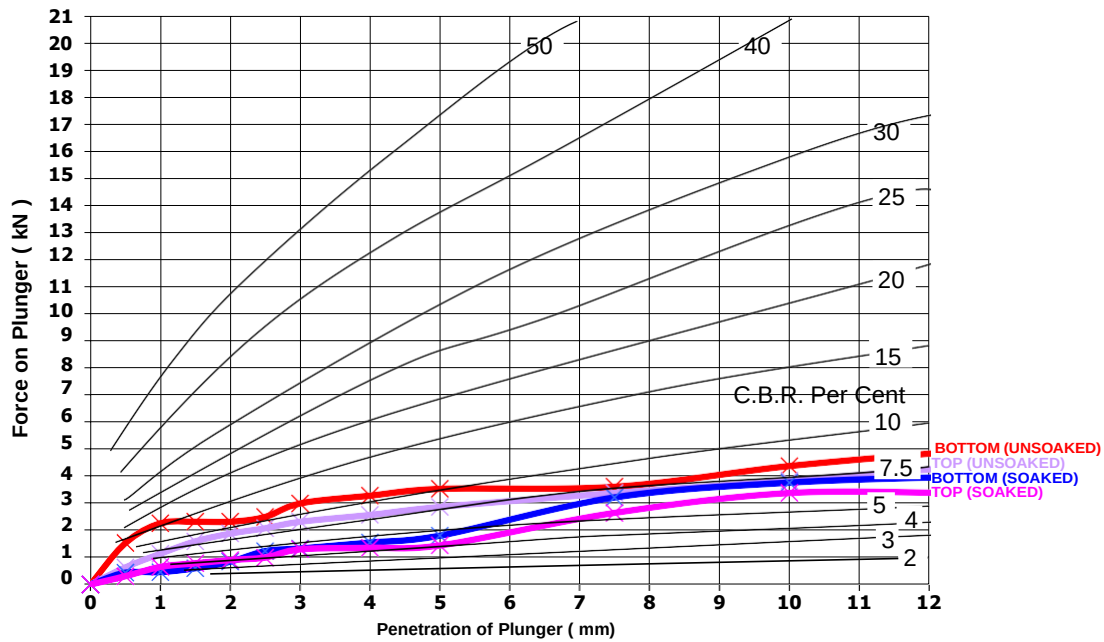
SURCHARGE

TEST ON TOP (SOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	28.00	60	72	83	91	119	124	132	242	309	309
Ditto corrected												
Load (KN)	0	0.30627	0.65629	0.78755	0.90787	0.99537	1.30164	1.35633	1.44384	2.64703	3.37989	3.37989
C. B. R. %												

SURCHARGE

	UNSOAKED		SOAKED	
	2.5mm	5.0mm	2.5mm	5.0mm
BOTTOM	18.83	17.7004	9.33188	9.04202
TOP	15.6908	14.3576	7.51506	7.23362



CALIFORNIA BEARING RATIO TEST

SAMPLE ID POINT 3
DATE 19/08/2023

UNSOAKED CBR VALUE: 6.48%
SOAKED CBR VALUE: 0.99%

TEST ON BOTTOM (UNSOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	24.00	43	65	80	87	96	106	108	148	173	187
Ditto corrected												
Load (KN)	0	0.26252	0.47034	0.71098	0.87505	0.95162	1.05006	1.15944	1.18132	1.61885	1.8923	2.04543
C. B. R. %												

SURCHARGE

TEST ON TOP (UNSOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	17.00	30	44	63	70	84	97	105	113	113	113
Ditto corrected												
Load (KN)	0	0.18595	0.32814	0.48128	0.6891	0.76567	0.9188	1.061	1.14851	1.23601	1.23601	1.23601
C. B. R. %												

SURCHARGE

TEST ON BOTTOM (SOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00
Ditto corrected												
Load (KN)	0	0.20782	0.20782	0.20782	0.20782	0.20782	0.20782	0.20782	0.20782	0.20782	0.20782	0.20782
C. B. R. %												

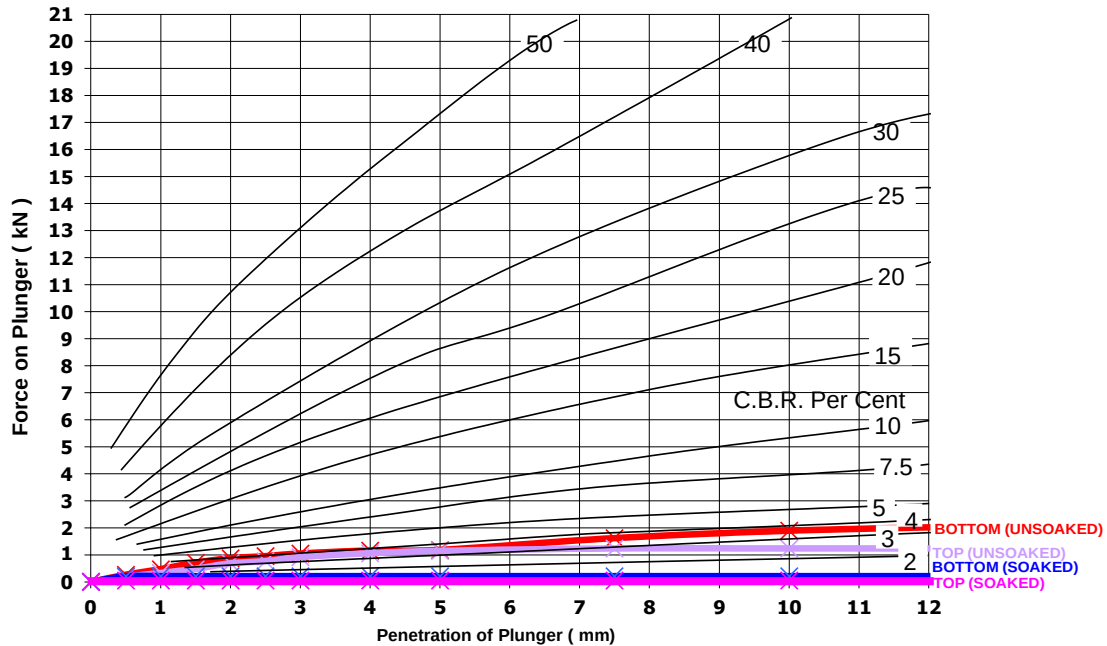
SURCHARGE

TEST ON TOP (SOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Ditto corrected												
Load (KN)	0	0.05469	0.05469	0.05469	0.05469	0.05469	0.05469	0.05469	0.05469	0.05469	0.05469	0.05469
C. B. R. %												

SURCHARGE

	UNSOAKED		SOAKED	
	2.5mm	5.0mm	2.5mm	5.0mm
BOTTOM	7.18	5.91841	1.56908	1.0412
TOP	5.78081	5.75401	0.41292	0.274



CALIFORNIA BEARING RATIO TEST

SAMPLE ID POINT 4
DATE 19/08/2023

UNSOAKED CBR VALUE: 12.92%
SOAKED CBR VALUE: 8.09%

TEST ON BOTTOM (UNSOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	60.00	92	121	147	173	194	219	222	265	305	353
Ditto corrected												
Load (KN)	0	0.65629	1.00631	1.32352	1.60791	1.8923	2.122	2.39545	2.42827	2.89861	3.33614	3.86117
C. B. R. %												

SURCHARGE

TEST ON TOP (UNSOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	70.00	97	122	131	140	151	159	164	190	248	296
Ditto corrected												
Load (KN)	0	0.76567	1.061	1.33445	1.4329	1.53134	1.65166	1.73917	1.79386	2.07825	2.71266	3.23769
C. B. R. %												

SURCHARGE

TEST ON BOTTOM (SOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	32.00	91	115	118	130	140	140	144	149	149	149
Ditto corrected												
Load (KN)	0	0.35002	0.99537	1.25789	1.2907	1.42196	1.53134	1.53134	1.57509	1.62978	1.62978	1.62978
C. B. R. %												

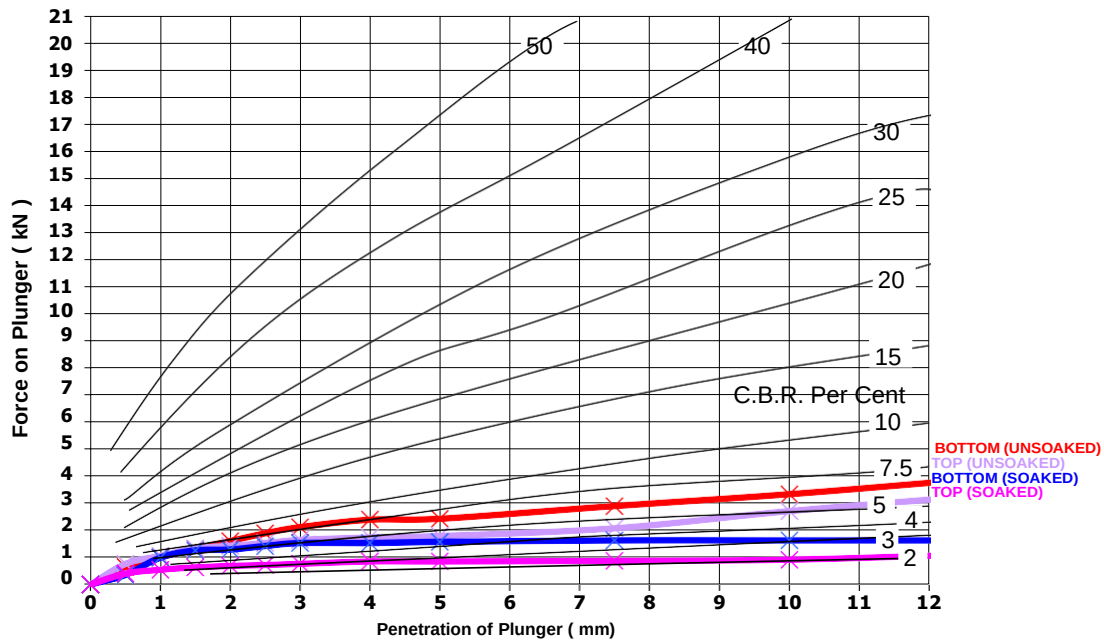
SURCHARGE

TEST ON TOP (SOAKED)

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	37.00	50	58	63	66	70	78	78	80	84	101
Ditto corrected												
Load (KN)	0	0.40471	0.54691	0.63441	0.6891	0.72192	0.76567	0.85318	0.85318	0.87505	0.9188	1.10475
C. B. R. %												

SURCHARGE

	UNSOAKED		SOAKED	
	2.5mm	5.0mm	2.5mm	5.0mm
BOTTOM	14.29	12.1656	10.7358	7.89122
TOP	11.5616	8.98722	5.45048	4.27441



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD/HEAVY COMPACTION

Project... **B.Eng.**

Sample No: **Point 1 (2% Caustic Soda Stabilization)**

Student... **Samuel Uche Ubah..**

Depth:...**1.0m**

Date: **19/08/2023...**

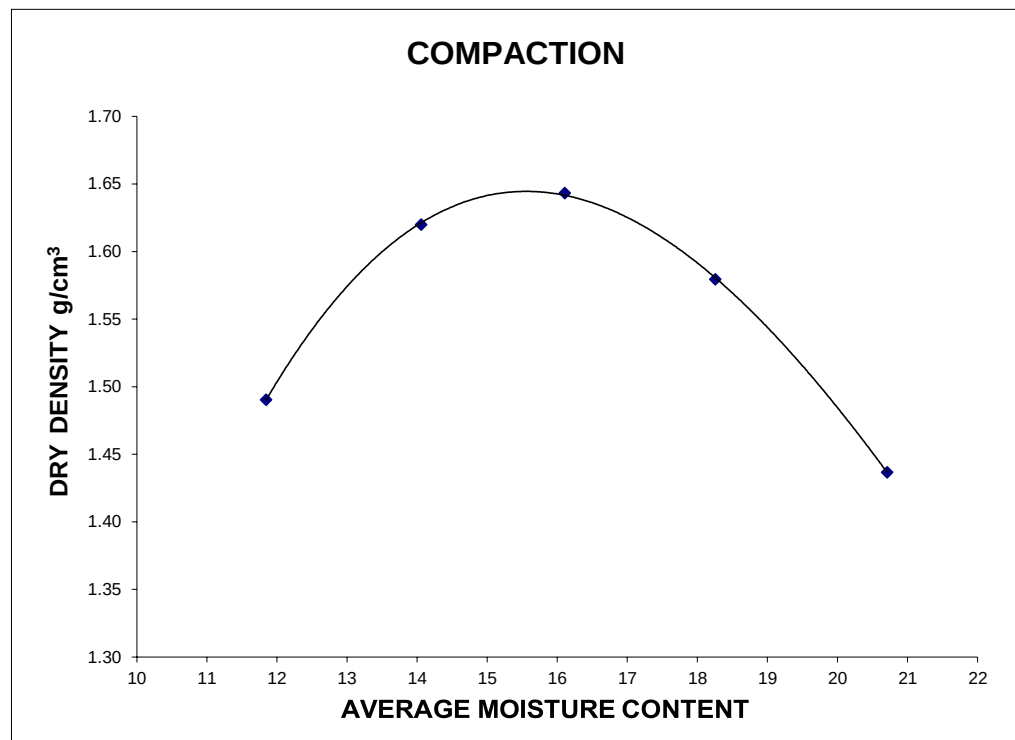
MDD: **1.64g/cm³**

Total weight of Sample.....**3000g**

OPT.MC: **15.4%**

B.S. / C.B.R. Mould.....**3490g**

Wt. of mould & wet Soil (W2) g	5150.00	5330.00	5390.00	5350.00	5217.00									
Wt. of mould (W1) g	3490.00	3490.00	3490.00	3490.00	3490.00									
Wt. of wet soil (W2-W1) g	1660.00	1840.00	1900.00	1860.00	1727.00									
Bulk Density (Pb) (W2-W1)/x g/cm ³	1.67	1.85	1.91	1.87	1.73									
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 995.79cm ³														
Container No.	KE	RT	OZ	OB	TH	RT	FI	OT	NO	OD				
Wt. of wet soil & container (g)	56.34	58.28	61.19	71.51	60.24	70.77	66.42	73.05	54.61	68.65				
Wt. of Dry soil & container (g)	51.89	53.99	55.81	64.82	54.06	63.37	58.56	64.54	48.48	60.04				
Wt. of Container (g)	14.46	17.62	17.44	17.34	15.66	17.46	15.83	17.55	19.05	18.21				
Wt. of dry soil (Wd) g	37.43	36.37	38.37	47.48	38.40	45.91	42.73	46.99	29.43	41.83				
Wt. of Moisture (Wm) g	4.45	4.29	5.38	6.69	6.18	7.40	7.86	8.51	6.13	8.61				
Moistur Content 100(Wm/Wd) %	11.89	11.80	14.02	14.09	16.09	16.12	18.39	18.11	20.83	20.58				
Average Moisture Content (m) %	11.84		14.06		16.11		18.25		20.71					
Dry Density = Pb/1+ (m/100) (g/cm ³)	1.49		1.62		1.64		1.58		1.44					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD/HEAVY COMPACTION

Project... **B.Eng.**

Sample No: **Point 1 (4% Caustic Soda Stabilization)**

Student... **Samuel Uche Ubah..**

Depth...**1.0m**

Date: **19/08/2023...**

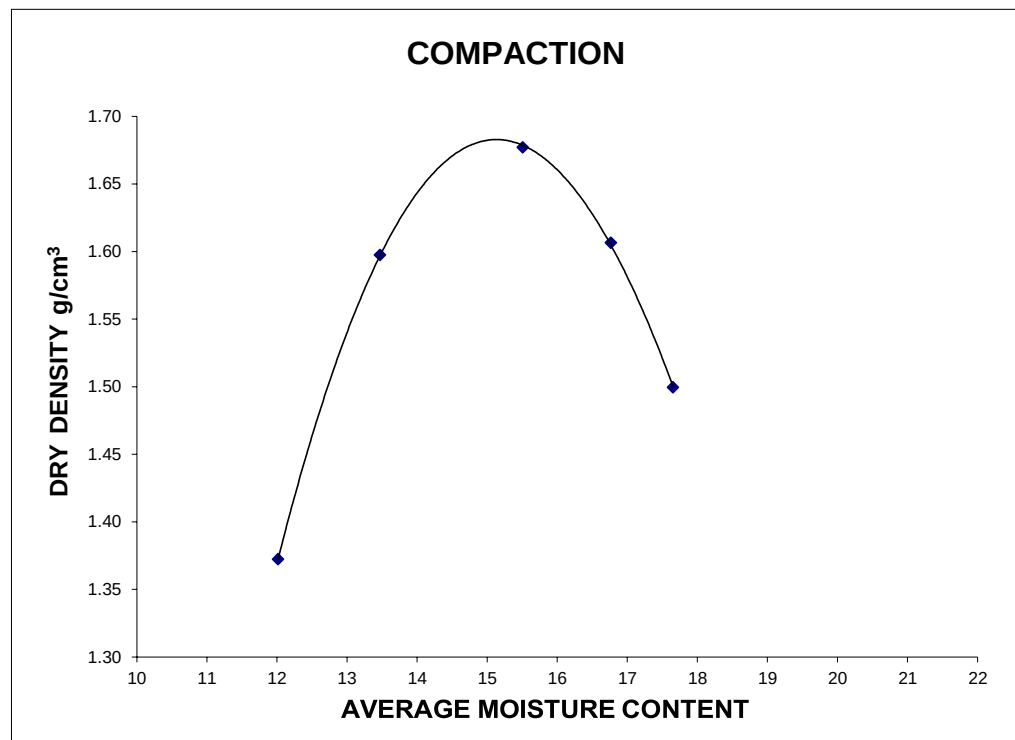
MDD: **1.68g/cm³**

Total weight of Sample.....**3000g**

OPT.MC: **15.0%**

B.S. / C.B.R. Mould.....**3383g**

Wt. of mould & wet Soil (W2) g	4914.00	5188.00	5312.00	5251.00	5140.00									
Wt. of mould (W1) g	3383.00	3383.00	3383.00	3383.00	3383.00									
Wt. of wet soil (W2-W1) g	1531.00	1805.00	1929.00	1868.00	1757.00									
Bulk Density (Pb) (W2-W1)/x g/cm ³	1.54	1.81	1.94	1.88	1.76									
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 995.79cm ³														
Container No.	NP	DD	VB	BS	PT	BO	PA	AE	EN	GI				
Wt. of wet soil & container (g)	50.60	49.60	59.90	63.80	44.60	41.70	50.90	47.50	49.70	52.60				
Wt. of Dry soil & container (g)	46.70	46.10	54.80	58.30	41.00	38.60	46.10	43.20	44.60	47.50				
Wt. of Container (g)	14.20	17.00	16.70	17.70	17.90	18.50	17.40	17.60	16.00	18.30				
Wt. of dry soil (Wd) g	32.50	29.10	38.10	40.60	23.10	20.10	28.70	25.60	28.60	29.20				
Wt. of Moisture (Wm) g	3.90	3.50	5.10	5.50	3.60	3.10	4.80	4.30	5.10	5.10				
Moistur Content 100(Wm/Wd) %	12.00	12.03	13.39	13.55	15.58	15.42	16.72	16.80	17.83	17.47				
Average Moisture Content (m) %	12.01		13.47		15.50		16.76		17.65					
Dry Density = Pb/1+ (m/100) (g/cm ³)	1.37		1.60		1.68		1.61		1.50					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD/HEAVY COMPACTION

Project... **B.Eng.**

Sample No: **Point 1 (6% Caustic Soda Stabilization)**

Student... **Samuel Uche Ubah..**

Depth:...**1.0m**

Date: **19/08/2023...**

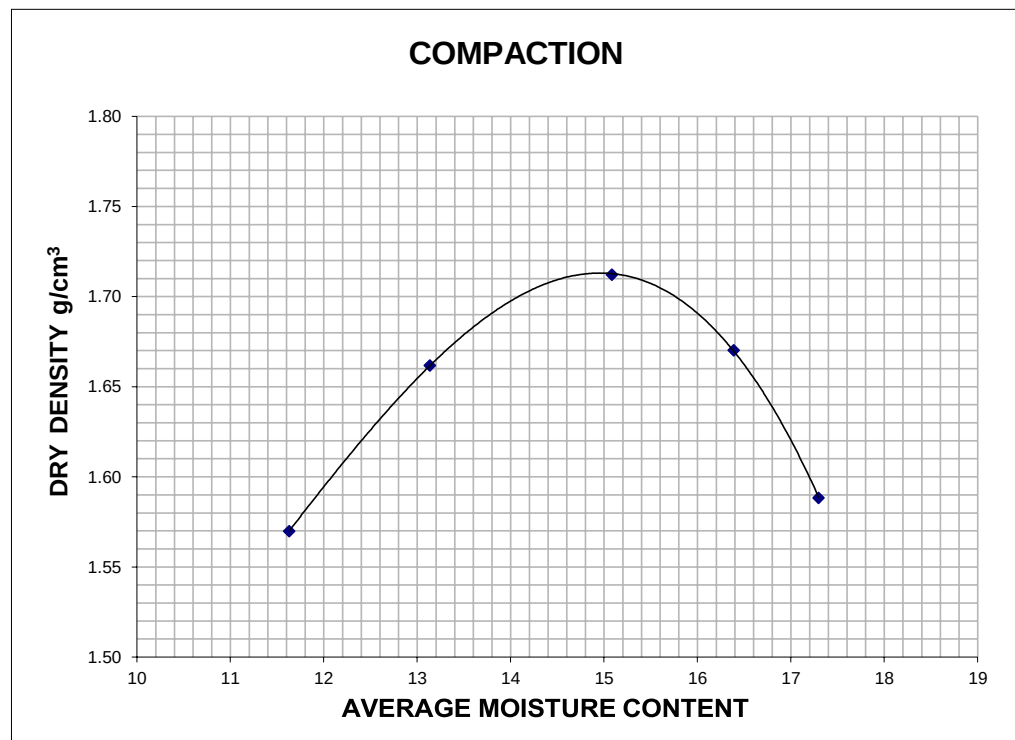
MDD: **1.71g/cm³**

Total weight of Sample.....**3000g**

OPT.MC: **14.8%**

B.S. / C.B.R. Mould.....**3383g**

Wt. of mould & wet Soil (W2) g	5030.00	5150.00	5235.00	5210.00	5134.00									
Wt. of mould (W1) g	3383.00	3383.00	3383.00	3383.00	3383.00									
Wt. of wet soil (W2-W1) g	1647.00	1767.00	1852.00	1827.00	1751.00									
Bulk Density (Pb) (W2-W1)/x g/cm³	1.75	1.88	1.97	1.94	1.86									
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 939.82cm³														
Container No.	OH	OB	JA	RT	OB	TW	VB	RZ	DE	JA				
Wt. of wet soil & container (g)	48.30	52.40	57.40	51.90	43.70	47.00	51.60	46.10	53.50	54.00				
Wt. of Dry soil & container (g)	44.90	48.80	52.80	47.90	40.20	43.20	46.60	41.80	48.40	48.60				
Wt. of Container (g)	15.70	17.80	17.60	17.60	17.00	18.00	16.60	15.10	18.90	17.40				
Wt. of dry soil (Wd) g	29.20	31.00	35.20	30.30	23.20	25.20	30.00	26.70	29.50	31.20				
Wt. of Moisture (Wm) g	3.40	3.60	4.60	4.00	3.50	3.80	5.00	4.30	5.10	5.40				
Moistur Content 100(Wm/Wd) %	11.64	11.61	13.07	13.20	15.09	15.08	16.67	16.10	17.29	17.31				
Average Moisture Content (m) %	11.63		13.13		15.08		16.39		17.30					
Dry Density = Pb/1+ (m/100) (g/cm³)	1.57		1.66		1.71		1.67		1.59					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD/HEAVY COMPACTION

Project... **B.Eng.**

Sample No: **Point 1 (8% Caustic Soda Stabilization)**

Student... **Samuel Uche Ubah..**

Depth:...**1.0m**

Date: **19/08/2023...**

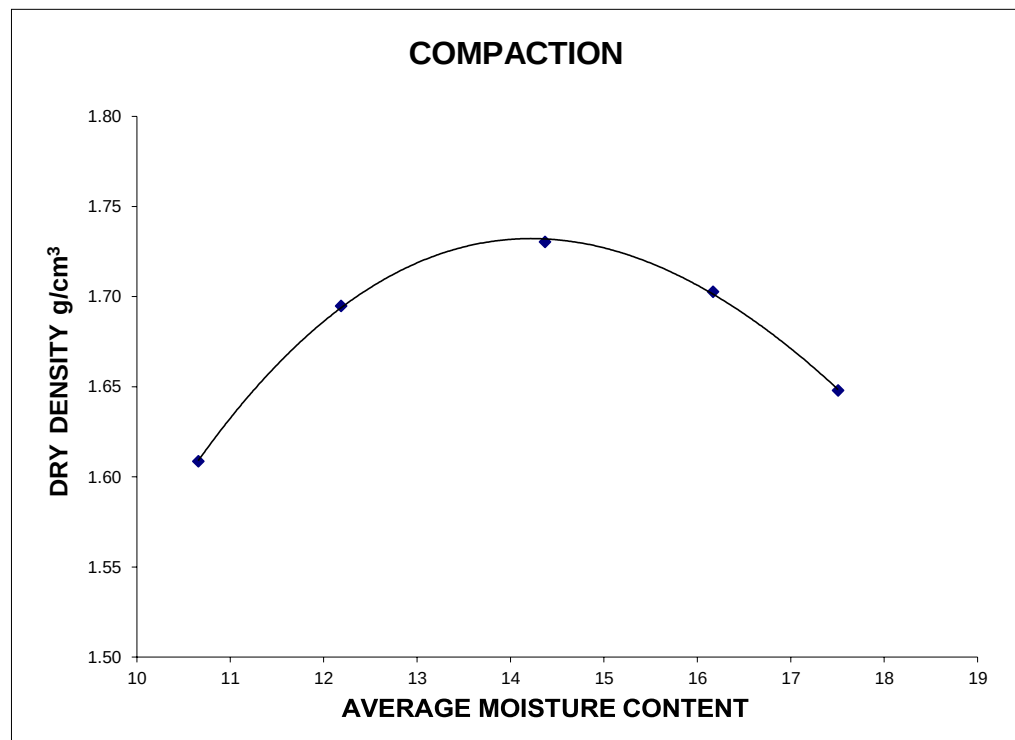
MDD: **1.73g/cm³**

Total weight of Sample.....**3000g**

OPT.MC: **14.1%**

B.S. / C.B.R. Mould.....**3383g**

Wt. of mould & wet Soil (W2) g	5056.00	5170.00	5243.00	5242.00	5203.00									
Wt. of mould (W1) g	3383.00	3383.00	3383.00	3383.00	3383.00									
Wt. of wet soil (W2-W1) g	1673.00	1787.00	1860.00	1859.00	1820.00									
Bulk Density (Pb) (W2-W1)/x g/cm ³	1.78	1.90	1.98	1.98	1.94									
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 939.82cm ³														
Container No.	RT	RF	ME	OB	PO	OH	VI	TA	PA	UK				
Wt. of wet soil & container (g)	46.70	56.60	56.50	58.00	53.10	54.40	52.60	66.30	42.10	42.50				
Wt. of Dry soil & container (g)	43.90	52.80	52.30	53.60	48.10	49.90	47.70	59.50	38.40	38.10				
Wt. of Container (g)	17.50	17.30	18.10	17.20	13.60	18.30	17.20	17.70	17.40	12.80				
Wt. of dry soil (Wd) g	26.40	35.50	34.20	36.40	34.50	31.60	30.50	41.80	21.00	25.30				
Wt. of Moisture (Wm) g	2.80	3.80	4.20	4.40	5.00	4.50	4.90	6.80	3.70	4.40				
Moistur Content 100(Wm/Wd) %	10.61	10.70	12.28	12.09	14.49	14.24	16.07	16.27	17.62	17.39				
Average Moisture Content (m) %	10.66	12.18	14.37	16.17	17.51									
Dry Density = Pb/1+ (m/100) (g/cm ³)	1.61	1.69	1.73	1.70	1.65									
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD/HEAVY COMPACTION

Project....**B.Eng.**

Sample No: **Point 1 (10% Caustic Soda Stabilization)**

Student... **Samuel Uche Ubah..**

Depth:...**1.0m**

Date: **19/08/2023...**

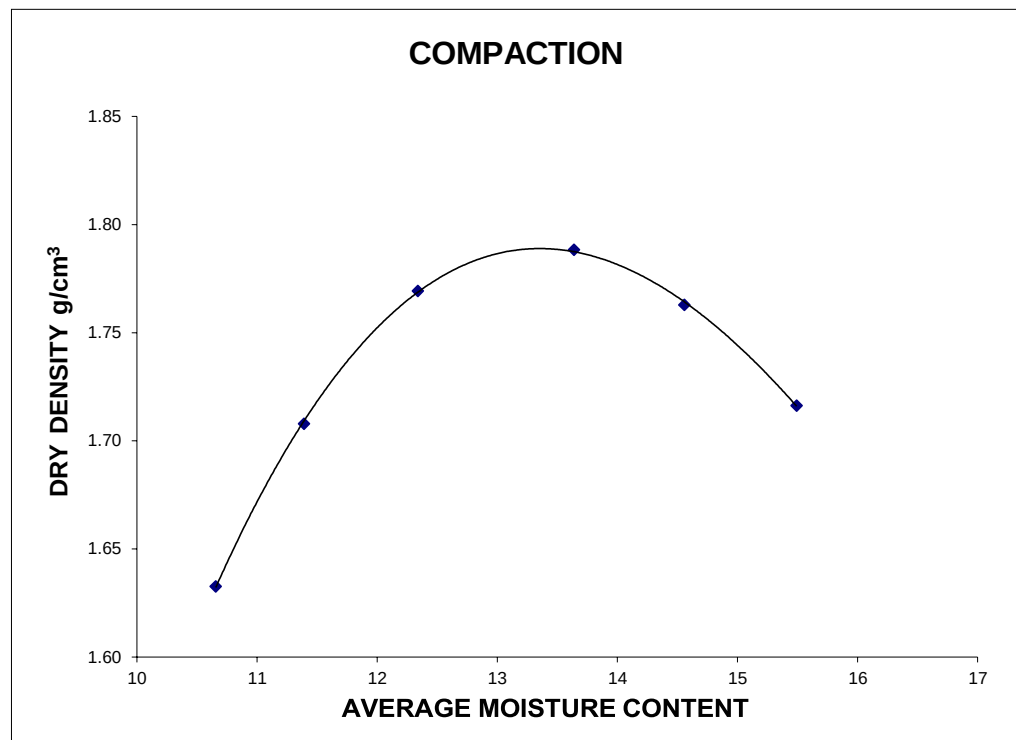
MDD: **1.79g/cm³**

Total weight of Sample.....**3000g**

OPT.MC: **13.3%**

B.S. / C.B.R. Mould.....**3222g**

Wt. of mould & wet Soil (W2) g	4920.00	5010.00	5090.00	5132.00	5120.00	5085.00								
Wt. of mould (W1) g	3222.00	3222.00	3222.00	3222.00	3222.00	3222.00								
Wt. of wet soil (W2-W1) g	1698.00	1788.00	1868.00	1910.00	1898.00	1863.00								
Bulk Density (Pb) (W2-W1)/x g/cm ³	1.81	1.90	1.99	2.03	2.02	1.98								
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 939.82cm ³														
Container No.	RT	RF	ME	OB	PO	OH	VI	TA	PA	UK	PA	UK		
Wt. of wet soil & container (g)	46.70	56.60	56.50	58.00	53.10	54.40	52.60	66.30	42.10	42.50	42.10	42.50		
Wt. of Dry soil & container (g)	43.90	52.80	52.60	53.80	48.80	50.40	48.40	60.40	38.90	38.80	38.80	38.50		
Wt. of Container (g)	17.50	17.30	18.10	17.20	13.60	18.30	17.20	17.70	17.40	12.80	17.40	12.80		
Wt. of dry soil (Wd) g	26.40	35.50	34.50	36.60	35.20	32.10	31.20	42.70	21.50	26.00	21.40	25.70		
Wt. of Moisture (Wm) g	2.80	3.80	3.90	4.20	4.30	4.00	4.20	5.90	3.20	3.70	3.30	4.00		
Moistur Content 100(Wm/Wd) %	10.61	10.70	11.30	11.48	12.22	12.46	13.46	13.82	14.88	14.23	15.42	15.56		
Average Moisture Content (m) %	10.66	11.39	12.34	13.64	14.56	15.49								
Dry Density = Pb/1+ (m/100) (g/cm ³)	1.63	1.71	1.77	1.79	1.76	1.72								
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD/HEAVY COMPACTION

Project....**B.Eng.**

Sample No: **Point 1**

Student... **Samuel Uche Ubah..**

Depth:...**1.0m**

Date: **19/08/2023...**

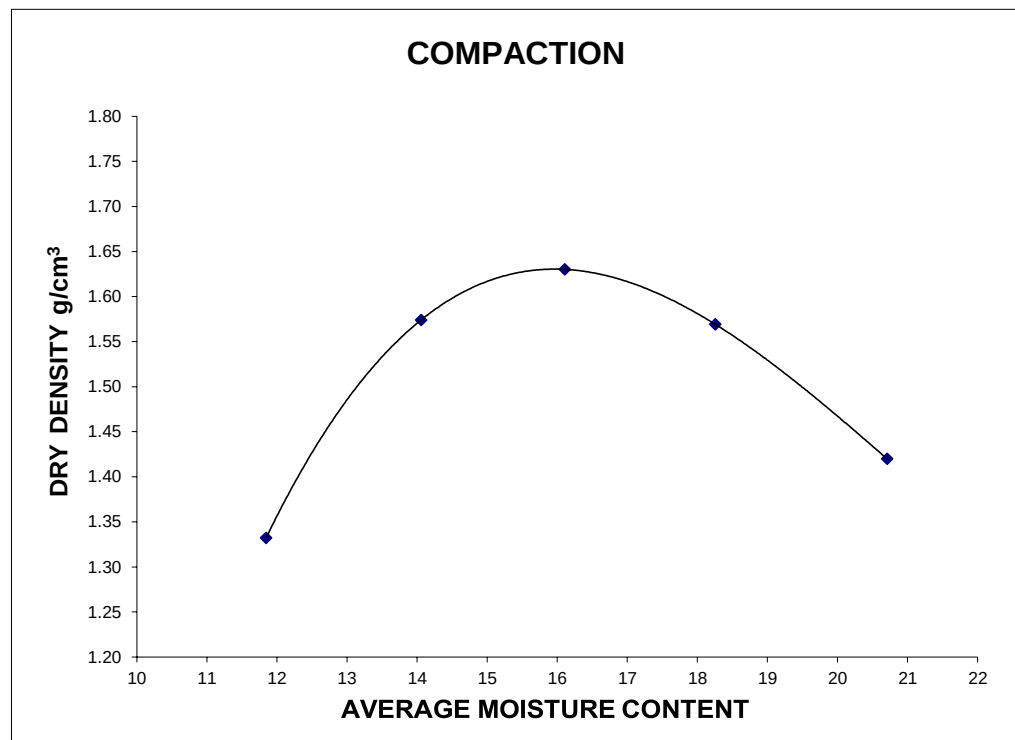
MDD: **1.63g/cm³**

Total weight of Sample.....**3000g**

OPT.MC: **15.7%**

B.S. / C.B.R. Mould.....**4662g**

Wt. of mould & wet Soil (W2) g	6146.00	6450.00	6547.00	6510.00	6369.00									
Wt. of mould (W1) g	4662.00	4662.00	4662.00	4662.00	4662.00									
Wt. of wet soil (W2-W1) g	1484.00	1788.00	1885.00	1848.00	1707.00									
Bulk Density (Pb) (W2-W1)/x g/cm ³	1.49	1.80	1.89	1.86	1.71									
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 995.79cm ³														
Container No.	KE	RT	OZ	OB	TH	RT	FI	OT	NO	OD				
Wt. of wet soil & container (g)	56.34	58.28	61.19	71.51	60.24	70.77	66.42	73.05	54.61	68.65				
Wt. of Dry soil & container (g)	51.89	53.99	55.81	64.82	54.06	63.37	58.56	64.54	48.48	60.04				
Wt. of Container (g)	14.46	17.62	17.44	17.34	15.66	17.46	15.83	17.55	19.05	18.21				
Wt. of dry soil (Wd) g	37.43	36.37	38.37	47.48	38.40	45.91	42.73	46.99	29.43	41.83				
Wt. of Moisture (Wm) g	4.45	4.29	5.38	6.69	6.18	7.40	7.86	8.51	6.13	8.61				
Moistur Content 100(Wm/Wd) %	11.89	11.80	14.02	14.09	16.09	16.12	18.39	18.11	20.83	20.58				
Average Moisture Content (m) %	11.84	14.06	16.11	18.25	20.71									
Dry Density = Pb/1+ (m/100) (g/cm ³)	1.33	1.57	1.63	1.57	1.42									
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD/HEAVY COMPACTION

Project....**B.Eng.**

Sample No: **Point 2 (2% Caustic Soda Stabilization)**

Student... **Samuel Uche Ubah..**

Depth:...**1.0m**

Date: **19/08/2023...**

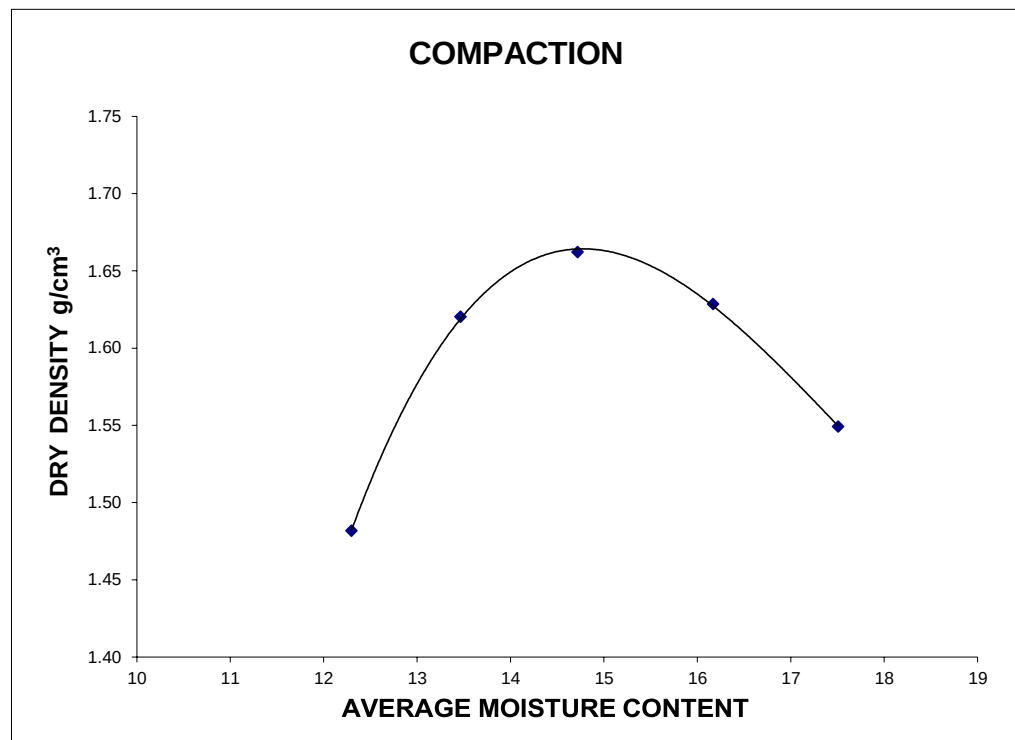
MDD: **1.66g/cm³**

Total weight of Sample.....**3000g**

OPT.MC: **14.7%**

B.S. / C.B.R. Mould.....**3492g**

Wt. of mould & wet Soil (W2) g	5056.00	5220.00	5284.00	5270.00	5203.00									
Wt. of mould (W1) g	3492.00	3492.00	3492.00	3492.00	3492.00									
Wt. of wet soil (W2-W1) g	1564.00	1728.00	1792.00	1778.00	1711.00									
Bulk Density (Pb) (W2-W1)/x g/cm ³	1.66	1.84	1.91	1.89	1.82									
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 939.82cm ³														
Container No.	RT	RF	ME	OB	PO	OH	VI	TA	PA	UK				
Wt. of wet soil & container (g)	46.70	56.60	56.50	58.00	53.10	54.40	52.60	66.30	42.10	42.50				
Wt. of Dry soil & container (g)	43.50	52.30	52.00	53.10	48.00	49.80	47.70	59.50	38.40	38.10				
Wt. of Container (g)	17.50	17.30	18.10	17.20	13.60	18.30	17.20	17.70	17.40	12.80				
Wt. of dry soil (Wd) g	26.00	35.00	33.90	35.90	34.40	31.50	30.50	41.80	21.00	25.30				
Wt. of Moisture (Wm) g	3.20	4.30	4.50	4.90	5.10	4.60	4.90	6.80	3.70	4.40				
Moistur Content 100(Wm/Wd) %	12.31	12.29	13.27	13.65	14.83	14.60	16.07	16.27	17.62	17.39				
Average Moisture Content (m) %	12.30		13.46		14.71		16.17		17.51					
Dry Density = Pb/1+ (m/100) (g/cm ³)	1.48		1.62		1.66		1.63		1.55					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD/HEAVY COMPACTION

Student: **Samuel Uche**

Sample ID: **Point 2, 4% Caustic Soda Stabilization**

Date: **22/08/23**

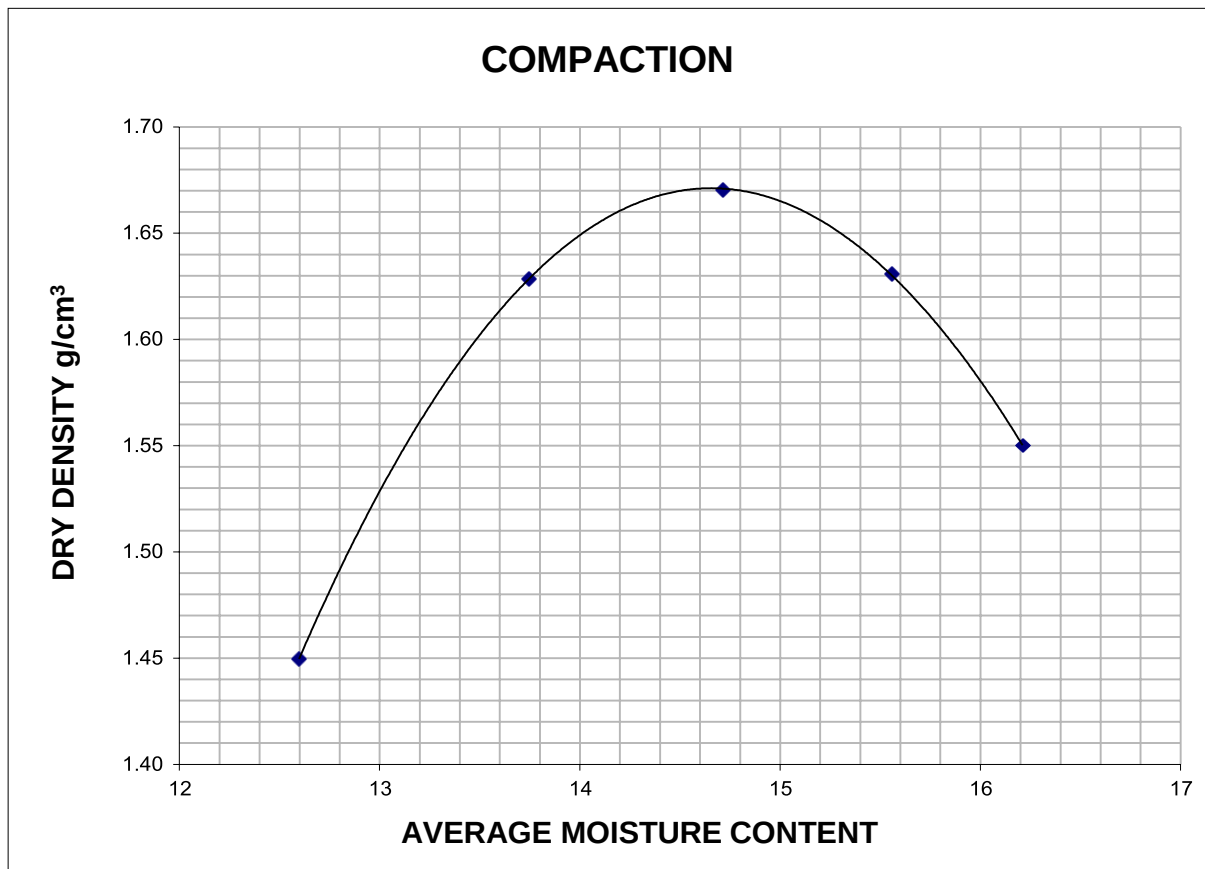
MDD: **1.67g/cm³**

Total weight of Sample: **...3000g.....**

OPT.MC: **14.6%**

B.S. / C.B.R. Mould **...3589g**

Wt. of mould & wet Soil (W2) g	5123.00	5330.00	5390.00	5360.00	5282.00									
Wt. of mould (W1) g	3589.00	3589.00	3589.00	3589.00	3589.00									
Wt. of wet soil (W2-W1) g	1534.00	1741.00	1801.00	1771.00	1693.00									
Bulk Density (Pb) (W2-W1)/x g/cm ³	1.63	1.85	1.92	1.88	1.80									
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 939.82 g/cm ³														
Container No.	OB	BZ	OH	DE	TA	RT	OZ	IR	OZ	OA				
Wt. of wet soil & container (g)	48.70	41.90	58.90	51.50	56.70	53.40	65.30	61.90	71.70	70.30				
Wt. of Dry soil & container (g)	45.30	39.10	54.10	47.50	51.60	48.80	57.50	55.90	64.00	63.10				
Wt. of Container (g)	17.90	17.20	18.80	18.70	17.30	17.20	7.40	17.30	16.80	18.40				
Wt. of dry soil (Wd) g	27.40	21.90	35.30	28.80	34.30	31.60	50.10	38.60	47.20	44.70				
Wt. of Moisture (Wm) g	3.40	2.80	4.80	4.00	5.10	4.60	7.80	6.00	7.70	7.20				
Moistur Content 100(Wm/Wd) %	12.41	12.79	13.60	13.89	14.87	14.56	15.57	15.54	16.31	16.11				
Average Moisture Content (m) %	12.60		13.74		14.71		15.56		16.21					
Dry Density = Pb/1+ (m/100) (g/cm ³)	1.45		1.63		1.67		1.63		1.55					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD/HEAVY COMPACTION

Project....**B.Eng.**

Sample No: **Point 2 (6% Caustic Soda Stabilization)**

Student... **Samuel Uche Ubah..**

Depth:...**1.0m**

Date: **19/08/2023...**

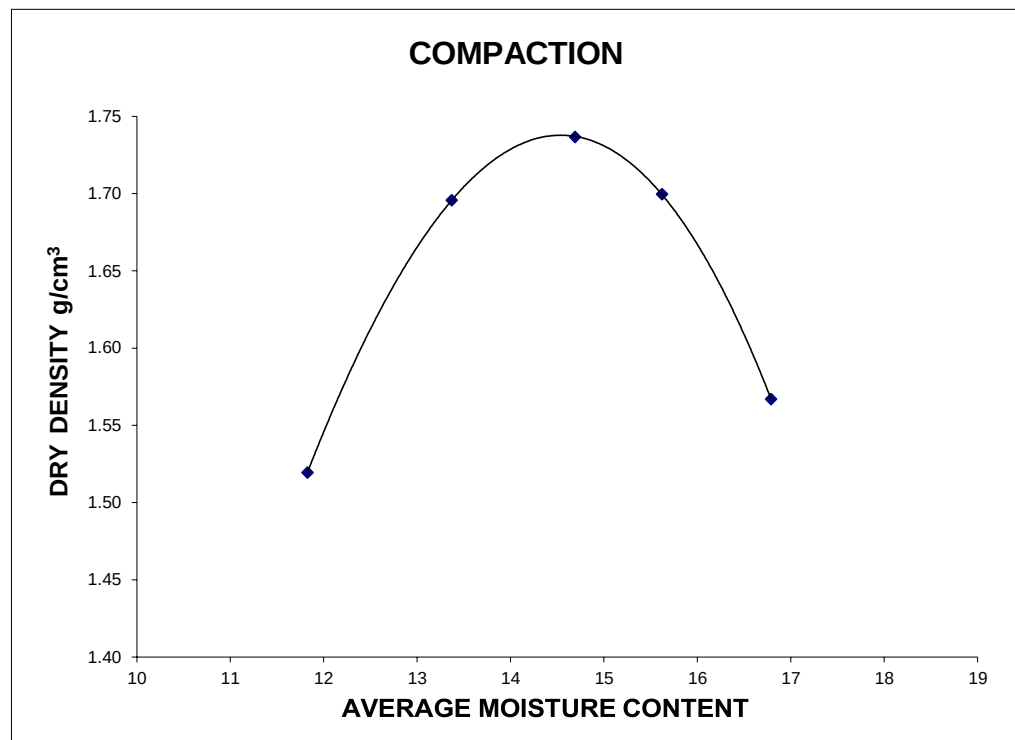
MDD: **1.74g/cm³**

Total weight of Sample.....**3000g**

OPT.MC: **14.5%**

B.S. / C.B.R. Mould.....**3413g**

Wt. of mould & wet Soil (W2) g	5010.00	5220.00	5285.00	5260.00	5133.00									
Wt. of mould (W1) g	3413.00	3413.00	3413.00	3413.00	3413.00									
Wt. of wet soil (W2-W1) g	1597.00	1807.00	1872.00	1847.00	1720.00									
Bulk Density (Pb) (W2-W1)/x g/cm ³	1.70	1.92	1.99	1.97	1.83									
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 939.82cm ³														
Container No.	ZT	OI	NT	SE	XU	GM	AK	OB	SA	PZ				
Wt. of wet soil & container (g)	59.10	50.50	54.60	55.00	50.30	47.50	61.80	68.00	62.70	61.20				
Wt. of Dry soil & container (g)	55.50	47.60	50.90	51.40	46.70	44.10	56.70	62.10	56.90	55.50				
Wt. of Container (g)	24.90	23.20	23.20	24.50	21.70	21.40	23.90	24.50	22.60	21.30				
Wt. of dry soil (Wd) g	30.60	24.40	27.70	26.90	25.00	22.70	32.80	37.60	34.30	34.20				
Wt. of Moisture (Wm) g	3.60	2.90	3.70	3.60	3.60	3.40	5.10	5.90	5.80	5.70				
Moistur Content 100(Wm/Wd) %	11.76	11.89	13.36	13.38	14.40	14.98	15.55	15.69	16.91	16.67				
Average Moisture Content (m) %	11.82		13.37		14.69		15.62		16.79					
Dry Density = Pb/1+ (m/100) (g/cm ³)	1.52		1.70		1.74		1.70		1.57					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD/HEAVY COMPACTION

Student: **Samuel Uche**

Sample ID: **Point 2, 8% Caustic Soda Stabilization**

Date: **22/08/23**

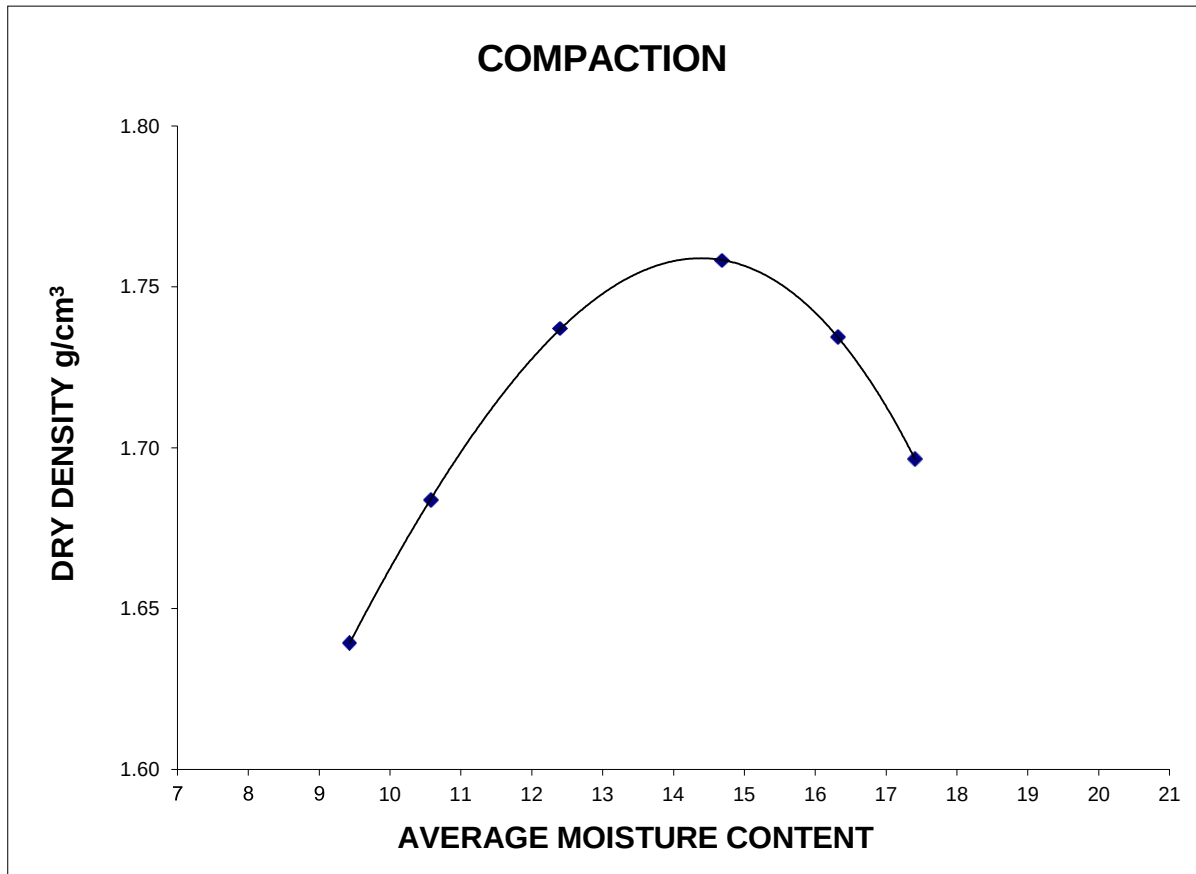
MDD: **1.76g/cm³**

Total weight of Sample: **...3000g.....**

OPT.MC: **14.3%**

B.S. / C.B.R. Mould: **...3355g**

Wt. of mould & wet Soil (W2) g	5041.00	5105.00	5190.00	5250.00	5251.00	5227.00								
Wt. of mould (W1) g	3355.00	3355.00	3355.00	3355.00	3355.00	3355.00								
Wt. of wet soil (W2-W1) g	1686.00	1750.00	1835.00	1895.00	1896.00	1872.00								
Bulk Density (Pb) (W2-W1)/x g/cm ³	1.79	1.86	1.95	2.02	2.02	1.99								
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 939.82 g/cm ³														
Container No.	MU	TE	RT	TB	JA	OH	EN	XX	ET	JA	TA	AT		
Wt. of wet soil & container (g)	51.00	42.20	54.30	54.50	51.00	55.70	58.10	55.90	64.70	61.80	54.80	57.70		
Wt. of Dry soil & container (g)	48.20	40.10	50.80	50.90	47.30	51.60	53.00	51.10	58.00	55.60	49.20	51.80		
Wt. of Container (g)	18.00	18.20	17.30	17.30	17.40	18.60	18.60	18.10	17.50	17.10	17.50	17.40		
Wt. of dry soil (Wd) g	30.20	21.90	33.50	33.60	29.90	33.00	34.40	33.00	40.50	38.50	31.70	34.40		
Wt. of Moisture (Wm) g	2.80	2.10	3.50	3.60	3.70	4.10	5.10	4.80	6.70	6.20	5.60	5.90		
Moistur Content 100(Wm/Wd) %	9.27	9.59	10.45	10.71	12.37	12.42	14.83	14.55	16.54	16.10	17.67	17.15		
Average Moisture Content (m) %	9.43		10.58		12.40		14.69		16.32		17.41			
Dry Density = Pb/1+ (m/100) (g/cm ³)	1.64		1.68		1.74		1.76		1.73		1.70			
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD/HEAVY COMPACTION

Project....**B.Eng.**

Sample No: **Point 2 (10% Caustic Soda Stabilization)**

Student... **Samuel Uche Ubah..**

Depth:...**1.0m**

Date: **19/08/2023...**

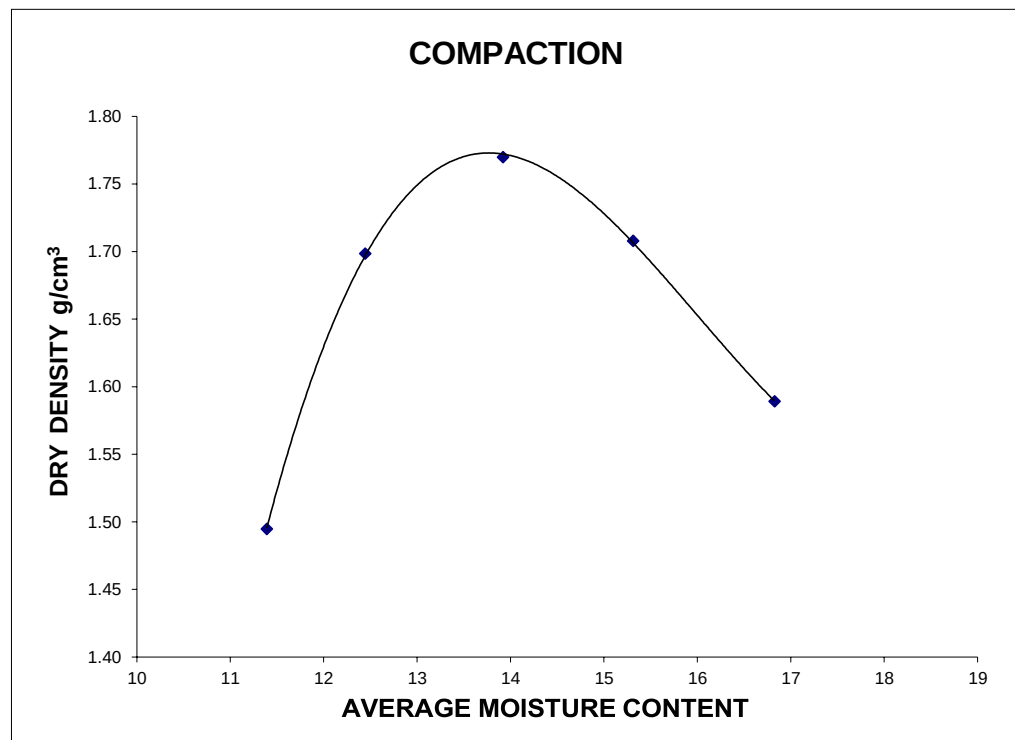
MDD: **1.77g/cm³**

Total weight of Sample.....**3000g**

OPT.MC: **13.8%**

B.S. / C.B.R. Mould.....**3355g**

Wt. of mould & wet Soil (W2) g	4920.00	5150.00	5250.00	5206.00	5100.00									
Wt. of mould (W1) g	3355.00	3355.00	3355.00	3355.00	3355.00									
Wt. of wet soil (W2-W1) g	1565.00	1795.00	1895.00	1851.00	1745.00									
Bulk Density (Pb) (W2-W1)/x g/cm ³	1.67	1.91	2.02	1.97	1.86									
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 939.82cm ³														
Container No.	WO	PI	RT	JA	JC	FH	TO	TN	TH	ME				
Wt. of wet soil & container (g)	46.50	56.00	50.30	46.10	46.00	58.50	52.80	52.70	42.70	42.30				
Wt. of Dry soil & container (g)	43.40	51.80	46.70	42.90	41.90	53.50	47.95	47.70	38.79	38.82				
Wt. of Container (g)	15.90	15.30	17.40	17.50	12.50	17.50	16.60	14.70	15.70	18.00				
Wt. of dry soil (Wd) g	27.50	36.50	29.30	25.40	29.40	36.00	31.35	33.00	23.09	20.82				
Wt. of Moisture (Wm) g	3.10	4.20	3.60	3.20	4.10	5.00	4.85	5.00	3.91	3.48				
Moistur Content 100(Wm/Wd) %	11.27	11.51	12.29	12.60	13.95	13.89	15.47	15.15	16.93	16.71				
Average Moisture Content (m) %	11.39		12.44		13.92		15.31		16.82					
Dry Density = Pb/1+ (m/100) (g/cm ³)	1.49		1.70		1.77		1.71		1.59					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD/HEAVY COMPACTION

Project....**B.Eng.**

Sample No: **Point 2**

Student... **Samuel Uche Ubah..**

Depth:..**1.0m**

Date: **19/08/2023...**

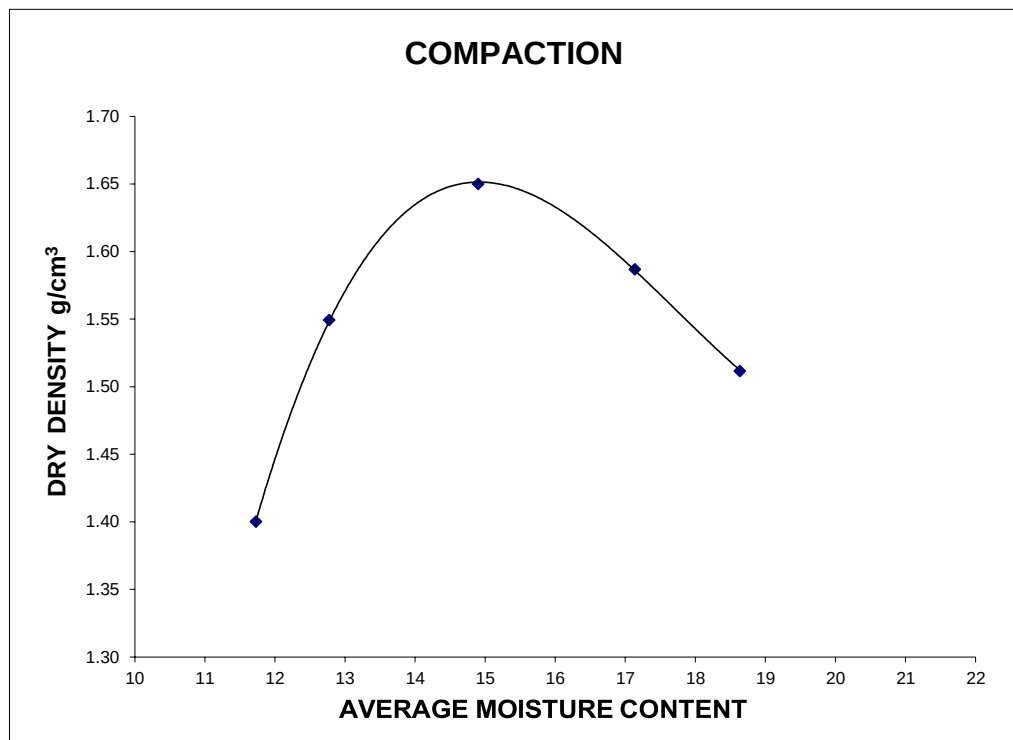
MDD: **1.65g/cm³**

Total weight of Sample.....**3000g**

OPT.MC: **14.8%**

B.S. / C.B.R. Mould.....**4662g**

Wt. of mould & wet Soil (W2) g	6220.00	6402.00	6550.00	6513.00	6448.00									
Wt. of mould (W1) g	4662.00	4662.00	4662.00	4662.00	4662.00									
Wt. of wet soil (W2-W1) g	1558.00	1740.00	1888.00	1851.00	1786.00									
Bulk Density (Pb) (W2-W1)/x g/cm ³	1.56	1.75	1.90	1.86	1.79									
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 995.79cm ³														
Container No.	JA	JB	B	HO	TE	UK	EN	NI	XO	DZ				
Wt. of wet soil & container (g)	45.00	52.54	63.68	57.46	70.23	58.79	62.92	60.67	54.71	49.17				
Wt. of Dry soil & container (g)	42.04	48.92	58.53	52.98	63.50	52.81	56.11	54.48	48.78	44.20				
Wt. of Container (g)	17.27	17.45	18.39	17.73	18.24	12.74	16.05	18.63	17.28	17.25				
Wt. of dry soil (Wd) g	24.77	31.47	40.14	35.25	45.26	40.07	40.06	35.85	31.50	26.95				
Wt. of Moisture (Wm) g	2.96	3.62	5.15	4.48	6.73	5.98	6.81	6.19	5.93	4.97				
Moistur Content 100(Wm/Wd) %	11.95	11.50	12.83	12.71	14.87	14.92	17.00	17.27	18.83	18.44				
Average Moisture Content (m) %	11.73		12.77		14.90		17.13		18.63					
Dry Density = Pb/1+ (m/100) (g/cm ³)	1.40		1.55		1.65		1.59		1.51					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD/HEAVY COMPACTION

Project... **B.Eng.**

Sample No: **Point 3 (2% Caustic Soda Stabilization)**

Student... **Samuel Uche Ubah..**

Depth:...**1.0m**

Date: **19/08/2023...**

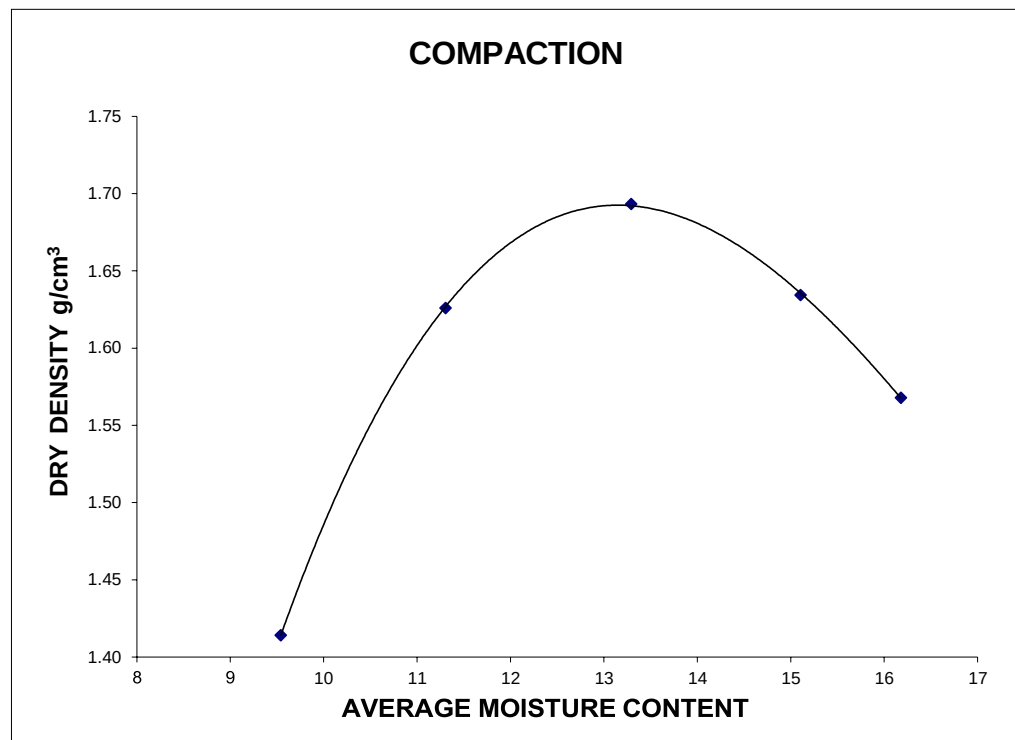
MDD: **1.69g/cm³**

Total weight of Sample.....**3000g**

OPT.MC: **13.1%**

B.S. / C.B.R. Mould.....**3492g**

Wt. of mould & wet Soil (W2) g	4948.00	5193.00	5295.00	5260.00	5204.00									
Wt. of mould (W1) g	3492.00	3492.00	3492.00	3492.00	3492.00									
Wt. of wet soil (W2-W1) g	1456.00	1701.00	1803.00	1768.00	1712.00									
Bulk Density (Pb) (W2-W1)/x g/cm ³	1.55	1.81	1.92	1.88	1.82									
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 939.82cm ³														
Container No.	FF	BZ	OA	B	PP	BO	JA	XY	OB	SA				
Wt. of wet soil & container (g)	56.30	44.20	47.80	52.40	54.20	55.30	53.70	46.30	57.60	50.30				
Wt. of Dry soil & container (g)	53.00	41.80	44.80	49.00	50.00	50.90	49.00	42.70	51.90	45.70				
Wt. of Container (g)	17.60	17.20	18.70	18.40	18.20	18.00	17.70	19.00	16.50	17.40				
Wt. of dry soil (Wd) g	35.40	24.60	26.10	30.60	31.80	32.90	31.30	23.70	35.40	28.30				
Wt. of Moisture (Wm) g	3.30	2.40	3.00	3.40	4.20	4.40	4.70	3.60	5.70	4.60				
Moistur Content 100(Wm/Wd) %	9.32	9.76	11.49	11.11	13.21	13.37	15.02	15.19	16.10	16.25				
Average Moisture Content (m) %	9.54		11.30		13.29		15.10		16.18					
Dry Density = Pb/1+ (m/100) (g/cm ³)	1.41		1.63		1.69		1.63		1.57					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD/HEAVY COMPACTION

Project... **B.Eng.**

Sample No: **Point 3 (4% Caustic Soda Stabilization)**

Student... **Samuel Uche Ubah..**

Depth...**1.0m**

Date: **19/08/2023...**

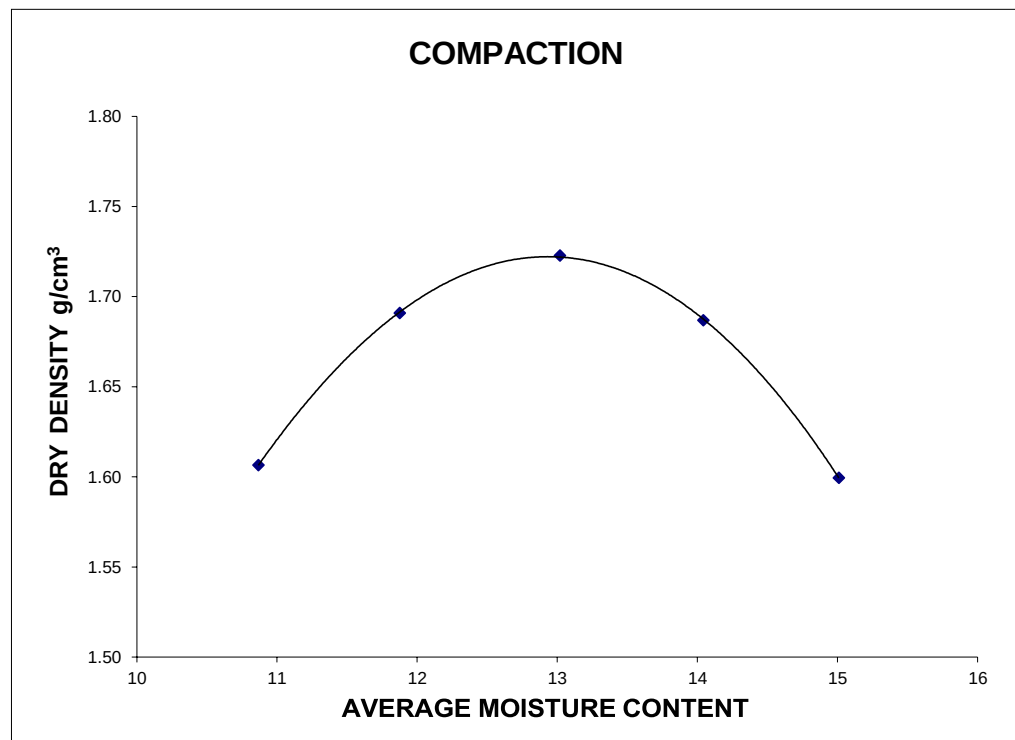
MDD: **1.72g/cm³**

Total weight of Sample.....**3000g**

OPT.MC: **12.9%**

B.S. / C.B.R. Mould.....**4682g**

Wt. of mould & wet Soil (W2) g	6356.00	6460.00	6512.00	6490.00	6411.00									
Wt. of mould (W1) g	4682.00	4682.00	4682.00	4682.00	4682.00									
Wt. of wet soil (W2-W1) g	1674.00	1778.00	1830.00	1808.00	1729.00									
Bulk Density (Pb) (W2-W1)/x g/cm ³	1.78	1.89	1.95	1.92	1.84									
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 939.82cm ³														
Container No.	OP	AB	NB	EI	OH	PN	LA	OC	R	RX				
Wt. of wet soil & container (g)	55.50	56.80	60.00	63.30	67.80	65.50	71.00	66.10	62.60	65.30				
Wt. of Dry soil & container (g)	51.70	52.80	55.40	58.40	62.05	59.95	64.50	60.20	56.45	59.00				
Wt. of Container (g)	17.00	15.70	16.80	17.00	17.90	17.30	18.20	18.20	15.50	17.00				
Wt. of dry soil (Wd) g	34.70	37.10	38.60	41.40	44.15	42.65	46.30	42.00	40.95	42.00				
Wt. of Moisture (Wm) g	3.80	4.00	4.60	4.90	5.75	5.55	6.50	5.90	6.15	6.30				
Moistur Content 100(Wm/Wd) %	10.95	10.78	11.92	11.84	13.02	13.01	14.04	14.05	15.02	15.00				
Average Moisture Content (m) %	10.87	11.88	13.02	14.04	15.01									
Dry Density = Pb/1+ (m/100) (g/cm ³)	1.61	1.69	1.72	1.69	1.60									
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD/HEAVY COMPACTION

Project... **B.Eng.**

Sample No: **Point 3 (6% Caustic Soda Stabilization)**

Student... **Samuel Uche Ubah..**

Depth:...**1.0m**

Date: **19/08/2023...**

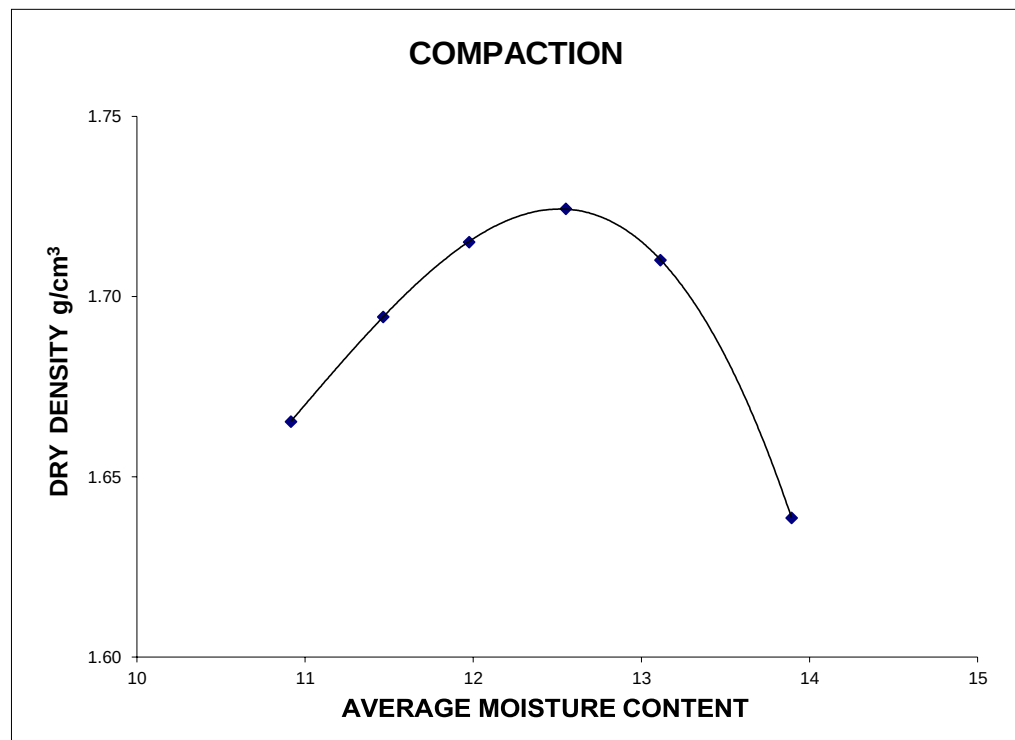
MDD: **1.73g/cm³**

Total weight of Sample.....**3000g**

OPT.MC: **12.5%**

B.S. / C.B.R. Mould.....**3216g**

Wt. of mould & wet Soil (W2) g	4952.00	4991.00	5021.00	5040.00	5034.00	4970.00								
Wt. of mould (W1) g	3216.00	3216.00	3216.00	3216.00	3216.00	3216.00								
Wt. of wet soil (W2-W1) g	1736.00	1775.00	1805.00	1824.00	1818.00	1754.00								
Bulk Density (Pb) (W2-W1)/x g/cm ³	1.85	1.89	1.92	1.94	1.93	1.87								
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 939.82cm ³														
Container No.	TN	PA	PS	NO	CB	PA	B	XY	TA	PA	IK	OT		
Wt. of wet soil & container (g)	45.80	45.70	53.50	47.60	57.80	54.70	60.40	60.70	64.80	69.00	64.60	61.70		
Wt. of Dry soil & container (g)	43.00	42.95	49.75	44.70	53.60	50.75	55.70	56.00	59.30	63.00	58.90	56.30		
Wt. of Container (g)	17.20	17.90	17.30	19.20	18.70	17.60	18.40	18.40	17.40	17.20	17.80	17.50		
Wt. of dry soil (Wd) g	25.80	25.05	32.45	25.50	34.90	33.15	37.30	37.60	41.90	45.80	41.10	38.80		
Wt. of Moisture (Wm) g	2.80	2.75	3.75	2.90	4.20	3.95	4.70	4.70	5.50	6.00	5.70	5.40		
Moistur Content 100(Wm/Wd) %	10.85	10.98	11.56	11.37	12.03	11.92	12.60	12.50	13.13	13.10	13.87	13.92		
Average Moisture Content (m) %	10.92		11.46		11.97		12.55		13.11		13.89			
Dry Density = Pb/1+ (m/100) (g/cm ³)	1.67		1.69		1.72		1.72		1.71		1.64			
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD/HEAVY COMPACTION

Project... **B.Eng.**

Sample No: **Point 3 (8% Caustic Soda Stabilization)**

Student... **Samuel Uche Ubah..**

Depth:...**1.0m**

Date: **19/08/2023...**

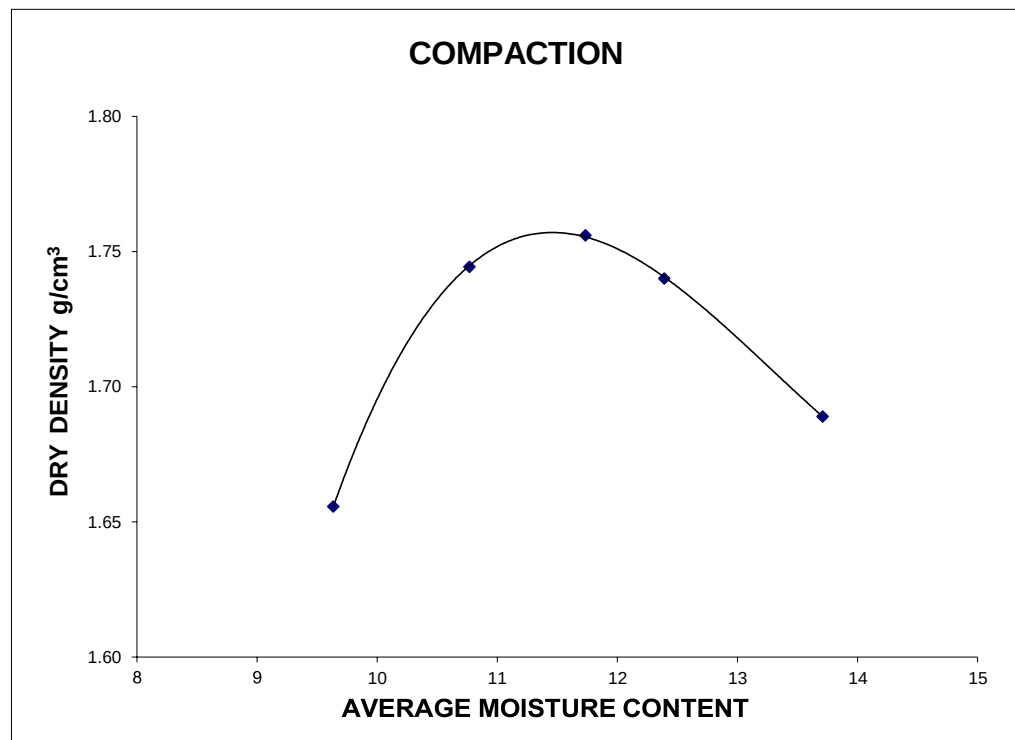
MDD: **1.76g/cm³**

Total weight of Sample.....**3000g**

OPT.MC: **11.4%**

B.S. / C.B.R. Mould.....**4706g**

Wt. of mould & wet Soil (W2) g	6412.00	6522.00	6550.00	6544.00	6511.00									
Wt. of mould (W1) g	4706.00	4706.00	4706.00	4706.00	4706.00									
Wt. of wet soil (W2-W1) g	1706.00	1816.00	1844.00	1838.00	1805.00									
Bulk Density (Pb) (W2-W1)/x g/cm ³	1.82	1.93	1.96	1.96	1.92									
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 939.82cm ³														
Container No.	OP	AB	NB	EI	OH	PN	LA	OC	R	RX				
Wt. of wet soil & container (g)	55.50	56.80	60.00	63.30	67.80	65.50	71.00	66.10	62.60	65.30				
Wt. of Dry soil & container (g)	52.20	53.10	55.80	58.80	62.60	60.40	65.20	60.80	56.90	59.50				
Wt. of Container (g)	17.00	15.70	16.80	17.00	17.90	17.30	18.20	18.20	15.50	17.00				
Wt. of dry soil (Wd) g	35.20	37.40	39.00	41.80	44.70	43.10	47.00	42.60	41.40	42.50				
Wt. of Moisture (Wm) g	3.30	3.70	4.20	4.50	5.20	5.10	5.80	5.30	5.70	5.80				
Moistur Content 100(Wm/Wd) %	9.37	9.89	10.77	10.77	11.63	11.83	12.34	12.44	13.77	13.65				
Average Moisture Content (m) %	9.63		10.77		11.73		12.39		13.71					
Dry Density = Pb/1+ (m/100) (g/cm ³)	1.66		1.74		1.76		1.74		1.69					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD/HEAVY COMPACTION

Project....**B.Eng.**

Sample No: **Point 3 (10% Caustic Soda Stabilization)**

Student... **Samuel Uche Ubah..**

Depth:...**1.0m**

Date: **19/08/2023...**

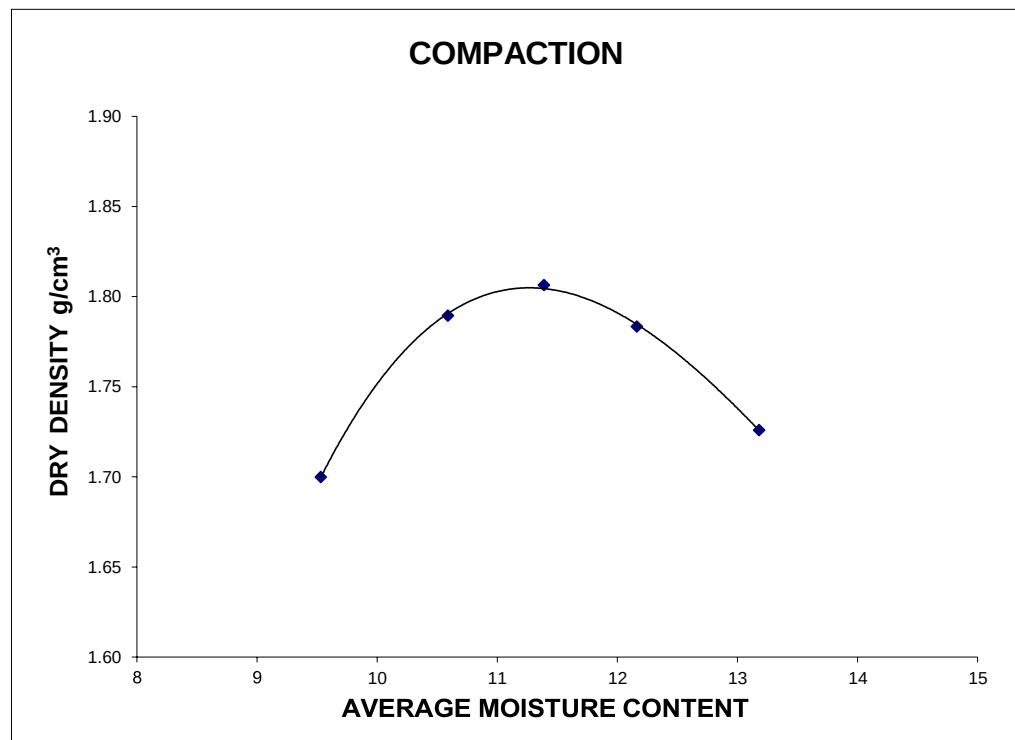
MDD: **1.80g/cm³**

Total weight of Sample.....**3000g**

OPT.MC: **11.2%**

B.S. / C.B.R. Mould.....**3110g**

Wt. of mould & wet Soil (W2) g	4860.00	4970.00	5001.00	4990.00	4946.00									
Wt. of mould (W1) g	3110.00	3110.00	3110.00	3110.00	3110.00									
Wt. of wet soil (W2-W1) g	1750.00	1860.00	1891.00	1880.00	1836.00									
Bulk Density (Pb) (W2-W1)/x g/cm ³	1.86	1.98	2.01	2.00	1.95									
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 939.82cm ³														
Container No.	OZ	AN	DR	MI	IK	OH	UR	CD	RB	DE				
Wt. of wet soil & container (g)	56.20	52.30	64.00	65.20	64.90	67.80	60.70	62.10	67.70	61.30				
Wt. of Dry soil & container (g)	52.80	49.30	59.60	60.60	59.90	62.70	56.00	57.40	61.80	56.30				
Wt. of Container (g)	16.80	18.10	18.10	17.10	16.30	17.60	17.70	18.40	17.10	18.30				
Wt. of dry soil (Wd) g	36.00	31.20	41.50	43.50	43.60	45.10	38.30	39.00	44.70	38.00				
Wt. of Moisture (Wm) g	3.40	3.00	4.40	4.60	5.00	5.10	4.70	4.70	5.90	5.00				
Moistur Content 100(Wm/Wd) %	9.44	9.62	10.60	10.57	11.47	11.31	12.27	12.05	13.20	13.16				
Average Moisture Content (m) %	9.53		10.59		11.39		12.16		13.18					
Dry Density = Pb/1+ (m/100) (g/cm ³)	1.70		1.79		1.81		1.78		1.73					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD/HEAVY COMPACTION

Project....**B.Eng.**

Sample No: **Point 3**

Student... **Samuel Uche Ubah..**

Depth:...**1.0m**

Date: **19/08/2023...**

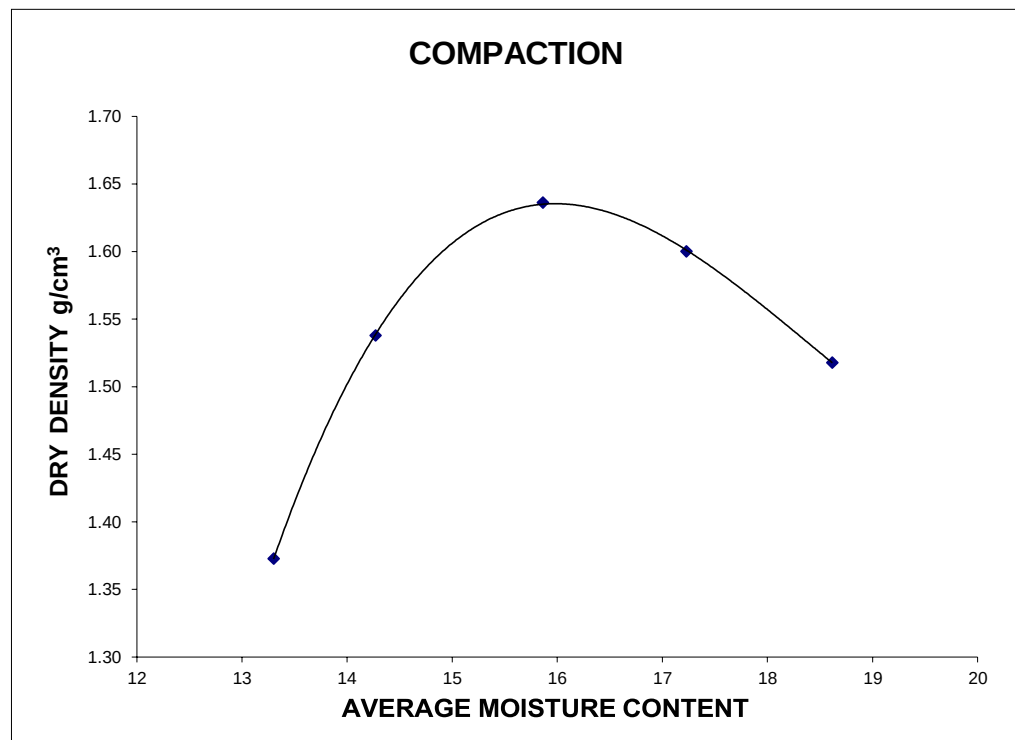
MDD: **1.63g/cm³**

Total weight of Sample.....**3000g**

OPT.MC: **15.9%**

B.S. / C.B.R. Mould.....**4662g**

Wt. of mould & wet Soil (W2) g	6211.00	6412.00	6550.00	6530.00	6455.00									
Wt. of mould (W1) g	4662.00	4662.00	4662.00	4662.00	4662.00									
Wt. of wet soil (W2-W1) g	1549.00	1750.00	1888.00	1868.00	1793.00									
Bulk Density (Pb) (W2-W1)/x g/cm ³	1.56	1.76	1.90	1.88	1.80									
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 995.79cm ³														
Container No.	VO	ZU	PA	OB	OH	DA	TA	CB	BB	CT				
Wt. of wet soil & container (g)	40.13	37.13	50.72	51.31	47.72	46.56	46.70	46.04	49.00	58.23				
Wt. of Dry soil & container (g)	37.34	34.94	46.60	46.80	43.60	42.60	42.40	42.00	44.10	51.90				
Wt. of Container (g)	16.39	18.45	17.33	15.62	17.63	17.63	17.32	18.66	17.50	18.25				
Wt. of dry soil (Wd) g	20.95	16.49	29.27	31.18	25.97	24.97	25.08	23.34	26.60	33.65				
Wt. of Moisture (Wm) g	2.79	2.19	4.12	4.51	4.12	3.96	4.30	4.04	4.90	6.33				
Moistur Content 100(Wm/Wd) %	13.32	13.28	14.08	14.46	15.86	15.86	17.15	17.31	18.42	18.81				
Average Moisture Content (m) %	13.30		14.27		15.86		17.23		18.62					
Dry Density = Pb/1+ (m/100) (g/cm ³)	1.37		1.54		1.64		1.60		1.52					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD/HEAVY COMPACTION

Project....**B.Eng.**

Sample No: **Point 4 (2% Caustic Soda Stabilization)**

Student... **Samuel Uche Ubah..**

Depth:...**1.0m**

Date: **19/08/2023...**

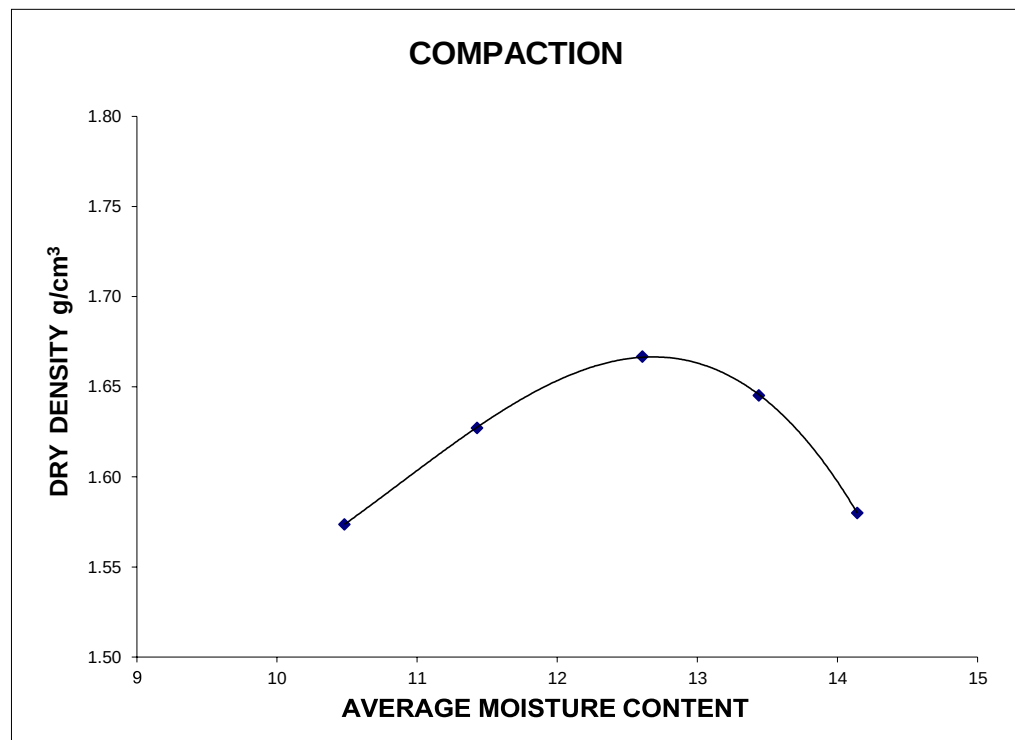
MDD: **1.67g/cm³**

Total weight of Sample.....**3000g**

OPT.MC: **12.6%**

B.S. / C.B.R. Mould.....**4706g**

Wt. of mould & wet Soil (W2) g	6340.00	6410.00	6470.00	6460.00	6401.00									
Wt. of mould (W1) g	4706.00	4706.00	4706.00	4706.00	4706.00									
Wt. of wet soil (W2-W1) g	1634.00	1704.00	1764.00	1754.00	1695.00									
Bulk Density (Pb) (W2-W1)/x g/cm ³	1.74	1.81	1.88	1.87	1.80									
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 939.82cm ³														
Container No.	GG	HI	PL	TO	IK	BO	SE	T	TO	IZ				
Wt. of wet soil & container (g)	58.90	51.40	57.60	61.30	59.30	66.00	70.10	67.90	62.90	60.00				
Wt. of Dry soil & container (g)	55.00	48.10	53.40	56.90	54.50	60.70	63.90	61.90	57.20	54.60				
Wt. of Container (g)	17.20	17.10	17.80	17.10	17.00	18.00	17.50	17.50	16.90	16.40				
Wt. of dry soil (Wd) g	37.80	31.00	35.60	39.80	37.50	42.70	46.40	44.40	40.30	38.20				
Wt. of Moisture (Wm) g	3.90	3.30	4.20	4.40	4.80	5.30	6.20	6.00	5.70	5.40				
Moistur Content 100(Wm/Wd) %	10.32	10.65	11.80	11.06	12.80	12.41	13.36	13.51	14.14	14.14				
Average Moisture Content (m) %	10.48		11.43		12.61		13.44		14.14					
Dry Density = Pb/1+ (m/100) (g/cm ³)	1.57		1.63		1.67		1.65		1.58					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD/HEAVY COMPACTION

Student: **Samuel Uche**

Sample ID: **Point 4, 4% Caustic Soda Stabilization**

Date: **22/08/23**

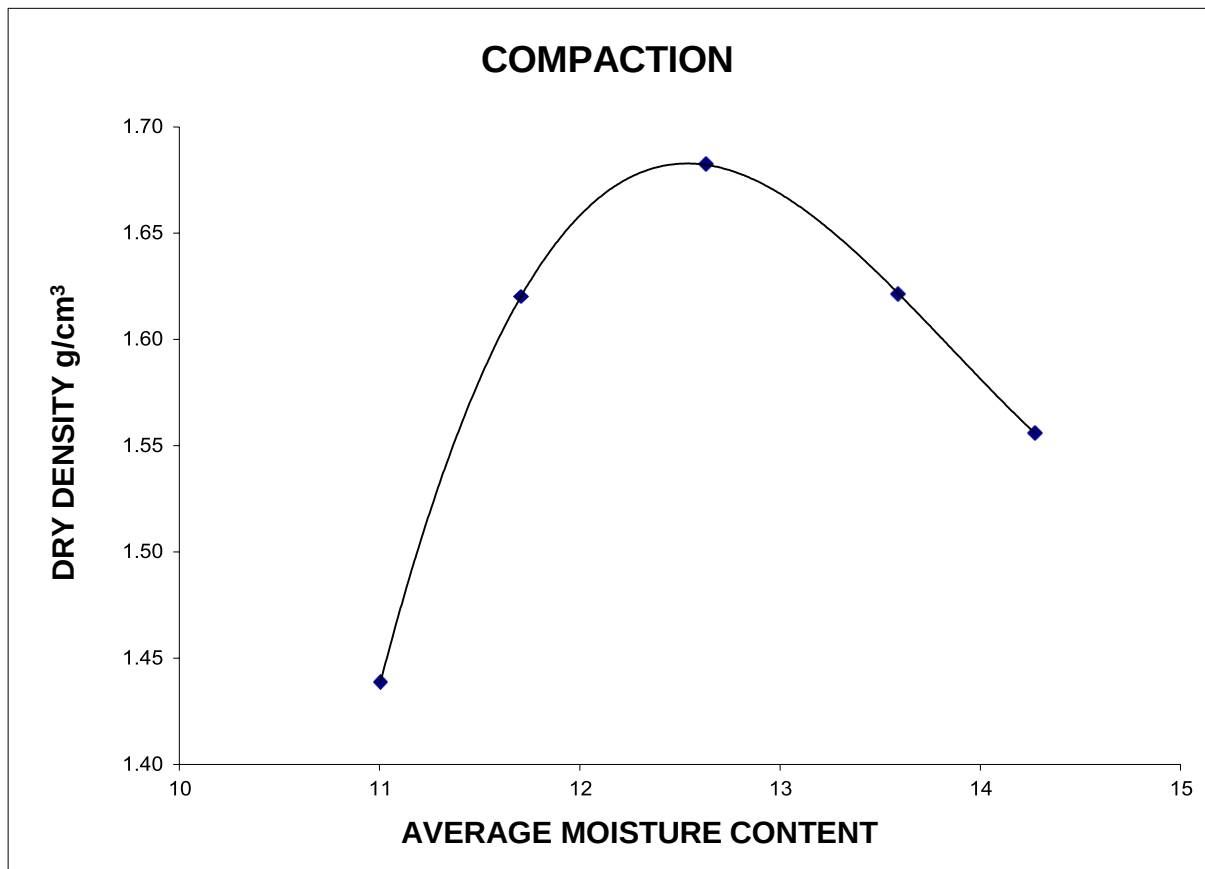
MDD: **1.68g/cm³**

Total weight of Sample: **...3000g.....**

OPT.MC: **12.5%**

B.S. / C.B.R. Mould **...3589g**

Wt. of mould & wet Soil (W2) g	5090.00	5290.00	5370.00	5320.00	5260.00									
Wt. of mould (W1) g	3589.00	3589.00	3589.00	3589.00	3589.00									
Wt. of wet soil (W2-W1) g	1501.00	1701.00	1781.00	1731.00	1671.00									
Bulk Density (Pb) (W2-W1)/x g/cm ³	1.60	1.81	1.90	1.84	1.78									
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 939.82 g/cm ³														
Container No.	VE	OH	JA	AB	ET	RT	LO	JA	RT	XX				
Wt. of wet soil & container (g)	45.50	35.90	46.60	41.20	56.80	55.70	55.00	50.90	37.90	66.80				
Wt. of Dry soil & container (g)	42.80	34.20	43.50	38.70	52.40	51.40	50.60	46.90	35.30	60.80				
Wt. of Container (g)	18.50	18.60	17.20	17.20	17.50	17.40	18.40	17.30	17.40	18.00				
Wt. of dry soil (Wd) g	24.30	15.60	26.30	21.50	34.90	34.00	32.20	29.60	17.90	42.80				
Wt. of Moisture (Wm) g	2.70	1.70	3.10	2.50	4.40	4.30	4.40	4.00	2.60	6.00				
Moistur Content 100(Wm/Wd) %	11.11	10.90	11.79	11.63	12.61	12.65	13.66	13.51	14.53	14.02				
Average Moisture Content (m) %	11.00		11.71		12.63		13.59		14.27					
Dry Density = Pb/1+ (m/100) (g/cm ³)	1.44		1.62		1.68		1.62		1.56					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD/HEAVY COMPACTION

Project... **B.Eng.**

Sample No: **Point 4 (6% Caustic Soda Stabilization)**

Student... **Samuel Uche Ubah..**

Depth:...**1.0m**

Date: **19/08/2023...**

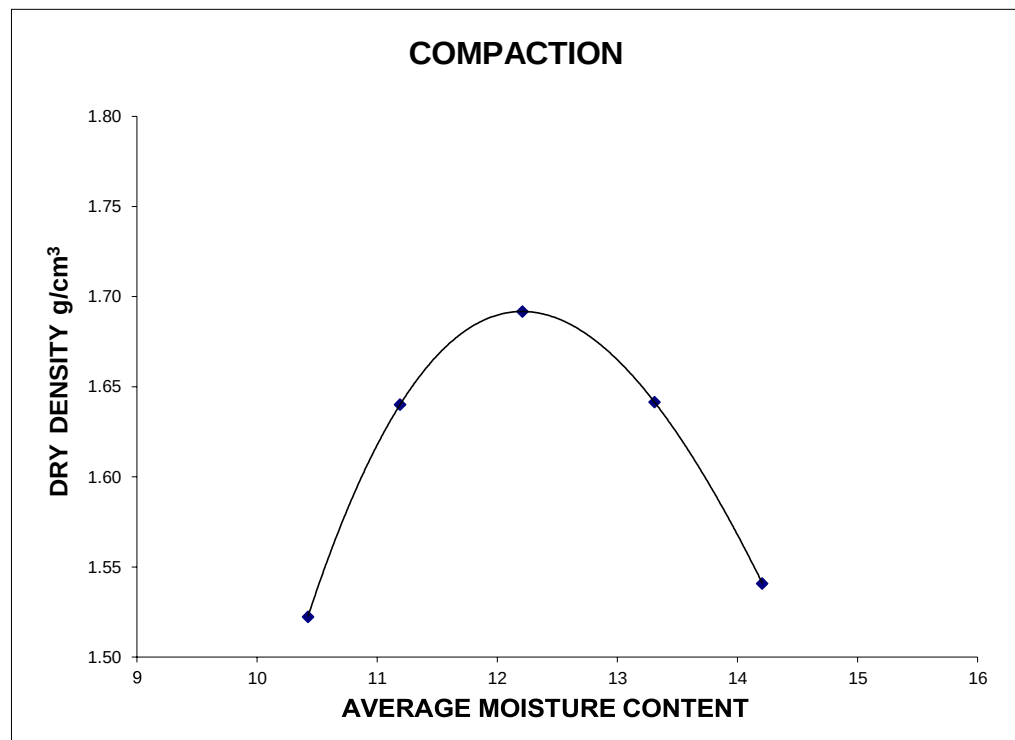
MDD: **1.69g/cm³**

Total weight of Sample.....**3000g**

OPT.MC: **12.2%**

B.S. / C.B.R. Mould.....**4706g**

Wt. of mould & wet Soil (W2) g	6286.00	6420.00	6490.00	6454.00	6360.00									
Wt. of mould (W1) g	4706.00	4706.00	4706.00	4706.00	4706.00									
Wt. of wet soil (W2-W1) g	1580.00	1714.00	1784.00	1748.00	1654.00									
Bulk Density (Pb) (W2-W1)/x g/cm ³	1.68	1.82	1.90	1.86	1.76									
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 939.82cm ³														
Container No.	IZ	RK	RZ	LE	OH	GE	S	ZE	ET	AC				
Wt. of wet soil & container (g)	55.20	55.90	55.00	57.80	59.00	57.10	47.60	56.40	59.00	58.10				
Wt. of Dry soil & container (g)	51.80	52.20	51.10	53.60	54.50	52.70	43.80	51.80	53.90	53.00				
Wt. of Container (g)	18.10	17.80	16.40	15.90	17.80	16.50	15.20	17.30	17.80	17.30				
Wt. of dry soil (Wd) g	33.70	34.40	34.70	37.70	36.70	36.20	28.60	34.50	36.10	35.70				
Wt. of Moisture (Wm) g	3.40	3.70	3.90	4.20	4.50	4.40	3.80	4.60	5.10	5.10				
Moistur Content 100(Wm/Wd) %	10.09	10.76	11.24	11.14	12.26	12.15	13.29	13.33	14.13	14.29				
Average Moisture Content (m) %	10.42		11.19		12.21		13.31		14.21					
Dry Density = Pb/1+ (m/100) (g/cm ³)	1.52		1.64		1.69		1.64		1.54					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD/HEAVY COMPACTION

Project... **B.Eng.**

Sample No: **Point 4 (8% Caustic Soda Stabilization)**

Student... **Samuel Uche Ubah..**

Depth:...**1.0m**

Date: **19/08/2023...**

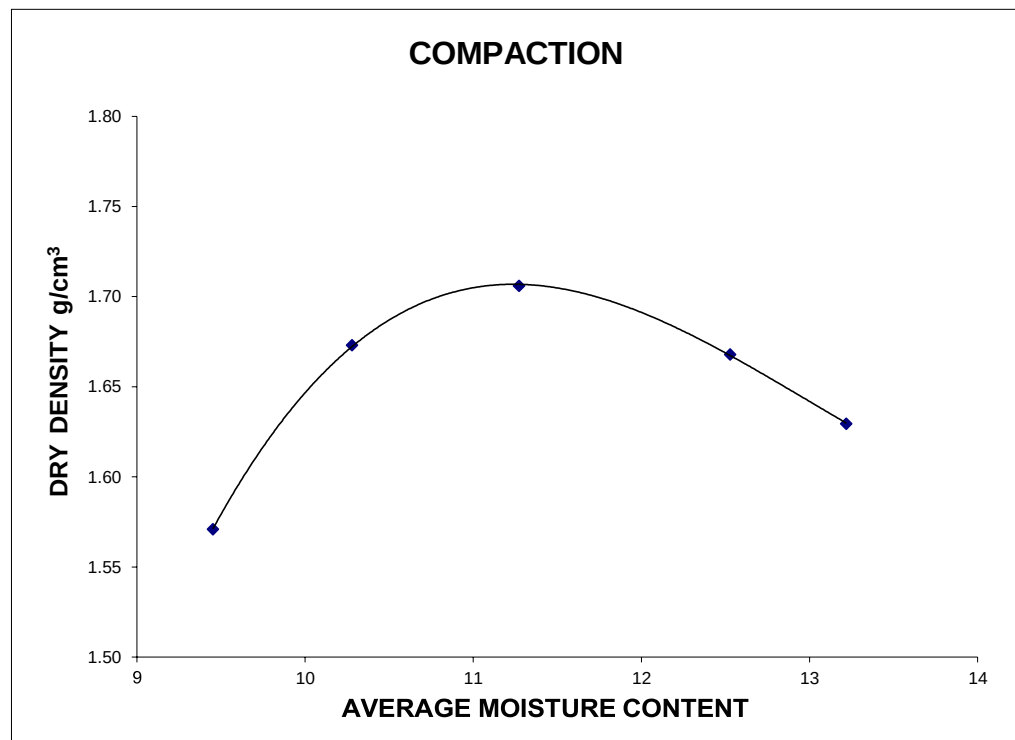
MDD: **1.71g/cm³**

Total weight of Sample.....**3000g**

OPT.MC: **11.2%**

B.S. / C.B.R. Mould.....**4706g**

Wt. of mould & wet Soil (W2) g	6322.00	6440.00	6490.00	6470.00	6440.00									
Wt. of mould (W1) g	4706.00	4706.00	4706.00	4706.00	4706.00									
Wt. of wet soil (W2-W1) g	1616.00	1734.00	1784.00	1764.00	1734.00									
Bulk Density (Pb) (W2-W1)/x g/cm ³	1.72	1.85	1.90	1.88	1.85									
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 939.82cm ³														
Container No.	OB	SS	BB	AN	JT	AC	TU	MZ	RE	OO				
Wt. of wet soil & container (g)	65.30	59.00	59.80	57.40	67.40	62.80	66.60	64.10	75.00	69.60				
Wt. of Dry soil & container (g)	61.20	55.40	55.80	53.80	62.20	57.90	61.20	58.60	68.20	63.70				
Wt. of Container (g)	17.60	17.50	17.40	18.30	16.20	14.30	17.90	14.90	17.50	18.40				
Wt. of dry soil (Wd) g	43.60	37.90	38.40	35.50	46.00	43.60	43.30	43.70	50.70	45.30				
Wt. of Moisture (Wm) g	4.10	3.60	4.00	3.60	5.20	4.90	5.40	5.50	6.80	5.90				
Moistur Content 100(Wm/Wd) %	9.40	9.50	10.42	10.14	11.30	11.24	12.47	12.59	13.41	13.02				
Average Moisture Content (m) %	9.45		10.28		11.27		12.53		13.22					
Dry Density = Pb/1+ (m/100) (g/cm ³)	1.57		1.67		1.71		1.67		1.63					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD/HEAVY COMPACTION

Project....**B.Eng.**

Sample No: **Point 4 (10% Caustic Soda Stabilization)**

Student... **Samuel Uche Ubah..**

Depth:...**1.0m**

Date: **19/08/2023...**

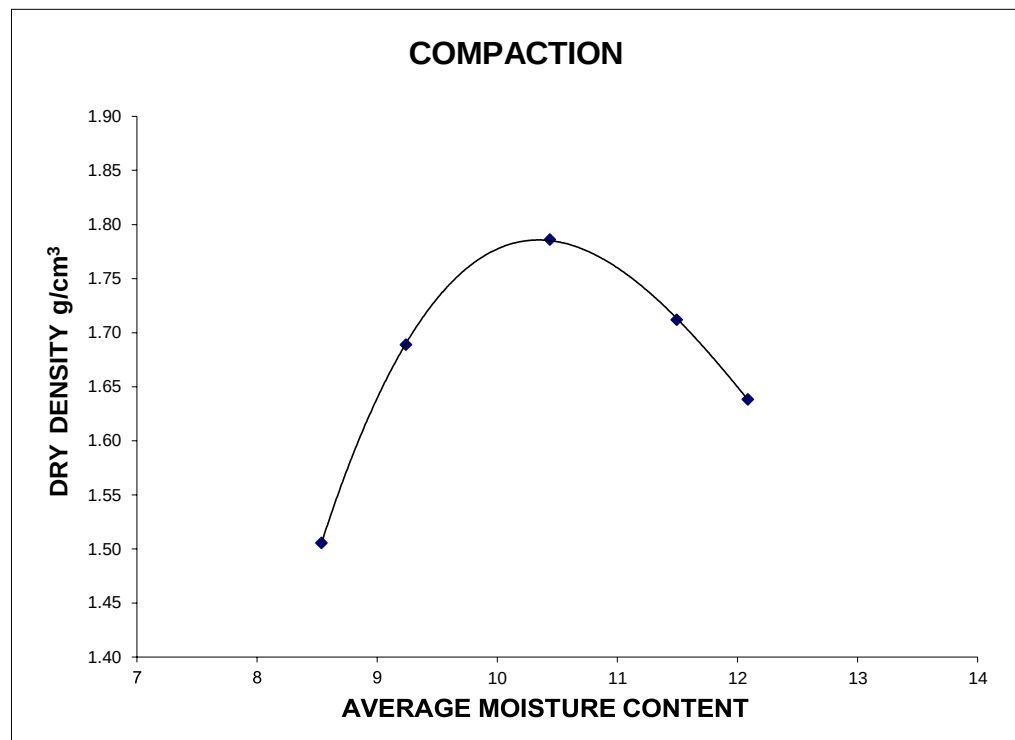
MDD: **1.79g/cm³**

Total weight of Sample.....**3000g**

OPT.MC: **10.3%**

B.S. / C.B.R. Mould.....**4706g**

Wt. of mould & wet Soil (W2) g	6242.00	6440.00	6560.00	6500.00	6432.00									
Wt. of mould (W1) g	4706.00	4706.00	4706.00	4706.00	4706.00									
Wt. of wet soil (W2-W1) g	1536.00	1734.00	1854.00	1794.00	1726.00									
Bulk Density (Pb) (W2-W1)/x g/cm ³	1.63	1.85	1.97	1.91	1.84									
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 939.82cm ³														
Container No.	QU	OS	AI	OB	TI	ME	CT	CB	SB	GL				
Wt. of wet soil & container (g)	62.80	61.50	65.00	64.00	56.80	59.10	68.70	65.40	67.50	60.30				
Wt. of Dry soil & container (g)	59.20	58.20	61.00	60.00	53.00	55.00	63.50	60.50	62.10	55.70				
Wt. of Container (g)	18.00	18.60	17.70	16.70	16.80	15.50	17.90	18.20	17.10	17.90				
Wt. of dry soil (Wd) g	41.20	39.60	43.30	43.30	36.20	39.50	45.60	42.30	45.00	37.80				
Wt. of Moisture (Wm) g	3.60	3.30	4.00	4.00	3.80	4.10	5.20	4.90	5.40	4.60				
Moistur Content 100(Wm/Wd) %	8.74	8.33	9.24	9.24	10.50	10.38	11.40	11.58	12.00	12.17				
Average Moisture Content (m) %	8.54		9.24		10.44		11.49		12.08					
Dry Density = Pb/1+ (m/100) (g/cm ³)	1.51		1.69		1.79		1.71		1.64					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD/HEAVY COMPACTION

Project....**B.Eng.**

Sample No: **Point 4**

Student... **Samuel Uche Ubah..**

Depth:...**1.0m**

Date: **19/08/2023...**

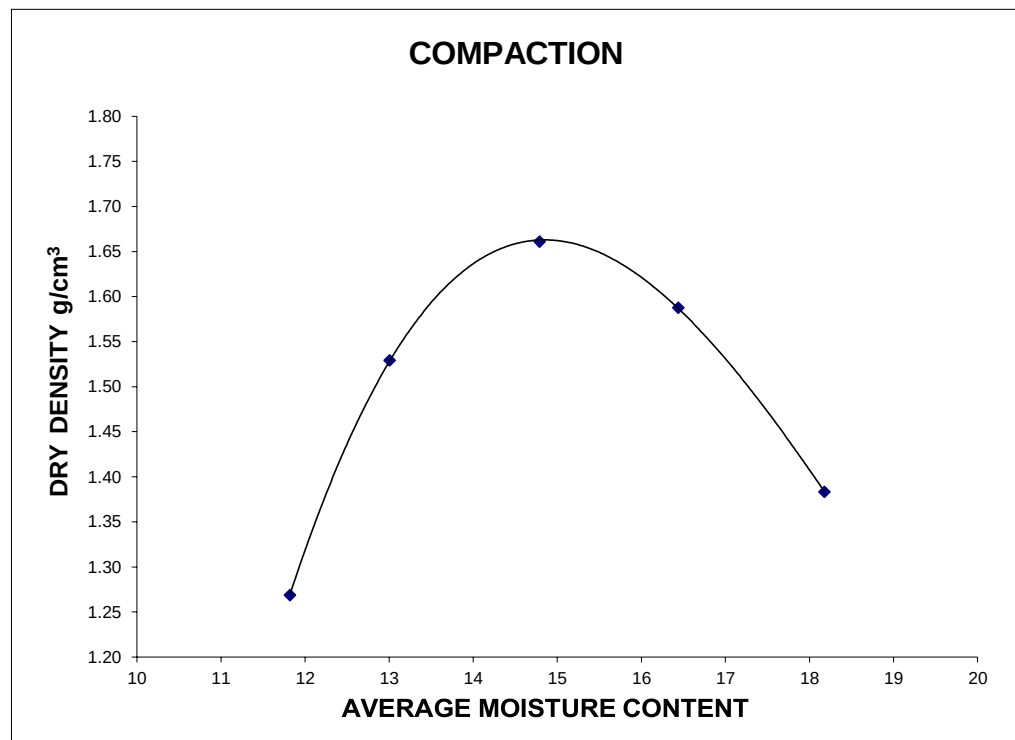
MDD: **1.66g/cm³**

Total weight of Sample.....**3000g**

OPT.MC: **14.8%**

B.S. / C.B.R. Mould.....**4662g**

Wt. of mould & wet Soil (W2) g	6075.00	6383.00	6561.00	6503.00	6290.00									
Wt. of mould (W1) g	4662.00	4662.00	4662.00	4662.00	4662.00									
Wt. of wet soil (W2-W1) g	1413.00	1721.00	1899.00	1841.00	1628.00									
Bulk Density (Pb) (W2-W1)/x g/cm ³	1.42	1.73	1.91	1.85	1.63									
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 995.79cm ³														
Container No.	DE	XX	OZ	ME	PA	OZ	JA	LA	PA	VP				
Wt. of wet soil & container (g)	41.83	50.01	52.20	51.90	44.46	47.06	46.81	52.98	48.32	51.13				
Wt. of Dry soil & container (g)	39.30	46.67	48.15	48.00	41.00	43.22	42.68	47.90	43.60	45.80				
Wt. of Container (g)	18.06	18.19	17.02	17.99	17.50	17.37	17.37	17.22	17.40	16.73				
Wt. of dry soil (Wd) g	21.24	28.48	31.13	30.01	23.50	25.85	25.31	30.68	26.20	29.07				
Wt. of Moisture (Wm) g	2.53	3.34	4.05	3.90	3.46	3.84	4.13	5.08	4.72	5.33				
Moistur Content 100(Wm/Wd) %	11.91	11.73	13.01	13.00	14.72	14.85	16.32	16.56	18.02	18.34				
Average Moisture Content (m) %	11.82		13.00		14.79		16.44		18.18					
Dry Density = Pb/1+ (m/100) (g/cm ³)	1.27		1.53		1.66		1.59		1.38					
C.B.R. (mseen of top & bottom) %														



UNIBEN GEOTECH LABORATORY
(DETERMINATION OF MOISTURE CONTENT OF SOIL PARTICLES)

STUDENT: **SAMUEL UCHE UBAH**

DATE: **19-08-2023**

S/N	LOCATION	CN	WWS+WC	WDS+WC	WC	WDS	WM	MC	AMC
1	POINT 1	IK	139.30	118.40	18.00	100.40	20.90	20.82	20.86
		NP	137.80	116.40	14.00	102.40	21.40	20.90	
2	POINT 2	ST	137.50	119.00	17.80	101.20	18.50	18.28	18.21
		JA	135.90	117.70	17.40	100.30	18.20	18.15	
3	POINT 3	OH	139.30	118.90	17.90	101.00	20.40	20.20	20.36
		OZ	138.90	118.20	17.30	100.90	20.70	20.52	
4	POINT 4	VO	131.70	113.20	18.00	95.20	18.50	19.43	19.28
		MU	138.80	119.30	17.40	101.90	19.50	19.14	

WC = M1
WWS+WC = M2
WDS+WC = M3
WDS = wt. of dry soil (M3-M1)
WM = wt. of moisture (M2-M3)
MC = Moisture Content $((M2-M3)/(M3-M1))*100$
AMC = Average moisture content(MC/2)

UNIBEN GEOTECH RESEARCH

GRAIN SIZE ANALYSIS BY WET-SIEVING

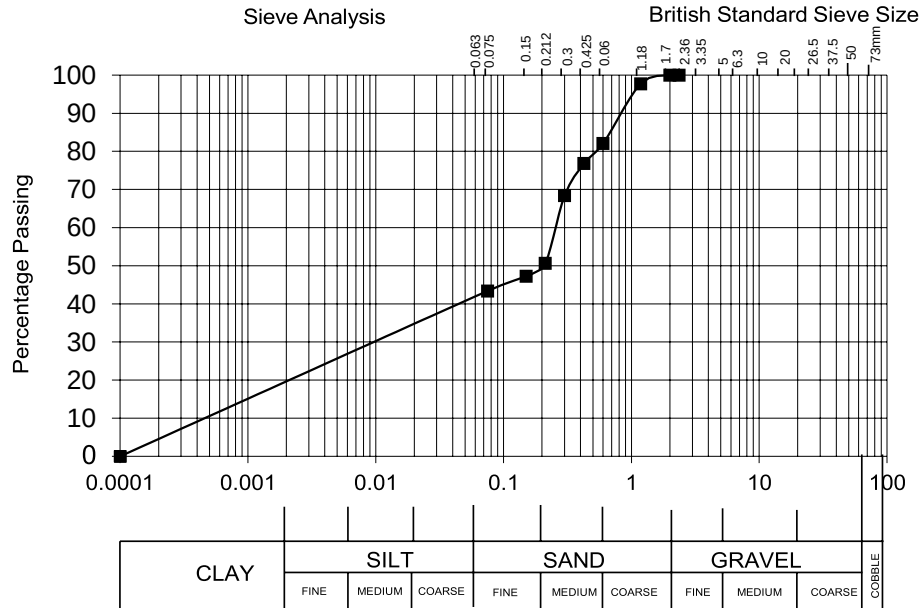
PROJECT: **B.Eng**

SAMPLE ID: **POINT**

DATE: **19/08/2023**

WEIGHT OF DRY MATERIAL IN GRAMS:....**100.**

SIEVE NO.				
APPROX IMPERIAL EQUIV (inches)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	
7	2.36	0	100	100
10	2	0	100	100
14	1.18	2.26	97.74	97.74
25	0.6	15.69	82.05	82.05
36	0.425	5.22	76.83	76.83
52	0.3	8.45	68.38	68.38
72	0.212	17.76	50.62	50.62
100	0.15	3.39	47.23	47.23
200	0.075	3.84	43.39	43.39
	0.0001			0



REMARK:

The soil composition ranges from fine gravel to clay as seen from the graph above

$D_{10} = 0.00045$ $D_{30} = 0.009$ $D_{60} = 0.25$

The Coefficient of Uniformity is 555 and the coefficient of curvature is 0.72.

These indicate the soil is poorly graded with voids due to some missing intermediate soil particles.

UNIBEN GEOTECH RESEARCH

GRAIN SIZE ANALYSIS BY WET-SIEVING

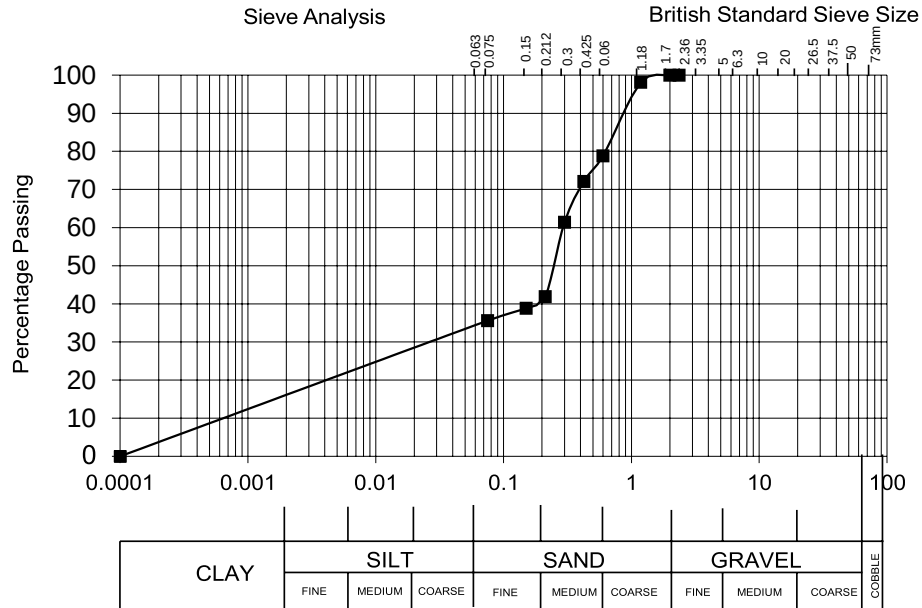
PROJECT: **B.Eng**

SAMPLE ID: **POINT**

DATE: **19/08/2023**

WEIGHT OF DRY MATERIAL IN GRAMS:....**100.**

SIEVE NO.				
APPROX IMPERIAL EQUIV (inches)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	
7	2.36	0	100	100
10	2	0	100	100
14	1.18	1.88	98.12	98.12
25	0.6	19.28	78.84	78.84
36	0.425	6.68	72.16	72.16
52	0.3	10.73	61.43	61.43
72	0.212	19.53	41.9	41.9
100	0.15	3.06	38.84	38.84
200	0.075	3.25	35.59	35.59
	0.0001			0



REMARK:

The soil composition ranges from fine gravel to clay as seen from the graph above

D₁₀ = 0.0006

D₃₀ = 0.025

D₆₀ = 0.28

The Coefficient of Uniformity is 467 and the coefficient of curvature is 3.72.

These indicate the soil is poorly graded with voids due to some missing intermediate soil particles.

UNIBEN GEOTECH RESEARCH

GRAIN SIZE ANALYSIS BY WET-SIEVING

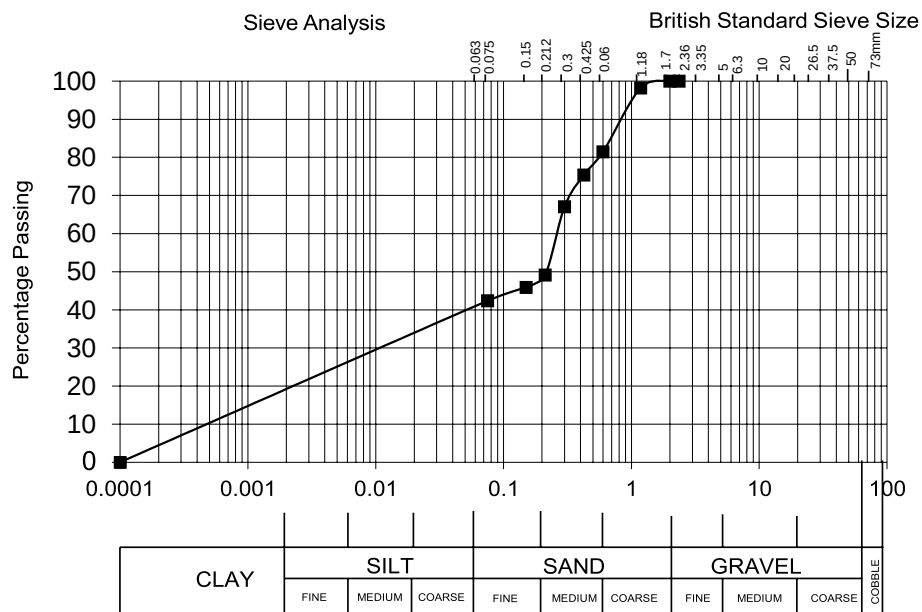
PROJECT: **B.Eng**

SAMPLE ID: **POINT**

DATE: **19/08/2023**

WEIGHT OF DRY MATERIAL IN GRAMS:....**100.**

SIEVE NO.				
APPROX IMPERIAL EQUIV (inches)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	
7	2.36	0	100	100
10	2	0	100	100
14	1.18	1.77	98.23	98.23
25	0.6	16.8	81.43	81.43
36	0.425	6.04	75.39	75.39
52	0.3	8.32	67.07	67.07
72	0.212	17.9	49.17	49.17
100	0.15	3.28	45.89	45.89
200	0.075	3.54	42.35	42.35
	0.0001			0



REMARK:

The soil composition ranges from fine gravel to clay as seen from the graph above

$D_{10} = 0.00047$ $D_{30} = 0.01$ $D_{60} = 0.26$

The Coefficient of Uniformity is 553 and the coefficient of curvature is 0.82.

These indicate the soil is poorly graded with voids due to some missing intermediate soil particles.

UNIBEN GEOTECH RESEARCH

GRAIN SIZE ANALYSIS BY WET-SIEVING

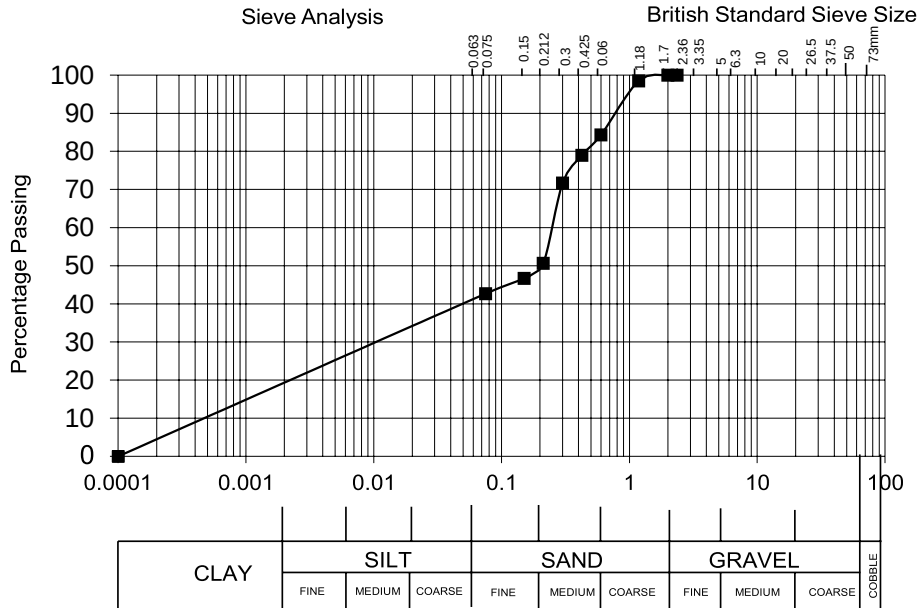
PROJECT: **B.Eng**

SAMPLE ID: **POINT**

DATE: **19/08/2023**

WEIGHT OF DRY MATERIAL IN GRAMS:....**100.**

SIEVE NO.				
APPROX IMPERIAL EQUIV (inches)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	
7	2.36	0.03	99.97	99.97
10	2	0	99.97	99.97
14	1.18	1.5	98.47	98.47
25	0.6	14.15	84.32	84.32
36	0.425	5.33	78.99	78.99
52	0.3	7.3	71.69	71.69
72	0.212	21.09	50.6	50.6
100	0.15	3.95	46.65	46.65
200	0.075	3.97	42.68	42.68
	0.0001			0



REMARK:

The soil composition ranges from fine gravel to clay as seen from the graph above

$D_{10} = 0.00047$ $D_{30} = 0.01$ $D_{60} = 0.26$

The Coefficient of Uniformity is 553 and the coefficient of curvature is 0.82.

These indicate the soil is poorly graded with voids due to some missing intermediate soil particles.

DETERMINATION OF SPECIFIC GRAVITY OF SOIL PARTICLES
(Standard Laboratory Method)

DATE: .. 19-08-2023

PROJECT: BENG

S/N	SAMPLE ID	BN	B+W	B+S+W	B+S	B	Ad. W	WWAS	WS	WOWDS	Gs	AGs
1	POINT 1	DN	75.76	85.48	41.45	23.84	51.92	44.03	17.61	7.89	2.23	2.25
		SB	78.83	88.66	41.28	23.75	55.08	47.38	17.53	7.70	2.28	
2	POINT 2	FO	74.67	84.81	40.27	22.80	51.87	44.54	17.47	7.33	2.38	2.37
		ZA	77.08	88.05	40.88	21.79	55.29	47.17	19.09	8.12	2.35	
3	POINT 3	DF	74.45	83.29	38.69	22.45	52.00	44.60	16.24	7.40	2.19	2.20
		PF	77.87	86.45	38.60	22.95	54.92	47.85	15.65	7.07	2.21	
4	POINT 4	JA	74.47	86.95	42.78	20.68	53.79	44.17	22.10	9.62	2.30	2.36
		DK	74.93	88.00	42.99	20.76	54.17	45.01	22.23	9.16	2.43	

B+W = Wt. of Bottle + Water (full) W4
 B+S+W = Wt. of Bottle + Soil+ Water W3
 B+S = Wt. of Bottle + Soil W2
 B = Wt. of Bottle W1
 Ad.W = Wt. of Added Water (full) (W4-W1)
 WWAS = Wt. of Water added to Soil (W3-W2)
 WS = Wt. of Soil (W2-W1)
 WOWDS = Wt. of Water Displaced by Soil (W4-W1)-(W3-W2) = W
 GS = Specific Gravity (W2-W1)/W

GEOTECHNICAL ENGINEERING LABORATORY TEST

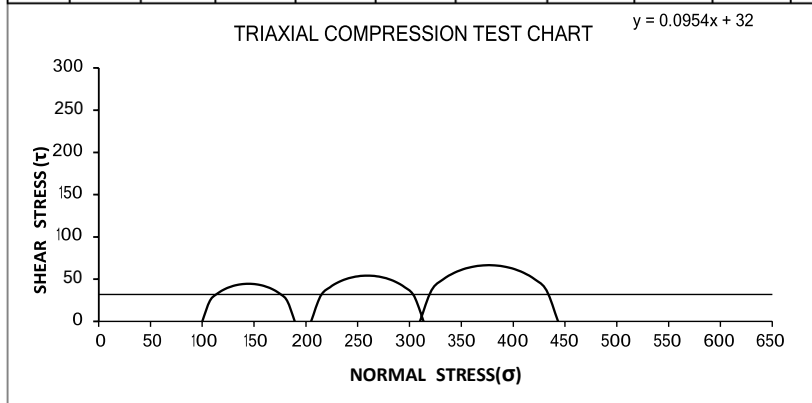
TRIAXIAL COMPRESSION TEST

SAMPLE ID: **POINT** DATE: **07/09/2023**.....

BULK DENSITY:....**1.71Kg/m³**... WET WEIGHT:....**159g,147g,135g**. CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:.. **5.45°**.... COHESION :...**32.00kN/m²**..... UNIT WEIGHT:..**16.79KN/m³**....

Strain Dial	Stress Dial 1	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %	DESCRIPTION OF SAMPLE
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00	.....
15	10	14	20	0.04	0.06	0.09	0.00115	37.11	51.95	74.21	0.50	.....
30	11	18	25	0.05	0.08	0.11	0.00115	40.82	66.79	92.77	1.00	.....
45	12	19.8	27.5	0.05	0.08	0.12	0.00116	44.15	72.84	101.17	1.50	
60	13	21	29.5	0.06	0.09	0.13	0.00116	47.82	77.25	108.52	2.00	
75	13.8	22.5	31.5	0.06	0.10	0.13	0.00117	50.33	82.06	114.89	2.50	
90	14.3	23.8	33	0.06	0.10	0.14	0.00118	51.71	86.07	119.34	3.00	
105	15	25	34.5	0.06	0.11	0.15	0.00118	54.25	90.41	124.77	3.50	
120	16	26	37.2	0.07	0.11	0.16	0.00119	57.38	93.24	133.40	4.00	
135	16.9	27.5	37.2	0.07	0.12	0.16	0.00119	60.60	98.62	133.40	4.50	
150	17.2	29	37.2	0.07	0.12	0.16	0.00120	61.17	103.13	132.29	5.00	
165	18	30.8	37.2	0.08	0.13	0.16	0.00121	63.48	108.62	131.19	5.50	
180	19	30.8	37.2	0.08	0.13	0.16	0.00121	67.01	108.62	131.19	6.00	
210	20.8	30.8	37.2	0.09	0.13	0.16	0.00122	72.75	107.73	130.12	7.00	
240	22.2	30.8	37.2	0.10	0.13	0.16	0.00124	80.18	106.00	128.02	8.00	
270	23.3	30.8	37.2	0.10	0.13	0.16	0.00125	83.64	105.15	127.00	9.00	
300	24.5	30.8	37.2	0.11	0.13	0.16	0.00127	84.00	103.49	125.00	10.00	
330	25	30.8	37.2	0.11	0.13	0.16	0.00128	89.35	102.68	124.02	11.00	
360	26.8	30.8	37.2	0.11	0.13	0.16	0.00130	87.97	101.10	122.11	12.00	
390	26.8	30.8	37.2	0.11	0.13	0.16	0.00131	87.30	100.33	121.18	12.00	
420	26.8	30.8	37.2	0.11	0.13	0.16	0.00131	87.30	100.33	121.18	13.00	
450	26.8	30.8	37.2	0.11	0.13	0.16	0.00133	85.99	98.82	119.36	14.00	
480	26.8	30.8	37.2	0.11	0.13	0.16	0.00134	85.35	98.09	118.47	15.00	SKETCH OF SAMPLE AFTER SHEAR
510	26.8	30.8	37.2	0.11	0.13	0.16	0.00136	84.09	96.64	116.72	16.00	
540	26.8	30.8	37.2	0.11	0.13	0.16	0.00137	83.48	95.94	115.87	17.00	
570	26.8	30.8	37.2	0.11	0.13	0.16	0.00139	82.28	94.56	114.21	18.00	
600	26.8	30.8	37.2	0.11	0.13	0.16	0.00139	82.28	94.56	114.21	19.00	
630	26.8	30.8	37.2	0.11	0.13	0.16	0.00143	79.98	91.91	111.01	20.00	
660	26.8	30.8	37.2	0.11	0.13	0.16	0.00144	79.42	91.27	110.24	21.00	Compressive Stress
690	26.8	30.8	37.2	0.11	0.13	0.16	0.00146	78.33	90.02	108.73	22.00	
720	26.8	30.8	37.2	0.11	0.13	0.16	0.00150	76.24	87.62	105.83	24.00	Corresponding Strain
750	26.8	30.8	37.2	0.11	0.13	0.16	0.00152	75.24	86.47	104.44	25.00	
				Ø1	Radius	Centre						
1	100.00	89.35	189.35	44.6738	144.674							
	0.00	24.70	33.28	38.69	42.13	44.05	44.67	44.05	42.13	38.69	33.28	24.70
	100.00	107.46	114.88	122.34	129.80	137.21	144.67	152.13	159.55	167.01	174.47	181.89
2	205.00	108.62	313.62	54.3117	259.312							
	0.00	30.03	40.46	47.03	51.22	53.55	54.31	53.55	51.22	47.03	40.46	30.03
	205.00	214.07	223.09	232.16	241.23	250.24	259.31	268.38	277.40	286.47	295.54	304.55
3	310.00	133.40	443.40	66.6998	376.7							
	0.00	36.88	49.69	57.76	62.90	65.77	66.70	65.77	62.90	57.76	49.69	36.88
	310.00	321.14	332.21	343.35	354.49	365.56	376.70	387.84	398.91	410.05	421.19	432.26



GEOTECHNICAL ENGINEERING LABORATORY TEST

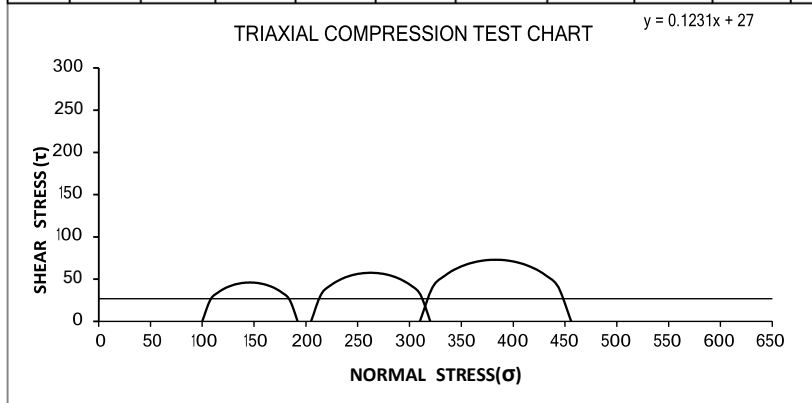
TRIAXIAL COMPRESSION TEST

SAMPLE ID: **POINT** DATE: **07/09/2023**.....

BULK DENSITY:....**1.80Kg/m³**... WET WEIGHT:....**159g,152g,152g**. CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:.. **7.02°**.... COHESION :...**27.00kN/m²**.... UNIT WEIGHT:..**17.63KN/m³**....

Strain Dial	Stress Dial 1	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %	DESCRIPTION OF SAMPLE		
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00	.....		
15	7.3	3	15	0.03	0.01	0.06	0.00115	27.09	11.13	55.66	0.50	.....		
30	7.9	10	19	0.03	0.04	0.08	0.00115	29.31	37.11	70.50	1.00	.....		
45	8.8	13.4	21	0.04	0.06	0.09	0.00116	32.37	49.30	77.25	1.50			
60	9.2	20	22	0.04	0.09	0.09	0.00116	33.84	73.58	80.93	2.00			
75	10	22	23	0.04	0.09	0.10	0.00117	36.47	80.24	83.89	2.50			
90	11	23.5	24	0.05	0.10	0.10	0.00118	39.78	84.99	86.79	3.00			
105	11.7	24.3	24.7	0.05	0.10	0.11	0.00118	42.31	87.88	89.33	3.50			
120	12.4	25	25.4	0.05	0.11	0.11	0.00119	44.47	89.65	91.08	4.00			
135	13.2	26	25.4	0.06	0.11	0.11	0.00119	47.34	93.24	91.08	4.50			
150	14	26.4	25.4	0.06	0.11	0.11	0.00120	49.79	93.88	90.33	5.00			
165	15	27	25.4	0.06	0.12	0.11	0.00121	52.90	95.22	89.58	5.50			
180	16	30.5	25.4	0.07	0.13	0.11	0.00121	56.43	107.57	89.58	6.00			
210	18	32.9	29	0.08	0.14	0.12	0.00122	62.96	115.08	101.44	7.00			
240	20.1	32.9	32	0.10	0.14	0.14	0.00124	76.74	113.22	110.13	8.00			
270	22.3	32.9	34.9	0.11	0.14	0.15	0.00125	84.32	112.32	119.14	9.00			
300	24.7	32.9	37.1	0.12	0.14	0.16	0.00127	92.07	110.55	124.66	10.00			
330	27.4	32.9	40	0.12	0.14	0.17	0.00128	91.35	109.68	133.35	11.00			
360	27.4	32.9	43.3	0.12	0.14	0.18	0.00130	89.94	108.00	142.14	12.00			
390	27.4	32.9	44.8	0.12	0.14	0.19	0.00131	89.26	107.17	145.94	12.00			
420	27.4	32.9	44.8	0.12	0.14	0.19	0.00131	89.26	107.17	145.94	13.00			
450	27.4	32.9	44.8	0.12	0.14	0.19	0.00133	87.91	105.56	143.74	14.00			
480	27.4	32.9	44.8	0.12	0.14	0.19	0.00134	87.26	104.77	142.67	15.00	SKETCH OF SAMPLE AFTER SHEAR		
510	27.4	32.9	44.8	0.12	0.14	0.19	0.00136	85.97	103.23	140.57	16.00			
540	27.4	32.9	44.8	0.12	0.14	0.19	0.00137	85.35	102.48	139.55	17.00			
570	27.4	32.9	44.8	0.12	0.14	0.19	0.00139	84.12	101.00	137.54	18.00			
600	27.4	32.9	44.8	0.12	0.14	0.19	0.00139	84.12	101.00	137.54	19.00			
630	27.4	32.9	44.8	0.12	0.14	0.19	0.00143	81.77	98.18	133.69	20.00			
660	27.4	32.9	44.8	0.12	0.14	0.19	0.00144	81.20	97.50	132.76	21.00	Compressive Stress		
690	27.4	32.9	44.8	0.12	0.14	0.19	0.00146	80.09	96.16	130.94	22.00			
720	27.4	32.9	44.8	0.12	0.14	0.19	0.00150	77.95	93.60	127.45	24.00	Corresponding Strain		
750	27.4	32.9	44.8	0.12	0.14	0.19	0.00152	76.92	92.37	125.77	25.00			
				Ø1	Radius	Centre								
1	100.00	92.07	192.07	46.0336	146.034									
	0.00	25.46	34.30	39.87	43.41	45.39	46.03	45.39	43.41	39.87	34.30	25.46	0.00	
	100.00	107.69	115.33	123.02	130.70	138.35	146.03	153.72	161.36	169.05	176.74	184.38	192.07	
2	205.00	115.08	320.08	57.5393	262.539									
	0.00	31.82	42.87	49.83	54.26	56.73	57.54	56.73	54.26	49.83	42.87	31.82	0.00	
	205.00	214.61	224.16	233.77	243.38	252.93	262.54	272.15	281.70	291.31	300.92	310.47	320.08	
3	310.00	145.94	455.94	72.9684	382.968									
	0.00	40.35	54.36	63.19	68.81	71.95	72.97	71.95	68.81	63.19	54.36	40.35	0.00	
	310.00	322.19	334.30	346.48	358.67	370.78	382.97	395.15	407.27	419.45	431.64	443.75	455.94	



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

SAMPLE ID: POINT

DATE: 07/09/2023.....

BULK DENSITY:....1.80Kg/m³...

WET WEIGHT:....158g,157g,148g.

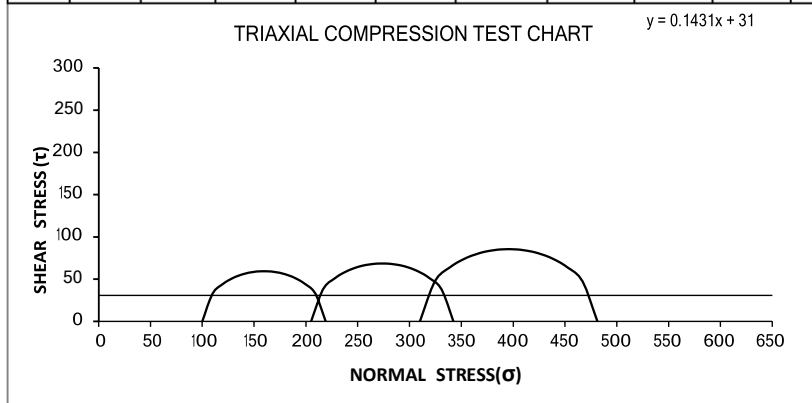
CELL PRESSURE: 100, 205, 310KN/m²

FRICTION ANGLE:.. 8.14°....

COHESION :...31.00kN/m².....

UNIT WEIGHT:..17.63KN/m³....

Strain Dial	Stress Dial 1	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %	DESCRIPTION OF SAMPLE		
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00	.....		
15	7	15.3	3.8	0.03	0.07	0.02	0.00115	25.98	56.77	14.10	0.50	.....		
30	12	18.5	3.8	0.05	0.08	0.02	0.00115	44.53	68.65	14.10	1.00	.....		
45	13.6	19.2	9.5	0.06	0.08	0.04	0.00116	50.03	70.63	34.95	1.50			
60	15	21.3	10	0.06	0.09	0.04	0.00116	55.18	78.36	36.79	2.00			
75	15.9	22.4	12.1	0.07	0.10	0.05	0.00117	57.99	81.70	44.13	2.50			
90	17	22.4	18	0.07	0.10	0.08	0.00118	61.48	81.01	65.10	3.00			
105	17.9	22.4	19.5	0.08	0.10	0.08	0.00118	64.73	81.01	70.52	3.50			
120	19	22.4	20.9	0.08	0.10	0.09	0.00119	68.13	80.33	74.95	4.00			
135	20	23.5	21.8	0.09	0.10	0.09	0.00119	71.72	84.27	78.17	4.50			
150	21.3	25	23.3	0.09	0.11	0.10	0.00120	75.75	88.90	82.86	5.00			
165	22.4	27.1	25.1	0.10	0.12	0.11	0.00121	79.00	95.57	88.52	5.50			
180	23.1	28.9	27	0.10	0.12	0.12	0.00121	81.47	101.92	95.22	6.00			
210	25.8	31.9	31.1	0.11	0.14	0.13	0.00122	90.24	111.58	108.78	7.00			
240	29	34.5	34.9	0.14	0.15	0.15	0.00124	110.13	118.73	120.11	8.00			
270	32	38.6	38.2	0.15	0.16	0.16	0.00125	119.14	131.78	130.41	9.00			
300	34.9	40.9	41.6	0.15	0.17	0.18	0.00127	117.27	137.43	139.78	10.00			
330	34.9	40.9	44.8	0.15	0.17	0.19	0.00128	116.35	136.36	149.36	11.00			
360	34.9	40.9	48.1	0.15	0.17	0.21	0.00130	114.56	134.26	157.89	12.00			
390	34.9	40.9	51.3	0.15	0.17	0.22	0.00131	113.69	133.23	167.11	12.00			
420	34.9	40.9	52.6	0.15	0.17	0.22	0.00131	113.69	133.23	171.35	13.00			
450	34.9	40.9	52.6	0.15	0.17	0.22	0.00133	111.98	131.23	168.77	14.00	SKETCH OF SAMPLE AFTER SHEAR		
480	34.9	40.9	52.6	0.15	0.17	0.22	0.00134	111.14	130.25	167.51	15.00			
510	34.9	40.9	52.6	0.15	0.17	0.22	0.00136	109.51	128.33	165.05	16.00			
540	34.9	40.9	52.6	0.15	0.17	0.22	0.00137	108.71	127.40	163.84	17.00			
570	34.9	40.9	52.6	0.15	0.17	0.22	0.00139	107.14	125.56	161.48	18.00			
600	34.9	40.9	52.6	0.15	0.17	0.22	0.00139	107.14	125.56	161.48	19.00			
630	34.9	40.9	52.6	0.15	0.17	0.22	0.00143	104.15	122.05	156.97	20.00			
660	34.9	40.9	52.6	0.15	0.17	0.22	0.00144	103.42	121.20	155.88	21.00	Compressive Stress		
690	34.9	40.9	52.6	0.15	0.17	0.22	0.00146	102.01	119.54	153.74	22.00			
720	34.9	40.9	52.6	0.15	0.17	0.22	0.00150	99.29	116.36	149.64	24.00	Corresponding Strain		
750	34.9	40.9	52.6	0.15	0.17	0.22	0.00152	97.98	114.83	147.67	25.00			
			Ø1	Radius	Centre									
1	100.00	119.14	219.14	59.5722	159.572									
	0.00	32.94	44.38	51.59	56.18	58.74	59.57	58.74	56.18	51.59	44.38	32.94	0.00	
	100.00	109.95	119.84	129.79	139.73	149.62	159.57	169.52	179.41	189.36	199.31	209.20	219.14	
2	205.00	137.43	342.43	68.7144	273.714									
	0.00	38.00	51.19	59.51	64.80	67.75	68.71	67.75	64.80	59.51	51.19	38.00	0.00	
	205.00	216.48	227.88	239.36	250.83	262.24	273.71	285.19	296.60	308.07	319.55	330.95	342.43	
3	310.00	171.35	481.35	85.6728	395.673									
	0.00	47.38	63.83	74.19	80.79	84.47	85.67	84.47	80.79	74.19	63.83	47.38	0.00	
	310.00	324.31	338.53	352.84	367.14	381.37	395.67	409.98	424.20	438.51	452.82	467.04	481.35	



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

SAMPLE ID: **POINT**

DATE: **07/09/2023**.....

BULK DENSITY:....**1.80Kg/m³**...

WET WEIGHT:....**162g,152g,149g**.

CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:.. **6.49°**....

COHESION :...**32.00kN/m²**....

UNIT WEIGHT:..**17.63KN/m³**....

Strain Dial	Stress Dial 1	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %	DESCRIPTION OF SAMPLE
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00	.....
15	12	6	3	0.05	0.03	0.01	0.00115	44.53	22.26	11.13	0.50	.....
30	13.5	6	4.5	0.06	0.03	0.02	0.00115	50.09	22.26	16.70	1.00	.....
45	14.8	7	15.5	0.06	0.03	0.07	0.00116	54.45	25.75	57.02	1.50	
60	16.1	12	21.5	0.07	0.05	0.09	0.00116	59.23	44.15	79.09	2.00	
75	17.1	15	24	0.07	0.06	0.10	0.00117	62.37	54.71	87.54	2.50	
90	18	19	26	0.08	0.08	0.11	0.00118	65.10	68.71	94.03	3.00	
105	19	20	27.5	0.08	0.09	0.12	0.00118	68.71	72.33	99.45	3.50	
120	20	20.5	29	0.09	0.09	0.12	0.00119	71.72	73.51	103.99	4.00	
135	21	21.7	30.5	0.09	0.09	0.13	0.00119	75.31	77.82	109.37	4.50	
150	22	22.5	32	0.09	0.10	0.14	0.00120	78.23	80.01	113.80	5.00	
165	23	23.3	34	0.10	0.10	0.15	0.00121	81.11	82.17	119.91	5.50	
180	24	25.5	35.8	0.10	0.11	0.15	0.00121	84.64	89.93	126.26	6.00	
210	26.9	29	39	0.11	0.12	0.17	0.00122	94.09	101.44	136.42	7.00	
240	26.9	32.5	42.8	0.11	0.14	0.18	0.00124	92.57	111.85	147.29	8.00	
270	26.9	35	42.8	0.11	0.15	0.18	0.00125	91.83	119.49	146.11	9.00	
300	26.9	37.5	42.8	0.11	0.16	0.18	0.00127	90.39	126.00	143.81	10.00	
330	26.9	37.5	42.8	0.11	0.16	0.18	0.00128	89.68	125.02	142.69	11.00	
360	26.9	37.5	42.8	0.11	0.16	0.18	0.00130	88.30	123.10	140.49	12.00	
390	26.9	37.5	42.8	0.11	0.16	0.18	0.00131	87.63	122.16	139.42	12.00	
420	26.9	37.5	42.8	0.11	0.16	0.18	0.00131	87.63	122.16	139.42	13.00	
450	26.9	37.5	42.8	0.11	0.16	0.18	0.00133	86.31	120.32	137.33	14.00	
480	26.9	37.5	42.8	0.11	0.16	0.18	0.00134	85.67	119.42	136.30	15.00	SKETCH OF SAMPLE AFTER SHEAR
510	26.9	37.5	42.8	0.11	0.16	0.18	0.00136	84.41	117.67	134.30	16.00	
540	26.9	37.5	42.8	0.11	0.16	0.18	0.00137	83.79	116.81	133.32	17.00	
570	26.9	37.5	42.8	0.11	0.16	0.18	0.00139	82.58	115.13	131.40	18.00	
600	26.9	37.5	42.8	0.11	0.16	0.18	0.00139	82.58	115.13	131.40	19.00	
630	26.9	37.5	42.8	0.11	0.16	0.18	0.00143	80.27	111.91	127.72	20.00	
660	26.9	37.5	42.8	0.11	0.16	0.18	0.00144	79.72	111.13	126.84	21.00	Compressive Stress
690	26.9	37.5	42.8	0.11	0.16	0.18	0.00146	78.62	109.61	125.10	22.00	
720	26.9	37.5	42.8	0.11	0.16	0.18	0.00150	76.53	106.68	121.76	24.00	Corresponding Strain
750	26.9	37.5	42.8	0.11	0.16	0.18	0.00152	75.52	105.28	120.16	25.00	
				Ø1	Radius	Centre						
1	100.00	94.09	194.09	47.0458	147.046							
	0.00	26.02	35.05	40.74	44.36	46.39	47.05	46.39	44.36	40.74	35.05	26.02
	100.00	107.86	115.67	123.52	131.38	139.19	147.05	154.90	162.71	170.57	178.43	186.23
2	205.00	126.00	331.00	63.0022	268.002							
	0.00	34.84	46.94	54.56	59.41	62.12	63.00	62.12	59.41	54.56	46.94	34.84
	205.00	215.52	225.98	236.50	247.02	257.48	268.00	278.52	288.98	299.50	310.02	320.48
3	310.00	147.29	457.29	73.6462	383.646							
	0.00	40.73	54.87	63.78	69.45	72.62	73.65	72.62	69.45	63.78	54.87	40.73
	310.00	322.30	334.52	346.82	359.12	371.35	383.65	395.95	408.17	420.47	432.77	444.99
												457.29

TRIAXIAL COMPRESSION TEST CHART

$$y = 0.1138x + 32$$

