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Geotechnical Characterization of Soil in Uya Oro/Eyoabsi Oron LGA in Akwa Ibom State

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Abstract **Case Studies**

This research work focused on geotechnical characterization of soils from Uya Oro/Eyoabsi in Oron LGA, Akwa Ibom State, aimed at generating location based engineering parameters for pavement and foundation design in the coastal plain environment. Laboratory testing were done in accordance with BS 1377 which revealed that the soils have low-plasticity cohesive materials (LL = 30%, PI = 10%) existing in a firm to stiff in-situ state (LI = 0.25) with a negative AASHTO Group Index (–4), indicating relatively favorable classification as subgrade material. However, strength based evaluation showed limited load resistance, with a dry unit weight of 17.85 kN/m³, unconfined compressive strength of 49 kN/m², and undrained shear strength of 24.5 kN/m², these results highlight the vulnerability of the soil to performance less under increased loading and wet conditions. The findings demonstrate that reliance on generalized coastal-plain parameters can be misleading, as acceptable index properties do not necessarily translate to sufficient structural capacity. The study therefore provides evidence based guidance which emphasizes moisture control, drainage provision and targeted stabilization as prerequisites for sustainable use of the soils in road pavement and foundation construction within Uya Oro/Eyoabsi and similar tropical coastal terrains.

Keywords: Geotechnical characterization, coastal plain soils, pavement and foundation design, soil strength properties, moisture control and stabilization.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

In the coastal plain region of southern Nigeria, Uya Oro/Eyoabsi (Oron LGA) is home to highly varied lateritic and alluvial deposits that significantly influence engineering behavior at shallow depths due to the weathering of parent rocks. Particle grading, plasticity, and moisture sensitivity properties that directly regulate compaction response, bearing capacity, and susceptibility to settlement, erosion soil under loads often exhibit significant geographical variation in these coastal-plain soils (Attah et al, 2021). Large variations in engineering performance are frequently explained by seemingly small variations in index properties (fines content, plasticity index, and maximum dry density) and in situ disturbance, according to local field evidence found elsewhere in Akwa Ibom State. Such disturbance includes collapsed structures and failing pavements. Geotechnical characterization in the Uya Oro/Eyoabsi area cannot rely on general regional tables because anthropogenic impacts in the area, such as oil and hydrocarbon residues from vehicle maintenance, inappropriate waste disposal, seasonal flooding, and shallow groundwater fluctuations, can change pore-fluid chemistry and lower strength indices (Umar, 2021).

According to recent studies conducted in Nigeria, laboratory parameters like CBR, Atterberg limits, compaction curves, and unconfined compressive strength are sensitive to both seasonal moisture change and local admixtures; they also vary significantly even over small lateral distances (Nwakaire *et al.*, 2024). An updated, site-specific geotechnical dataset is therefore essential for rational design, material selection and suitable stabilization recommendations for infrastructure planning in Oron LGA, where many foundations are shallow and roads are built on locally sourced borrow soils (Attah *et al.*, 2021; Nwakaire *et al.*, 2024).

1.2 Statement of the Problem

Although housing and road construction in Uya Oro/Eyoabsi is accelerating, comprehensive geotechnical data for the area is still lacking and frequently derived from nearby LGAs, which leads to two interconnected issues. First, due to unrecognized high plasticity, low bearing capacity, or seasonal weakening, designers and contractors frequently use generalized "coastal-plain" parameter ranges or borrow materials without first conducting laboratory verification. This increases the risk of early pavement failure, foundation settlement, and localized collapses (Atat *et al.*, 2023).

However, there is mounting evidence that the native lateritic soils in some areas of Oron LGA interact with site contamination (oil spills, organic wastes) and a high shallow water table to reduce compacted density, lower soaked CBR, and alter Atterberg limits. These effects are not captured by out-of-date or regionally averaged data (Umar, 2021; Attah *et al.*, 2021). Because of these gaps, Uya Oro/Eyoabsi's current construction practices lack a solid foundation for (a) choosing appropriate borrow-pit materials; (b) defining stabilization (lime/cement, agro-ash, or other admixtures) at the proper dosages; or (c) designing shallow foundations and road pavement layers that will withstand seasonal loading and increased groundwater fluctuation. Thus, a thorough geotechnical assessment is desperately needed such encompassing particle size distribution, Atterberg limits, specific gravity, compaction characteristics, soaked/unsoaked CBR and basic strength tests which are to be carried out across wet and dry seasons in the representative locations within Uya Oro/Eyoabsi so that engineering designs and local material-use policies can be evidence-based (Attah *et al.*, 2021; Nwakaire *et al*., 2024).

1.3 Aim and Objectives of the Study

The aim of this study is to assess the geotechnical characteristics of the soils in Uya Oro/Eyoabsi, Oron LGA, in order to formulate reliable engineering parameters which shall be a guide to the safe and sustainable design of road pavements, foundations and other civil engineering structures in the area.

To achieve the stated aim, the study were pursued with the following specific objectives:

1. Sampling, assessment and classification of the predominant soil in a few selected Uya Oro/Eyoabsi areas using visual inspection and terrain characteristics.
2. Determination of the fundamental index properties of the soils such as particle size distribution, Atterberg limits, natural moisture content, specific gravity and soil classification using BS laboratory procedures.
3. Evaluation of the geotecnical properties of the soils such as compaction characteristics (maximum dry density and optimum moisture content), California Bearing Ratio (CBR), unconfined compressive strength (UCS) (maximum dry density and optimum moisture content), California Bearing Ratio (CBR), unconfined compressive strength (UCS).
4. Draw recommendation based on the geotechnical properties of the soil to be a

guide on material selection, pavement design and soil improvement strategies for civil engineering works in Uya Oro/Eyoabsi.

1.4 Significance of the Study

This study is significant for several reasons:

1.4.1 Development of Reliable Geotechnical Data for Design

The study closes the current gap in soil information required for safe foundation design, pavement construction, drainage systems, zoning and urban planning by providing precise, site-specific geotechnical characteristics of the soil for Uya Oro/Eyoabsi.

1.4.2 Optimization of Material Management, Safety and Construction Quality

The study helps reduce structural failures such as settlement, pavement deformation, and collapse while advising contractors on appropriate material selection, borrow-pit management, and soil-stabilization needs by illuminating soil behavior under moisture and load fluctuations.

1.4.3 Promotion of Knowledge, Sustainability, and Local Development

The results improve resilience to climate-related pressures, promote sustainable infrastructure development in a coastal environment vulnerable to flooding, and provide fresh empirical data to professional, academic, and regulatory organizations for next studies and engineering practice.

1.5 Scope of the Study

The broad geotechnical evaluation of the soils in Uya Oro and Eyoabasi in Oron LGA, Akwa Ibom State, is the main emphasis of this study. It covers areas that are 5–10 km from important infrastructure corridors and habitation clusters. Field tests like DCP and in-situ density checks are used to assist the collection of disturbed and undisturbed samples from specific boreholes and trial pits. Grain size distribution, Atterberg limits, moisture content, specific gravity, compaction, CBR, shear strength, permeability, and other factors that directly affect foundation behavior, slope stability, pavement performance, and overall construction suitability are the only parameters that can be analyzed in a lab.

Using the USCS and AASHTO systems, the study classifies the soils and assesses their compressibility, load-bearing capability and anticipated performance under civil engineering projects. Long-term settlement monitoring, sophisticated geophysical surveys, pollution investigations, groundwater modeling, and socioeconomic evaluations are not included. The study is limited to producing reliable geotechnical data and interpretations that might have direct future impact on engineering planning and construction decisions in the Uya Oro/Eyoabasi area such as structural design solutions that are not offered.

1.6 Limitations of the Study

The naturally occurring geographical variation of tropical lateritic soils, particularly micro-variations, may not be adequately reflected in this study due to its reliance on soil samples collected exclusively from accessible places within Uya Oro and Eyoabasi. Seasonal limitations also had an impact on the study because it was not possible to monitor continuously throughout the year. As a result, variations in the moisture content and groundwater levels that are typical of humid coastal environments may have an impact on soil behavior that goes beyond the values recorded during the sampling periods.

Without having the assistance of geophysical or geochemical techniques that could offer a deeper understanding of subterranean conditions, anisotropy, or potential contamination, the investigation is further restricted to traditional laboratory studies. Access to several low-lying or marshy locations was limited due to logistical issues, especially during the rainy season, which could have resulted in data gaps. However, the research generates dependable geotechnical information adequate for preliminary and intermediate engineering decisions in the Uya Oro–Eyoabasi region.

CHAPTER 2

LITERATURE REVIEW

2.1 Variability and Challenges of Lateritic/Coastal-Plain Soils in Nigeria

Studies across Nigeria demonstrate that lateritic or coastal-plain soils—common in southern states—exhibit substantial spatial and temporal variability in geotechnical properties, making generalized soil tables unreliable. For instance, in a geotechnical assessment of foundation sub-soils in parts of Port Harcourt and Obio/Akpor (Rivers State), subsoils comprised overlying sandy clay and underlying poorly graded sands, with clay zones classified as low-to-intermediate plasticity (CL–CI), and significant variation in stratification and shear strength with depth (Udom and John, 2023). In similar vein, a geotechnical profiling study in Abuja area councils found heterogeneous lateritic soils across different localities, reinforcing the need for site-specific characterization rather than reliance on uniform regional soil classifications (Ndububa *et al.*, 2025)

Closer to the coastal plain environment of your study area, a comprehensive investigation into coastal-plain soils in Akwa Ibom State revealed that natural lateritic soils are often dilatant (i.e. sensitive to moisture and structural change), and require composite stabilization (e.g. admixtures, sand or chemical treatment) before use in road sub-grade or sub-base applications (Udo, 2021). This indicates that soils in coastal regions may not meet standard load-bearing or deformation criteria without modification which strongly validated the premise of study that generic regional tables may misrepresent local soil behaviour.

Moreover, geotechnical investigations in Osogbo (Southwest Nigeria) carried out by Oyelami et al., 2022; show that lateritic soils tested for subgrade suitability recorded wide ranges in natural moisture content (6.2–29.4 %), plasticity indices, compaction, and CBR (at 2.5 mm and 5.0 mm penetration). The substantial variation emphasizes that lateritic soils even within relatively small geographic areas can behave very differently under load or moisture conditions, underscoring the necessity of localized sampling and testing (Onyechere *et al.*, 2021).

2.2 Influence of Seasonal Moisture Variability and Climate on Soil Properties and Pavement Suitability

Recent research by Oba et al, (2024) highlights that seasonal fluctuations in moisture and groundwater significantly affect key geotechnical properties such as Atterberg limits, compaction density, and CBR — all critical to road and foundation performance. A case study along a roadway corridor in Maiduguri documented marked differences between wet- and dry-season soil properties: for instance, Liquid Limit (LL) increased from 17.5 % (dry) to 22.8 % (wet), Plastic Limit (PL) and Plasticity Index (PI) rose similarly, maximum dry density (MDD) dropped from 2.1 Mg/m³ to 1.8 Mg/m³ under wet conditions, and CBR values decreased from 27.5 % (dry) to 18.9 % (wet). This seasonal sensitivity illustrates how moisture regimes in tropical climates can degrade subgrade strength and stability, a phenomenon likely to affect coastal-plain soils in Akwa Ibom State with similar climate and hydrology (Atat *et al.*, 2023).

Also, elevated temperature and prolonged heating have been shown to alter index and engineering properties of lateritic soils. A recent experiment from Ado-Ekiti revealed that heating lateritic soils affects their plasticity and strength parameters, a finding that, while more applicable to thermal stabilization studies, nevertheless underscores the sensitivity of lateritic materials to environmental treatments and conditions (Afolagboye et al, 2024). These observations confirm that soil behaviour in southern Nigeria's coastal or forested zones cannot be assumed stable; seasonal, climatic, and environmental influences must be explicitly considered in geotechnical design.

2.3 Soil Stabilization and the Need for Composite Treatment in Coastal Regions

Because of the inherent weaknesses and variability of natural lateritic soils, especially in coastal zones, recent works advocate composite stabilization techniques before using such soils as subgrade or sub-base materials. In a study on coastal-plain lateritic soils in Akwa Ibom, for example, mixing with river sand and chemical binders significantly improved strength, reduced permeability, and decreased deformability, making the treated soils more viable for construction and roadworks (Ita et al., 2025).

In contrast, untreated soils generally show poor performance: many recorded CBR values and compaction characteristics fall below acceptable limits when compared against federal or standard specifications (Oyelami *et al.*, 2022). This underscores that for infrastructure stability in coastal and humid regions, stabilization must be guided by empirical data — something the proposed current study will produce for Uya Oro/Eyoabasi (Attah *et al.*, 2023).

2.4 Gaps in Current Knowledge & Justification for This Study

While multiple recent studies confirm the variability and moisture-affected behaviour of lateritic and coastal-plain soils in Nigeria, there remains a distinct lack of site-specific geotechnical datasets for many localities including Oron LGA (Uya Oro/Eyoabasi). The studies from Port Harcourt, Abuja, Osogbo, and Akwa Ibom (coastal areas) highlight broad trends, but none provide dense, seasonally stratified sampling across both wet and dry seasons combined with composite stabilization evaluation (Ogheneovo *et al.*, 2023).

Also, most previous works focus on either subgrade suitability, sub-base material testing, or soil classification; few extend to comprehensive evaluation covering grain size, compaction, plasticity, shear strength, permeability and soaked/unsoaked CBR over different seasons. Thus, there is still a knowledge gap in delivering a holistic geotechnical profile that supports sustainable civil engineering design in humid tropical zones (Umar, 2021).

Given environmental stressors in coastal Akwa Ibom (high rainfall, shallow groundwater, anthropogenic contamination) and the frequency of infrastructure failure, a fresh, context-specific investigation is strongly warranted. This study's comprehensive sampling, lab testing and classification approach will fill that gap, providing reliable empirical data for safe design, stabilization recommendations, and long-term infrastructure resilience in Uya Oro/Eyoabasi.

CHAPTER 3

MATERIALS ANDB METHODS

3.1 Study Area

Uya Oro/Eyoabasi is located in Oron Local Government Area of Akwa Ibom State, within the coastal belt of old eastern Nigeria, lying approximately between latitudes 4°45′–4°55′ N and longitudes 8°10′–8°20′ E. The area is characterized by low-lying coastal plain topography, generally less than 30 m above sea level, with gently sloping terrain that promotes surface ponding and seasonal flooding during intense rainfall. Geologically, it is underlain by the Benin Formation of the Niger Delta Basin, consisting predominantly of unconsolidated to poorly consolidated sands, silty sands, and interbedded clay lenses, which control groundwater flow and contribute to variable subgrade strength. The soils are mainly sandy clay and silty sand with localized organic deposits, exhibiting moderate to low bearing capacity and high moisture susceptibility due to a shallow groundwater table. These geographical and geological conditions strongly influence drainage behavior, foundation performance and pavement durability within the Uya Oro/Eyoabasi axis.

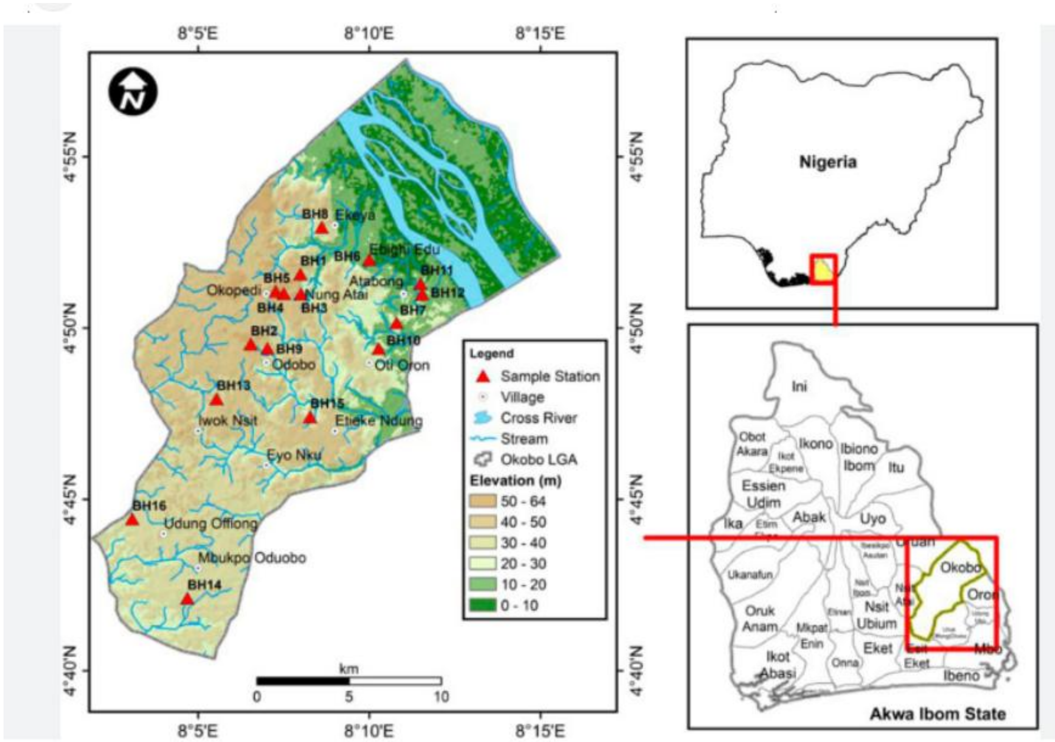


Figure 1: Study map of Uya Oro/Eyoabasi

3.2 Materials

3.2.1 Field Sampling Materials

For the soil material collection and sampling in the field, the material tools used were; Hand auger and auger extensions, Shovel, spade, and pickaxe, Core cutter and sampling tubes, Undisturbed soil sampling rings, Polythene sample bags and airtight containers, Permanent markers and sample labels, Measuring tape and GPS device, Field notebook and camera, Rubber gloves and safety boots.

3.2.2 Soil Index and Classification Test Materials

For the particle size distribution analysis and atterberg limit tests, the material tools used in the laboratory were; Standard sieve set (4.75 mm, 2.00 mm, 0.425 mm, 0.075 mm), Mechanical sieve shaker, measuring cylinder, Casagrande liquid limit device, Grooving tool and glass plate (plastic limit test), Distilled water, Balance (±0.01 g sensitivity) and Drying oven (105–110 °C).

3.2.3 Compaction and Strength Test Materials

For the compaction characteristics and California Bearing Ratio (CBR) tests, the material tools used in the laboratory were; Standard Proctor compaction apparatus, 101.6 mm diameter mould, 2.5 kg rammer, California Bearing Ratio (CBR) testing machine, CBR moulds, spacers, surcharge weights, Soaking tank and water bath, Dial gauges (0.01 mm sensitivity) and Loading frame with proving ring or load cell.

3.2.4 Shear Strength and Compressibility Materials

For determination of the Unconfined Compressive Strength (UCS) and Shear strength of the soil samples, the material tools used in the laboratory were; Direct shear test apparatus, Triaxial compression testing machine and Porous stones and filter papers.

3.3 Methods

The conventional soil mechanics tests relevant to the intended research were carried out. The tests were conducted in accordance with BS 1377, Methods of testing of soils are given below:

3.3.1 Moisture Content

The moisture content was determined by dying selected moist soil materials for at least 12hours to a constant mass in an 110^{o}c drying oven. Difference in mass of material when wet and when dry was taken. The mass of materials remaining after drying was used as the mass of the solid particles. The ratio of the mass of water to measured mass of the solid particles was the moisture content of the materials. This ratio can exceed I (or 100%) Ref: BC 1377: part 2:1990.

3.3.2 Atterberg Limits

Atterberg Limits were determined on the soil specimens with a particle size of less than 0.425mm. The Atterberg limits refer to arbitrary defined boundaries between the liquid limit (LL) and plastic states and between the plastic limit (PL) and brittle states of fine-grained soils. They are expressed as water contents, in percentage.

The liquid limit (LL) is the water content at which a part of soil placed in a standard cup and cut by groove of standard dimensions flows together at the base of the groove, when the cup is subjected to 275 standard shocks. The one-point liquid test was carried out. Distilled water was added during soil mixing to achieve the required consistency.

The plastic limit (PL) is the water content at which a soil can no longer be deformed by rolling into 3mm diameter threads without crumbling. The range of water content over which a soil behaves plastically is the plasticity index (IP). This is the difference between the liquid limit and the plastic limit, (LL-PL). Ref: BS13377; part 2: 1990.

3.3.3 Unconfined Compressive Strength (UCS)

This was performed on re-moulded sample of cohesive soils. Depending on the consistency of the cohesive material, the test specimen was prepared and trimming the sample or by pushing UCS cylindrical mould into the sample. A latex membrane with thickness of approximately 0.2mm was placed around the specimen. A lateral confining pressure was applied on the specimen until it resist the applied load and fails, the load at which there was resistance and failure becomes the compression loading of the specimen. The area of the cylinder was determined using its diameter and height. The compression load was divided by the area to gives the UCS value of the soil sample in KN/m^2.

3.3.4 Shear Strength (s)

The shear strength of the soil sample was determined by taking half the unconfined Compressive strength (Arora, 2014). That, shear strength s equals UCS (qu) divided by 2.

3.3.5 Unit Weight

The unit weight was determined from measurements of mass and volume of the soil. The unit weight Y (KN/m^2) refers to the weight of the soil at the sampled water content. The dry unit Wight Y_d was determined from the mass of oven dried soil and the initial volume. Reference test standard Bs 1377; part 2:1990.

3.3.6 Particle Size Analysis

Particle size analysis was performed by means of sieving. Dry sieving is presented on logarithmic scale so that two soils having the same degree of uniformity are represented by curves of the same shape regardless of their positions on the particle size distributions plot. The general slope of the distribution curve may be described by the coefficient of uniformity Cu, where $Cu = {D60}/{D10}$ and the coefficient of curvature $c = \frac{(D30)^2}{(D60 \times D10)}$.

3.3.7 Compaction Test

The objective of the compaction test is to obtain the moisture content – dry density relationship for a soil and hence to determine the optimum moisture content and maximum dry density.

This test is conducted on soil passing a 2.00 mm test sieve compacted in a specified manner over a range of moisture contents. The range includes the optimum moisture content at which the maximum dry density for this degree of compaction is obtained. In this test a 2.5 kg rammer falling through a height of 300 mm is used to compact the soil with 26 blows each in three layers into a 942cm^3 compaction mould. The test was carried out in accordance to BS 1377-4:1990 Clause 3.

The compaction tests were conducted on the soil samples. The Maximum Dry density (MDD) and Optimum Moisture Content (OMC) and plots of the Dry Density versus the Moisture content.

Equations used for Calculations

1. The dry unit weight γ_d $\gamma_d = \rho_d \times g$ i

2. Bulk Unit Weightγ: $\gamma = \rho_b \times g$ ii

3. $Plastic\ Index\ PL = LL - PL$ iii

4. $Liquidity\ Index\ LI = \frac{(w-PL)}{(LL-PL)}$ iv

5. $\mathrm{GI} = (\mathrm{F} - 35)[0.2 + 0.005(\mathrm{LL} - 40)] + 0.1(\mathrm{F} - 15)(\mathrm{PI} - 10)$ V.

6. To plot the zero air void curve: $\rho_{dth.} = \frac{G\rho_w(100-V_a)}{100(1+wG-w)}$ vi

7. Unconfined Compressive Strength (qu) $q_u = \frac{P}{A}$ vii

8. Shear Strength (s): $s = \frac{q_u}{2}$ viii

Where

G = specific gravity of the soil (G =2.67)

w = moisture Content (%)

LL = Liquid Limit (%)

PL = Plastic Limit (%)

PI = Plastic Index

GI = Group Index of the soil

F= Percentage passing through sieve number 200 (0.075mm)

ρ_w = density 1.0 g/cm^3

$\rho_d = \ Dry\ Density\ of\ soil$

$\rho_b = \ Wet\ Density\ of\ soil$

$\gamma = \ Bulk\ unit\ Weight\ of\ soil$

$\gamma_d = \ Dry\ unit\ Weight\ of\ soil$

$V_a = \ Percentage\ of\ void$

$\rho_{dth} = \ Dry\ Density\ of\ soil\ at\ a\ given\ void$

$g = \ Acceleration\ due\ to\ gravity\ (9.81 m/s^2)$

$q_u = \ UCS\ or\ Bearing\ capacity\ (KN/m^2)$

$P = \ Applied\ load\ or\ Force$

$A = \ Area\ of\ the\ sanple$

$s = \ Shearstrength (KN/m^2)$

3.3.8 California Bearing Ratio Test (CBR)

The objective of the California Bearing Ratio test is to determine the CBR value for a soil under consideration as a pavement foundation. This value is a percentage comparison with the standard crushed rock from California. This test covers the laboratory determination of the California Bearing Ration (CBR) of a compacted soaked sample of soil. The principle is to determine the relationship between force and penetration when a cylindrical plunger of a standard cross-sectional area is made to penetrate the soil at a given rate. At certain values of penetration (2.5mm and 5.0mm) the ratio of the applied force to a standard force, expressed as a percentage, is defined as the California Bearing Ratio (CBR). The CBR test was carried out on material passing the 2.0 mm test sieve prepared as described in clause 7.6.5

of BS 1377-1:1990. The samples were thoroughly mixed using the Optimum Moisture Content (OMC) obtained in the compaction test, sealed and stored for 24hours before compaction into the test mould. The compacted sample in the mould was soaked for 48hours before the CBR test. The soaked CBR was selected because the critical behavior of the soil is always when under water (Saturated). The test was carried out in accordance to BS 1377-4:1990 Clause 7.2. The values of Standard Proving Ring Constant (PRC) used for the CBR are shown in the following Table.

Table 3.1: Standard Proving Ring (PRC) California Bearing Ratios

Load (kN)	13.6	20.4
Penetration (mm)	2.5	5.0

CHAPTER 4

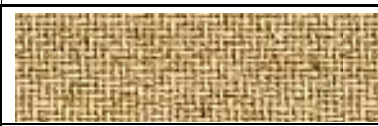
RESULTS AND DISCUSSION

4.1 Results Presentation

4.1.1 Soil Profile

The Table 4.1 below shows the soil profile and description of the Uya Oro Eyo Abasi at depth of 0.75m and 1.5m

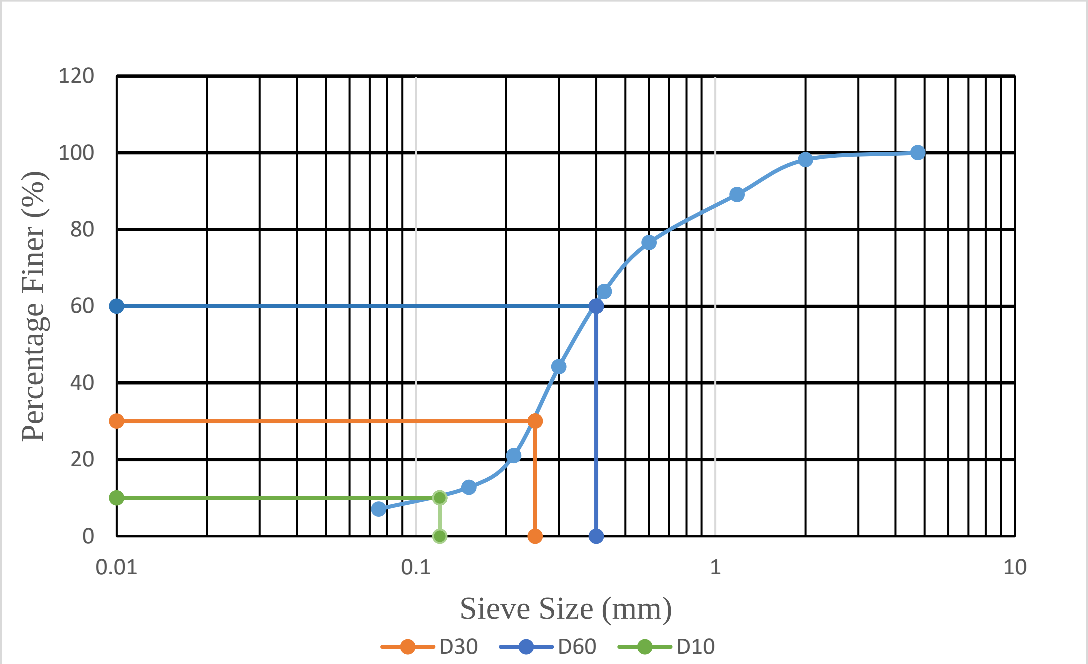
Table 4.1: The Soil profile of area

SOIL PROFILE (SH/AE/EDISCO/ UYA ORO/EYOABASI 1 & 2)		
Drilled Depth (m)	**Description**	**Lithology**
0 – 0.75m	LATERITE, Silt-Clay, Soft light Brownish	
0.75m - 1.5m	LATERITE, Silt-Clay, Stiff Brownish	

Source: Field

4.1.2 Particle Size Distribution

Figure 4.1 below shows the logarithm graph of the particle size distribution analysis of the soil and the values of the coefficient of uniformity (CU) and coefficient of curvature (Cc).



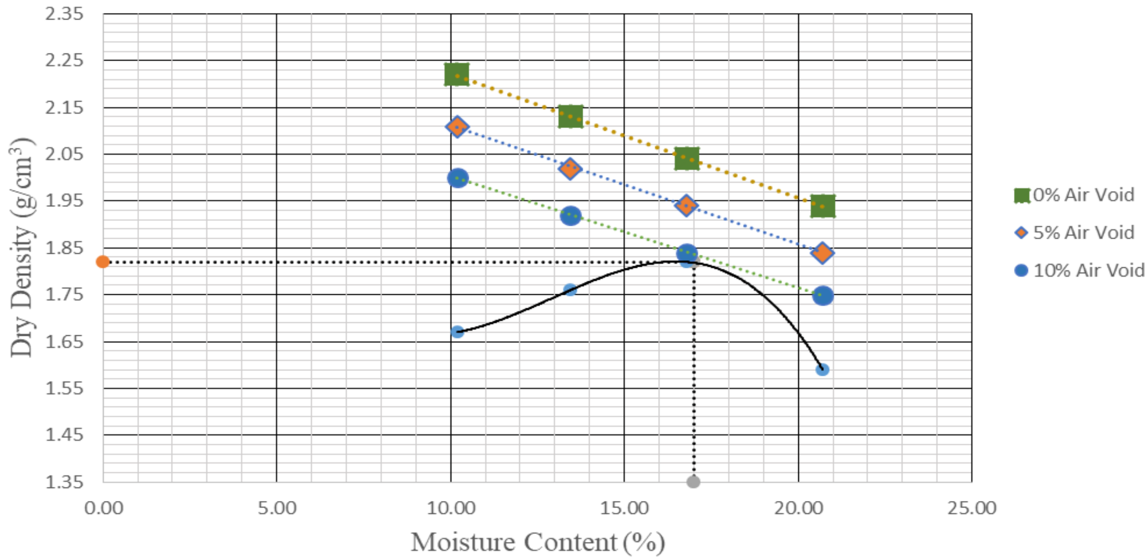
$D10 = 0.12$ $D30 = 0.25$ $D60 = 0.40$

$C_U = 3.3$ $C_c = 1.3$

Figure 4.1: Particle size distribution graph

4.1.3 Compaction Characteristics

The Figure 4.2 below present the compaction characteristics graph of the soil, it balso show the air void graph at 0%, 5% and 10%.



Results **MDD (g/cm^3) = 1.82** **OMC (%) = 17.0**

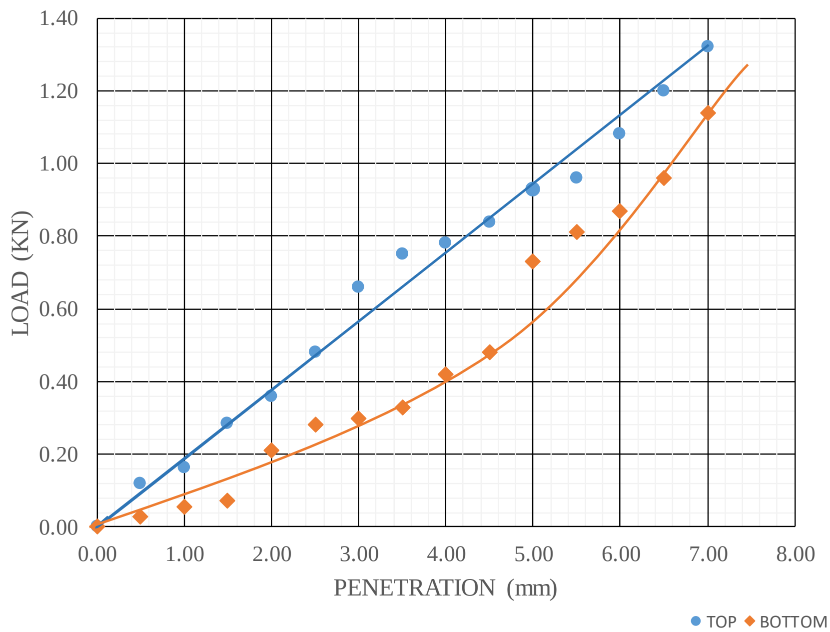
Figure 4.2: Compaction test graph

4.1.4 California Bearing Ratio (CBR)

The Figure 4.3 below present the soaked California Bearing Ratio (CBR) result of the soil sample.

CALIFORNIA BEARING RATIO TEST		
	Job Ref	
Location: Edisco Avenue/Uya Oro/Eyoabasi ROAD, ORON LGA, AKS CH 0 + 450.	Borehore/Pit No.	1
Source of Material: Edisco Avenue/Uya Oro/Eyoabasi Road	Sample No.	SH1/EYA/ORON
Soil Description: Natural Material	Depth	1.0 meters
Test Method: BS 1377: Part 4: 7.4	Date	28/03/2025
Force Measuring Device No.	**Soaked**	48 Hours

	TOP	**BOTTOM**
Pen	**Load**	**Load**
mm	**KN**	**KN**
0.00	0.00	0.00
0.50	0.12	0.03
1.00	0.17	0.05
1.50	0.29	0.07
2.00	0.36	0.21
2.50	0.48	0.28
3.00	0.66	0.30
3.50	0.75	0.33
4.00	0.78	0.42
4.50	0.84	0.48
5.00	0.93	0.73
5.50	0.96	0.81
6.00	1.08	0.87
6.50	1.20	0.96
7.00	1.32	1.14



LOADING RESULTS			CBR RESULTS		
	TOP	BOTTOM		TOP	BOTTOM
PEN. (mm	(KN)	(KN)	PEN. (mm	%	%
2.50	0.48	0.28	2.50	3.53	2.06
5.00	0.93	0.73	5.00	4.56	3.58
AVERAGE CBR (%)			**4.07**		

Figure 4.3: CBR result and graph

4.1.5 Summary Results

Table 4.2 below shows the summary the index and geotechnical properties of the soil samples. The results were the average values of the samples results obtained in the laboratory.

Table 4.2: Summary Results of the soil samples

TESTED PARAMETERS	**AVERAGE**
Moisture Content (%)	22.5
Liquid Limited (%)	30
Plastic Limited (%)	20

Plasticity Index (%)	10
Liquidity Index (LI)	0.25
Group Index (GI) of the soil	-4
Bulk Unit weight (KN/m^3**)**	24.26
Dry unit weight (KN m^3)	17.85
UCS (KN/ m^2)	49.00
Shear Strength (KN/m^2)	24.50
Soaked CBR (%)	4.07

Source: Laboratory Results

4.2 DISCUSSION

The index properties indicate that the soil is a low-plasticity cohesive material with moderate moisture sensitivity. The liquid limit (30%) and plasticity index (10%) classify the soil as a lean clay or silty clay, suggesting limited volume change potential compared with highly plastic clays. The liquidity index of 0.25 shows that the in-situ moisture content is only slightly above the plastic limit, implying that the soil is in a firm to stiff consistency state under natural conditions. The negative Group Index (–4) further indicates relatively good subgrade quality within the AASHTO system, suggesting that, from a classification standpoint, the soil may perform reasonably well for light to moderate pavement support if moisture ingress is adequately controlled.

The engineering strength parameters support this assessment but also reveal limitations under loading and wet conditions. The dry unit weight of 17.85 kN/m^3 reflects a fairly dense soil structure, while the unconfined compressive strength of 49 kN/m^2 corresponds to a soft to medium cohesive soil, yielding an undrained shear strength of 24.50 kN/m^2. Although these values indicate some inherent strength, they are insufficient for high-stress applications without improvement, particularly in environments prone to seasonal moisture variation. Consequently, while the soil may be marginally suitable as a subgrade material, compaction control, drainage provision, and possible stabilization would be required to ensure reliable long-term performance.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

From the findings of the research, the following conclusions were derived;

1. The soil is classified as a low-plasticity cohesive material (lean clay/silty clay) with limited swelling potential, indicating relatively stable volumetric behavior compared with highly plastic clays.

2. A liquidity index of 0.25 confirms that the soil exists in a firm to stiff state in-situ, suggesting that the soil have adequate short-term stability under natural moisture conditions.

3. The negative Group Index (–4) signifies comparatively good subgrade quality within the AASHTO system, making the soil conditionally suitable for light to moderate pavement support.

4. Despite its favorable index properties, the low UCS (49 kN/m^2) and shear strength (24.50 kN/m^2) indicate that the soil has

limited resistance to higher traffic loads and is vulnerable to strength loss under wet conditions.

5. Overall, the soil is marginally adequate as a subgrade material, with performance highly dependent on effective moisture control and construction quality.

5.2 Recommendations

Based on the conclusions, the following recommendations were made;

1. Strict moisture control during construction should be enforced, with compaction carried out near the plastic limit to maintain the soil in its firm-to-stiff consistency range.
2. Adequate surface and subsurface drainage systems should be provided to prevent water infiltration and seasonal softening that could significantly reduce shear strength.
3. For roads subjected to moderate to heavy traffic loading, chemical stabilization (e.g., lime or cement treatment) is recommended to improve UCS, shear strength and long-term durability.
4. Enhanced compaction specifications should be adopted to maintain or exceed the observed dry unit weight, thereby improving load distribution and minimizing deformation.
5. Where stabilization is not feasible, the soil should be used only in low-stress pavement layers, with stronger materials introduced in upper structural layers to compensate for its limited strength.

5.3 Contribution to Knowledge

The findings of the research work have the following contribution to knowledge;

1. This study provides quantified evidence linking liquidity index, UCS, and shear strength to the practical subgrade performance of low-plasticity cohesive soils under tropical conditions.
2. It demonstrates that a negative AASHTO Group Index does not necessarily imply adequate structural capacity, highlighting the need to supplement classification-based assessment with strength testing.
3. The research establishes threshold strength limitations (UCS ≈ 49 kN/m²; cu ≈ 24.5 kN/m²) beyond which lean clays become unsuitable for moderate to heavy pavement loading without stabilization.
4. It clarifies the critical role of moisture control near the plastic limit in preserving the in-situ stiffness of low-plasticity cohesive soils.
5. The findings offer a context-specific framework for deciding when stabilization or drainage enhancement is required, improving subgrade design decision-making for similar tropical soil environments.

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