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RESEARCH ARTICLE

ASSESSING GEOTECHNICAL PROPERTIES OF WETLANDS AREA IN LAGOS MAINLAND WESTERN NIGERIA

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ABSTRACT

Assessing geotechnical properties of Wetlands Area in Lagos Mainland Western Nigeria. This geotechnical research was conducted at Iyana-Ipaja community in Alimosho Local Government Area of Lagos State. Six soil samples and control samples were collected from seven different sampling points within this region for geotechnical analysis. Geotechnical properties index was carryout on the soil samples. Grain size The analysis, Specific Gravity, Atterberg Limits, Compaction Test, and Triaxial Tests was carried-out on Sample A, Sample B and Sample C. The liquid limit (LL) values for sample A, Sample B, and Sample C were 44.40%, 44.82%, and 45.13% respectively, while the plastic limit values were 28.63%, 33.30%, and 33.46% respectively. The plastic index values for samples A, B, and C were 16.76, 11.53, and 11.67 respectively. These soil samples were classified as inorganic clays of low to medium plasticity (CL) and were considered moderately plastic based on their plasticity index (PI) values being less than 17%. The natural moisture content values for soil samples A, B, and C were 98.02%, 33.22%, and 31.19% respectively. The percentages of fine Sand passing the 200 sieves were 84.35%, 65.29%, and 59.96% for samples A, Sample B and Sample C respectively, leading to their classification as Silty Sand (SM) with uniformly graded sand and silt mixture. The OMC and MDD for Sample A, Sample B and Sample C were found to be 24.4%, 26.3%, 27.5% and .34g/cm3, 1.17g/cm3, 1.27g/cm3 respectively. Wet weight measurements indicated variability but suggested characteristics of clay ranging from Very soft to Firm. The research suggests and concluded that the soil samples from the Iyana-Ipaja area of Alimosho LGA, Lagos, requires chemical stabilization, preferably with cement or lime, to be suitable for construction and geotechnical purposes.

KEYWORD

Wetland, Stabilization, Mohr circles, Shear strength and Plasticity

1. INTRODUCTION

Wetlands serve as crucial subsystems within the broader ecosystem, playing essential roles in maintaining both surface and groundwater resources on Earth. Despite their significance (Ajibola et al., 2016). Wetland soil pertains to the soil present in wetland ecosystems, where the land remains saturated with water either throughout the year or for extended periods. These ecosystems encompass diverse environments like marshes, swamps, bogs, and floodplains. The attributes of wetland soils are shaped by the distinct hydrological conditions and the specific vegetation types thriving in these regions.

Wetlands soils are typically characterized by hydric conditions, meaning they remain saturated, flooded, or have a high water table for a significant portion of the growing season. These persistent waterlogged conditions profoundly impact the physical and chemical properties of the soil, as illustrated in Figure 1. Due to the limited oxygen supply in wetland soils, anaerobic (low oxygen) conditions prevail, influencing the types of microbial activity and decomposition processes. The unique conditions of wetland soils often give rise to distinctive colors, influenced by factors like the presence of reduced iron (Fe) and organic matter. Common soil hues in wetlands include grays, blues, and mottled patterns indicative of fluctuating water levels (Carl C. Trettin, 2020). Accumulation of organic matter, primarily from plant material decomposition, is typical in wetlands. This organic material contributes to the formation of peat in certain wetland types, such as bogs. Wetland soils may exhibit distinct horizons (layers) that reflect the dynamic interplay between water and soil-forming processes. For instance, the upper layer might be enriched with organic material, while deeper layers may show evidence of mineral deposition. Understanding wetland soils is imperative for managing and conserving these ecosystems. The unique properties of wetland soils play a pivotal role in supporting diverse plant and animal species adapted to these specific conditions. Moreover, wetlands provide essential ecological services, including water purification, flood control, and wildlife habitat. Wetlands stand out as some of the most productive ecosystems globally (Wahied and Sachdeep, 2021).

Wetland soils in Nigeria are commonly found in three main landforms: inland depressions, floodplains, and coastal plains (Farina, 2005). These soils often display wetness indicators such as mottling or gleying in their profiles, resulting in the formation of gleyic and histic horizons. In Nigeria, the major types of wetland soils have been classified into Gleysols/Fluvisols, Alfisols, Inceptisols, Entisols, Histosols, and Vertisols. (Babalola et al, 2011).

According to Cowardin et al. of the U.S. Fish and Wildlife Service, wetlands are categorized into coastal (tidal or estuarine) and inland (non-tidal, freshwater, or palustrine) types (Cowardin et al., 1979). However, researchers in 2003 expanded this classification by grouping wetland ecosystems into three broader categories: freshwater, man-made, and

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saltwater wetland ecosystems (Oyebande et al., 2003). This broader classification scheme accounts for a wider range of wetland types by including human-made wetlands alongside natural ones.

Wetlands are defined in accordance with the Ramsar Convention as "areas of marsh, fen, peatland, or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, or salt, including areas of marine water the depth of which at low tide does not exceed 6 meters" (Oyebande et al., 2003). Researchers in 1990 highlights that around six percent of the Earth's land area is occupied by wetland ecosystems, which are widely regarded as highly endangered environmental assets (Turner, 1990). Over recent years, both the geographical coverage and ecological richness of wetlands have experienced notable declines (Turner, 1990). To evaluate the geotechnical properties of wetland areas in Lagos, Nigeria, specifically the mainland and island regions, comprehensive studies would be necessary.

Geotechnical properties play a critical role in comprehending soil behavior and identifying potential challenges related to construction, land use planning, and environmental management. The objective of this research is to assess the geotechnical properties of soil samples collected from three sites within the Iyana-Ipaja area of Alimosho Local Government Area, Lagos. The research aims to offer valuable information for decision-making in construction projects and land development initiatives within the study area. Recommendations for soil improvement techniques, such as compaction, stabilization, or drainage measures, may be provided based on the findings to enhance the soil's suitability for construction purposes and mitigate potential risks associated with its use.

2. Description Of The Study

The soil samples were collected from the Iyana-Ipaja area of Alimosho LGA, Lagos, situated in the western part of Nigeria. Lagos, a city in the southwestern region of Nigeria, lies on the Atlantic coast of the Gulf of Benin, west of the Niger Delta Formation. The study area spans from Longitude 6̊ 40′ 30″N to 6̊ 31′ 30″N and Latitude 3̊ 12′ 30″ E to 3̊ 17′ 30″E, specifically within the Iyana-Ipaja locality of Alimosho L.G.A, Lagos. Topographically, the area is positioned at the lowest elevation point, sloping gently upwards towards the Iyana-Ipaja market and the Aboru region. A canal system serves as the primary drainage system, with gutter networks directing runoff towards it. According to local residents, the study area was previously inundated before the construction of the canal system. Consequently, the soil in the area contains a high concentration of organic content, with traces of carbon materials, including low-grade coal, although the precise grade falls beyond the scope of this study. Additionally, some areas are covered with freshly deposited sands, believed to result from overflow from the canal system during rainy seasons. Iyana-Ipaja is primarily a residential area within Alimosho L.G.A, characterized by easy accessibility via numerous minor streets. Alimosho is notably the largest local government area in Lagos State, covering a landmass of 138.7 square kilometers and hosting a population of 2,047,024 inhabitants (Source: Lagos State Bureau of Statistics, 2006). Lagos experiences two distinct rainy seasons, with the most intense rainfall occurring from April to July, and a milder rainy season in October and November. There is a brief period of relatively dry weather in August and September, followed by a longer dry season extending from December to March. During the peak rainy months of May and June, monthly rainfall averages over 400 millimeters, while in August and September, it decreases to around 200 millimeters. By December, rainfall levels drop significantly to as low as 25 millimeters. The main dry season is accompanied by harmattan winds originating from the Sahara Desert, which typically occur between December and early February. The mean daily temperature range is approximately 8 degrees Celsius, with the mean maximum temperature reaching around 22 degrees Celsius. The highest temperatures are typically recorded in March and April, while the lowest temperatures occur in July and August. Humidity levels in Lagos hover around 80%. The study area has extensive road networks; with Lagos having the largest road network in West Africa it also has suburban trains and some ferry services. The study area was majorly accessible by motorcycle as the road had been eroded by floods. The drainage system of Lagos is characterized by a complex network of lagoons and waterways, which account for approximately 22% or 787 square kilometers of the state's total landmass. Among the major water bodies are the Lagos and Lekki lagoons, as well as the Yewa and Ogun Rivers. Additionally, there are smaller water bodies such as the Ologe lagoon, Kuramo waters, and the Badagry, Five Cowries, and Omu creeks. The relief of Lagos is primarily lowland, also referred to as an alluvial plain, with an average elevation of about 35 meters above sea level. However, some areas are situated below sea level. Alimosho Local Government, where the study area is located, lies approximately 30-32 meters above sea level and features gentle slopes and flat terrain. Additionally, the area possesses a few wetlands and creeks. The study area itself is positioned at the bottom of a steep slope, intersected by a canal system, which likely influences its hydrological characteristics and drainage patterns. Two main vegetation types are identifiable in Lagos state. Swamp forest of the coastal belt and dry lowland rainforest. The dominant vegetation of Alimosho local government is the swamp forest consisting of fresh natural water with simple and wild aquatic animals. This is also fertile land suitable for both subsistence and arable farming. The swamp forest in Lagos State represents a unique blend of mangrove forest and coastal vegetation, thriving in the brackish conditions of coastal areas and the freshwater swamps of lagoons and estuaries. Lagos State serves as a significant financial, cultural, industrial, and entertainment hub in Africa, boasting a large and diverse population from various sectors including education, entertainment, finance, and industry. The study area under consideration is primarily a residential zone with limited industrial activity. Alimosho, being an urban center, sees minimal arable farming practices, with backyard farming and small-scale vegetation cultivation near the Lagos State University (LASU) area of the local government. While some individuals reside in the creek areas and engage in small-scale fishing, the predominant activities in Alimosho revolve around residential living and small-scale commercial ventures such as markets, schools, and businesses. Industrial presence in the area is relatively sparse.

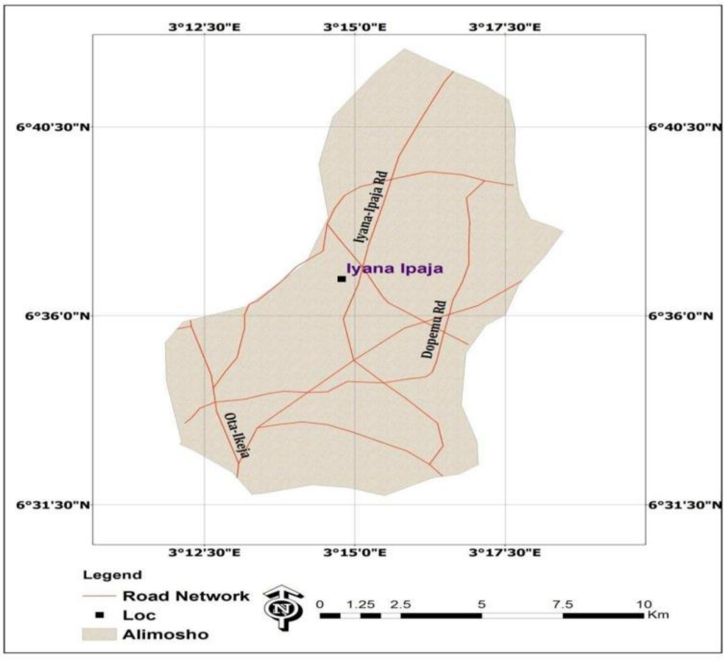

Figure 1: Map of Alimosho Local Government Area (Source: Lagos State Surveyor General Office)

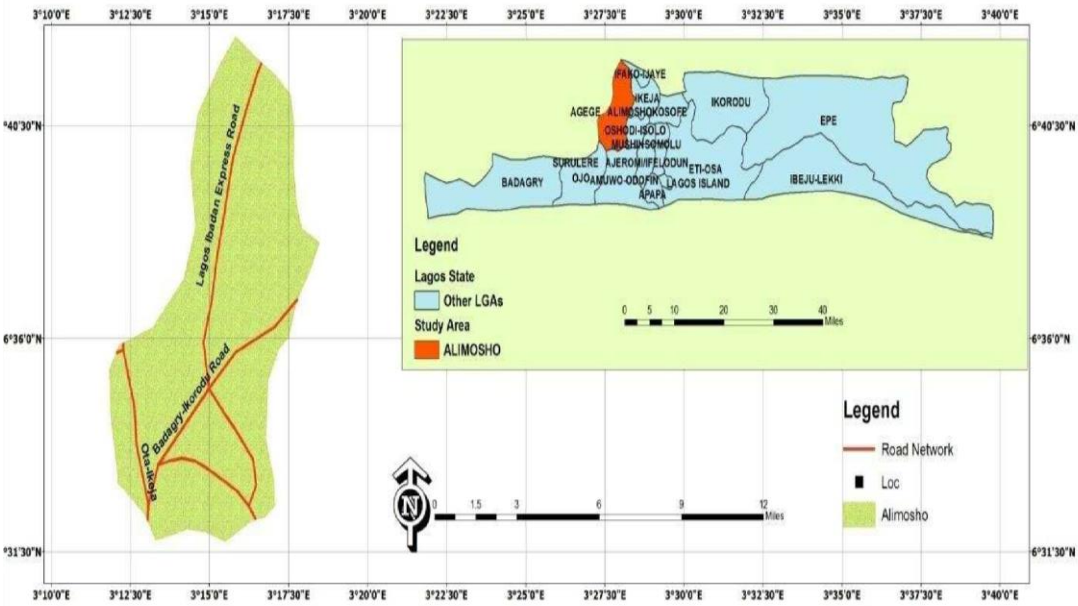

Figure 2: Map of Lagos Showing Alimosho Local Government (Source: Lagos State Surveyor General Office)

3. GENERAL GEOLOGY OF LAGOS STATE

Lagos State is predominantly underlain by a foundation of alluvial deposits, primarily consisting of coastal plain sands, clayey materials and sandstone (Jones and Hockney, 1964). The surface geology is characterized by two main formations: the Benin Formation, which ranges from the Miocene to recent periods, and recent litoral alluvial deposits. The Benin Formation is primarily sedimentary in nature and comprises thick layers of yellowish and white sand. These sands are friable and poorly sorted, often containing intercalations of shale, clay, and sandy clay with lignite deposits. This geological formation contributes significantly to the overall landscape and geotechnical characteristics of Lagos State. The Benin Formation reaches thicknesses of approximately 200 meters in various locations and is frequently overlain by substantial layers of regolith, which are composed of weathered and ferruginized rock material. These geological features contribute to the diverse landscape and soil characteristics observed throughout the state.

Geologically, Lagos is situated within the Dahomey Basin, which extends from Accra in Ghana through the Republic of Togo to the western flanks of the Niger Delta in the east as shown in Figure 3.

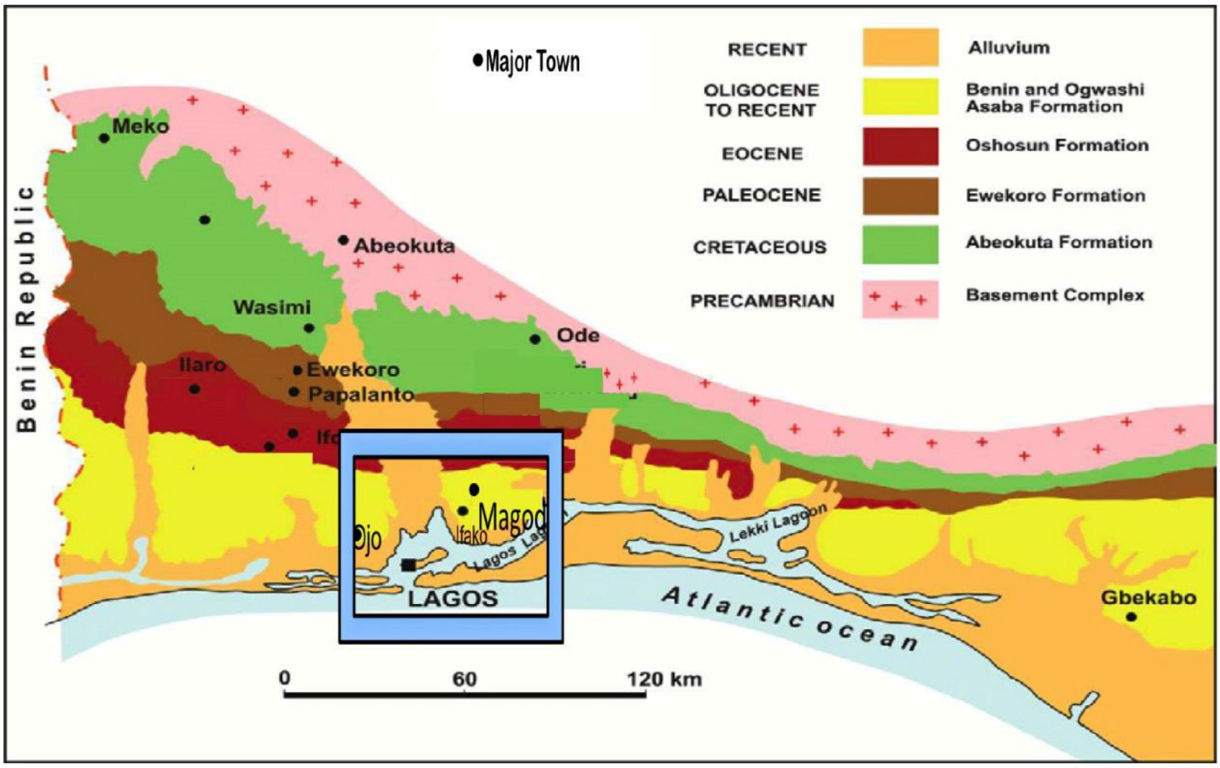

Figure 3: Geological Map of Lagos (Bankole et al., 2007)

4. MATERIAL AND METHOD

4.1 Material

To accomplish the stated objectives, an experimental approach was employed, necessitating the collection of soil samples and control samples from seven sampling points within three areas of the study site. The following materials were utilized for sample collection: Global Positioning System (GPS) for precise location determination, sample bags for containment, shovels for excavation, marker pens for labelling, and a measuring staff for depth measurement. The samples were collected at a depth of 0.5 meters (approximately 1.6 feet) to minimize the influence of organic and biogenic matter on the engineering properties of the soil. This depth selection aimed to capture representative soil characteristics relevant to the study objectives.

4.2 Method

After collection, the soil samples were transported to the laboratory for analysis. Several tests were conducted on the soil samples to assess their engineering properties. These tests included: Particle size analysis: Determining the distribution of particle sizes within the soil sample; Specific gravity test: Measuring the density of the soil particles relative to the density of water; Natural moisture content test: Determining the amount of water present in the soil sample in its natural state; Atterberg limit tests: Assessing the consistency and plasticity of the soil through tests for plastic limit, liquid limit, and plasticity index; Compaction test: Evaluating the soil's ability to be compacted and its maximum dry density under controlled conditions; Triaxial tests: Assessing the shear strength and stress-strain behaviour of the soil sample under different confining pressures. These tests provide valuable insights into the engineering properties of the soil, which are essential for various construction and geotechnical applications.

4.2.1 Atterberg limits test

4.2.1.1 Liquid limit

There are two specified methods for the determination of the liquid limit of a soil which are: Cone penetrometer method and Casagrande method

4.2.1.1.1 Casagrande Method

Sample Preparation: 200 grams of each air-dried soil sample was sieved through a 425-micrometer sieve to remove coarse particles; mixing with Water: The sieved soil was then mixed with a small amount of distilled water to form a thick paste. This paste was left overnight to ensure thorough moisture absorption; Preparation of Soil Cup: The cup of the testing apparatus was half-filled with the wet soil paste and leveled off at the top; Grooving the Soil: A 2mm groove was made at the middle of the soil surface using a grooving tool; Testing Procedure: The handle of the testing apparatus was rotated at a speed of 2 revolutions per second, causing the cup to lift 10mm and then fall onto a rubber base continuously; The number of blows required to close the groove over a distance of 13mm was recorded; Moisture Content Determination: After each test, a portion of the soil from the tested position was removed for moisture content determination; Repetitions: The test was repeated five more times, with a slightly increased amount of water added to the soil paste for each test; Data Analysis: The variations of moisture content were plotted against the corresponding number of blows. A best-fit curve was drawn across the points, and the moisture content corresponding to 25 blows was taken as the liquid limit.

4.2.1.2 Plastic Limit

Procedure: Sample Preparation: Approximately 20 grams of each soil sample utilized in the liquid limit examination; Mixing with Water: The soil was amalgamated with water on a glass plate until achieving the desired plasticity for shaping into a ball; Rolling into a Thread: Subsequently, the soil paste was rolled out between the hand and the glass plate to create a thread; Determination of Plastic Limit: The soil attained its plastic limit when the thread commenced crumbling at a diameter of 3mm. At this juncture, a portion of the thread was extracted for moisture content analysis; Repetitions: This procedure underwent replication three more times for each soil specimen; Moisture Content Determination: Subsequent to each trial, the moisture content of the soil thread at the plastic limit was evaluated; Calculation: The average moisture content derived from the four trials was computed and considered as the plastic limit of the soil sample.

4.2.1.3 Plasticity Index

The plasticity index (PI) of a soil is defined as a measure of its plasticity, indicating the range of water contents within which the soil demonstrates plastic characteristics. It is calculated by subtracting the plastic limit (PL) from the liquid limit (LL), expressed by the formula:

$$P.I = L.L - P.L \qquad (1)$$

Where P.I = plasticity index

4.2.2 Natural moisture content

Procedure: Weighing the Sample: An Approximately 50 gram of each soil sample was weighed in a container of known weight. This initial weight was recorded; Oven Drying: The samples were subsequently dried in an oven until reaching a consistent weight within a temperature range of approximately 105°C to 110°C. This drying process removes all moisture from the soil sample; Cooling and Weighing: After drying, the samples were allowed to cool in a desiccator to prevent moisture absorption from the atmosphere. Once cooled, the samples were re-weighed; Calculation of Natural Moisture Content: The loss in weight of the sample resulting from moisture removal during oven drying was documented. This loss in weight is the weight of water in the sample. The natural moisture content was determined by calculating the percentage of the weight of water relative to the dry weight of the sample.

$$\text{Moisture content} = \frac{w1-w2}{w2-w3} \times \frac{100}{1} \qquad (2)$$

Where: W1 = weight of wet soil

W2 = weight of dry soil

W3 = weight of moisture lost

4.2.3 Particle size analysis

4.2.3.1 Procedure

4.2.3.1.1 Sieving Analysis

Recording Sieve Weights: The weight of each sieve, including the bottom pan, was recorded before beginning the sieve analysis; Sample Preparation: Approximately 100 grams of the soil sample was weighed and soaked in water; Wet Sieving: The soaked soil samples were washed through the 425-micron and 75-micron sieves to separate the finer particles from the coarser ones; Drying: After wet sieving, the separated soil fractions were dried for 24 hours to remove excess moisture; Assembly of Sieves: The sieves were assembled in ascending order of sieve numbers, with the #4 sieve placed at the top and the #200 sieve at the bottom. The bottom pan was placed below the #200 sieve to collect the finest particles; Loading the Sample: The dry soil sample was carefully poured into the top sieve, and a cap was placed over it to prevent spillage; Mechanical Shaking: The stack of sieves was placed in a mechanical shaker and shaken for 10 minutes to facilitate the separation of soil particles based on size; Weighing: After shaking, the stack of sieves was removed from the shaker, and each sieve, along with its retained soil, was carefully weighed. The weight of the soil retained on each sieve and in the bottom pan was recorded.

4.2.3.1.2 Hydrometer analysis

The fine soil retrieved from the bottom of the sieve set was transferred into a beaker, followed by the addition of 125ml of a dispersing agent solution containing sodium hexametaphosphate (40g/L). The mixture was stirred thoroughly until the soil became completely saturated, after which it was left to soak for a duration of ten minutes. During this soaking period, 125ml of the dispersing agent solution was poured into the control cylinder and topped up with distilled water to the designated mark. Subsequently, the soil slurry was transferred into a mixer, and additional distilled water was added until the mixing cup was filled to at least halfway. The solution underwent mixing for duration of two minutes. Immediately after mixing, the soil slurry was carefully transferred into an empty sedimentation cylinder, and distilled water was added to reach the predetermined mark. The open end of the cylinder was then covered with a stopper and securely held in place with the palm of the hand.

The cylinder was inverted and returned to an upright position repeatedly for one minute, ensuring approximately 30 inversions during this period. After one minute and forty seconds had elapsed, the hydrometer was delicately inserted into the suspension for the first reading. It was crucial to insert or remove the hydrometer slowly, taking about 10 seconds, to minimize disturbance. Additionally, the hydrometer release needed to be as close to the reading depth as possible to prevent excessive bobbing. The reading was obtained by observing the top of the meniscus formed by the suspension and the hydrometer stem. After each reading, the hydrometer was carefully removed and returned to the control cylinder, where it was gently spun to dislodge any adhered particles. Subsequent hydrometer readings were taken at intervals of 2, 5, 8, 15, 31, and 60 minutes from the start of the analysis.

4.2.4 Specific gravity determination

Procedure: There are two major methods of determining specific gravity, but the procedures are similar. The density bottle method and 1 litre gas jar method.

For this project, the density bottle method was employed. Initially, the density bottle underwent drying and subsequent weighing. Next, it was filled with distilled water, and the resulting weight was documented. Following this, approximately one-third of the soil sample was introduced into the dried density bottle and weighed. Subsequently, the density bottle containing the soil sample was replenished with distilled water and left

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undisturbed for 24 hours, after which its weight was measured. Through mathematical computations, the weights of the soil sample and an equivalent volume of water were derived. The ratio between these weights served as the specific gravity of the soil. The detailed mathematical calculation process is outlined below:

$$S.G = W_2 - W_1 \quad (3)$$

W1 = weight of bottle

W2 = weight of bottle + soil

4.2.5 Compaction test

Procedure: The process began by sieving the air-dried sample through a 4.75mm sieve, yielding 3kg of collected sample. This sample was then mixed with approximately 6% distilled water and promptly placed into a cylindrical compaction mould, with an extension (collar) added. The mould, boasting a diameter of 105mm, was utilized for the compaction process. Employing a rammer that descends freely from a height of 50cm, the soil was compacted in the mould in three layers, each layer receiving 25 blows to achieve the desired Proctor density. Special care was taken to ensure that the final compacted layer did not fall below the collar joint, nor exceed 1cm above it. Subsequently, the mould extension was removed, and the soil was trimmed to be level with the mould before being weighed. Following this, a 2% increment of water was added, and the test was repeated five times. It was noted that there was a notable decrease in weight during the fourth and fifth repetitions of the test. The outcomes of these tests were graphically represented by a moisture-density curve, where the dried density for each determination was depicted on the ordinate axis, and the corresponding moisture content was represented on the abscissa axis.

4.2.6 Triaxial test

The purpose of this procedure is to assess the shear strength parameters and bearing capacity of cohesive soil. This test involves measuring the failure load on a solid sample, allowing the computation of deviator stresses. The resultant data enables the construction of Mohr circles, facilitating the calculation of shear strength parameters for the soil. Typically, the test conducted is the quick unconsolidated undrained triaxial shear stress, employing a 76mm-high solid sample. Confining cell pressures of 100, 205, and 310kN/m^2 are commonly utilized during the testing process. The procedures for triaxial test are as follows:

- Prepare 3 set of soil samples of known length and diameter, using a sample extruder.
- Measure the highest of sample using vernier calipers
- Enclose the samples appropriately into a thin rubber membrane using condom
- Put porous plates above and below the sample, making sure they are held in place by a suitable rubber band.
- Insert sample in the triaxial apparatus, then flood it with water
- Apply a pre-determined lateral pressure (hand pump) starting from 100kN/m2 for the test.
- The dial readings were taken at each deflection of 30until the material fails. Failure occurs if the dial reading reaches a constant value thrice.
- Remove the soil specimen from the apparatus, record the failure length and note the shape
- Repeat step 5 to 8 with the remaining samples.

The most widely used relationship is the Mohr-Coulomb strength theory equation is

$$Ʈ = C + \sigma_n \tan Ø \quad (4)$$

Where Ʈ stand for shear strength, C is cohesion, σ_n is normal stress and Ø is frictional angle

$$\text{Normal stress } (\sigma) = \frac{\sigma 1+\sigma 3}{2} + \frac{\sigma 1-\sigma 3}{2} * \cos 2Ø \quad (5)$$

σ_1 and σ_3 is cell pressure

5. INTERPRETATION OF RESULT AND DISCUSSION

5.1 Atterberg limits test

The liquid limit (LL) values of sample A, B, and C are: 44.40%, 44.82%, 45.13% while the plastic limits values are; 28.63%, 33.30%, 33.46% respectively and the plastic index values of sample A, B and C are 16.76, 11.53 and 11.67 respectively as shown in Table 1, 2 and 3. The liquid limit values ranges from 44.40% to 45.13%. According to researchers in 2001 and 2024 when LL < 50% it donates that the clay is inorganic clay of medium plasticity (CL) (Akpokodge, 2001; Andre-Obayanju, 2024). According to Unified Soil Classification System classified soil sample A, B and C collected from the three sampling location as inorganic clay of low to medium plasticity (CL). The plasticity index (PI) of soil samples A, B and C values ranges from 11.53 to 16.76. All three soil samples (A, B, and C) are classified as inorganic clays of low to medium plasticity (CL) and are considered moderately plastic based on their plasticity index (PI) values being less than 17% (Akpokodge, 2001; Andre-Obayanju, 2024).

Table 1: Liquid and Plastic Limit, Linear Shrinkage for Sample A

Liquid and Plastic Limit, Linear Shrinkage for Sample A					
Date: 22/11/2022 Liquid Limit: 44.40 Plastic Limit: 28.63 Plastic Index: 16.76					
Proportion of sample retained on No. 36 B.S. Steve = Per cent					
Type of Test	LL	LL	LL	LL	LL
No. of Blows/shrinkage %	45	35	25	18	13
Container No.	L	GMI	GM	07	VT
Wt. of wet soil & container (g)	62.57	50.87	54.25	50.7	42.34
Wt. of dried soil & container (g)	50.92	42.32	44.36	42.03	36.29
Wt. of container (g)	21.69	21.51	21.42	23.2	23.91
Wt. of dry soil (Wd) (g)	29.23	20.81	22.94	18.83	12.38
Wt. of moisture (Wm) (g)	11.65	8.55	9.89	8.67	6.05
Moisture contain 100 (Wm/Wd)	39.86	41.09	43.11	46.04	48.87
Type of Test		PL	PL	PL	
No. of Blows/shrinkage %					
Container No.		CO	PL	EK	
Wt. of wet soil & container (g)		25.83	29.03	28.3	
Wt. of dried soil & container (g)		23.89	26.62	25.91	
Wt. of container (g)		17.12	18.2	17.56	
Wt. of dry soil (Wd) (g)		6.77	8.42	8.35	
Wt. of moisture (Wm) (g)		1.94	2.41	2.39	
Moisture contain 100 (Wm/Wd)		28.66	28.62	28.62	

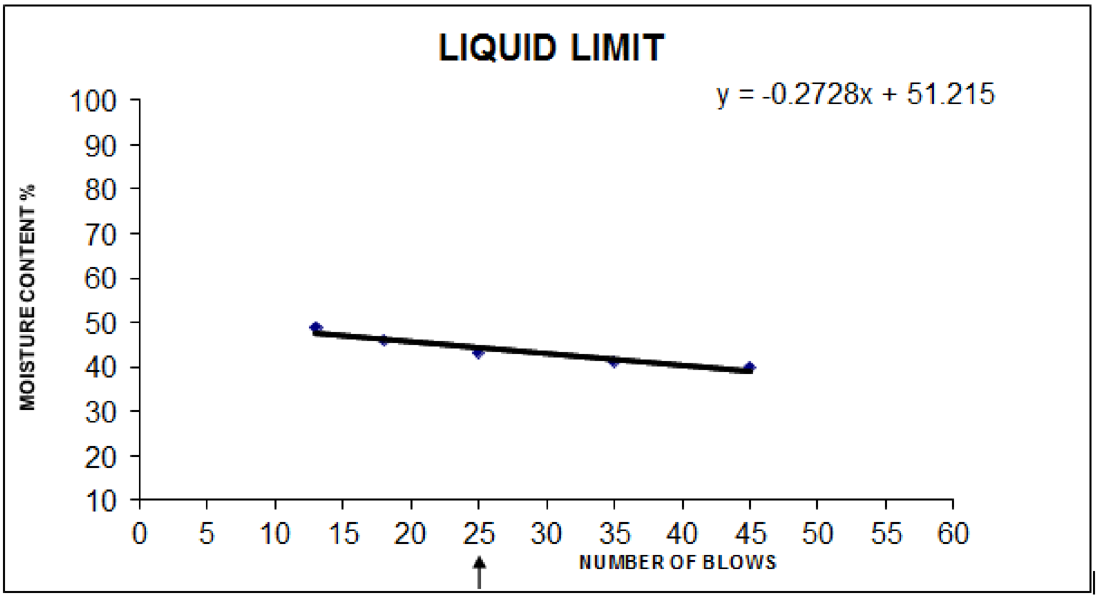


Table 2: Liquid and Plastic Limit, Linear Shrinkage for Sample B

Liquid and Plastic Limit, Linear Shrinkage for Sample B					
Date: 22/11/2022 Liquid Limit: 44.82 Plastic Limit: 33.30 Plastic Index: 11.53					
Proportion of sample retained on No. 36 B.S. Steve = Per cent					
Type of Test	LL	LL	LL	LL	LL
No. of Blows/shrinkage %	45	44	25	17	13
Container No.	O	OI	NN	9	05
Wt. of wet soil & container (g)	54.33	52.64	45.3	43.38	50.82
Wt. of dried soil & container (g)	46.17	43.49	38.07	36.86	41.17
Wt. of container (g)	26.19	21.25	21.33	22.76	21.33
Wt. of dry soil (Wd) (g)	19.98	22.24	16.74	14.1	19.84
Wt. of moisture (Wm) (g)	8.16	9.15	7.23	6.52	9.65
Moisture contain 100 (Wm/Wd)	40.84	41.14	43.19	46.24	48.64
Type of Test		PL	PL	**PL**	
No. of Blows/shrinkage %					
Container No.		OX	04	RT	
Wt. of wet soil & container (g)		26.47	28.36	25.85	
Wt. of dried soil & container (g)		24.25	26.13	23.84	
Wt. of container (g)		17.53	19.73	17.56	
Wt. of dry soil (Wd) (g)		6.72	6.4	6.28	
Wt. of moisture (Wm) (g)		2.22	2.23	2.01	
Moisture contain 100 (Wm/Wd)		33.04	34.84	32.01	

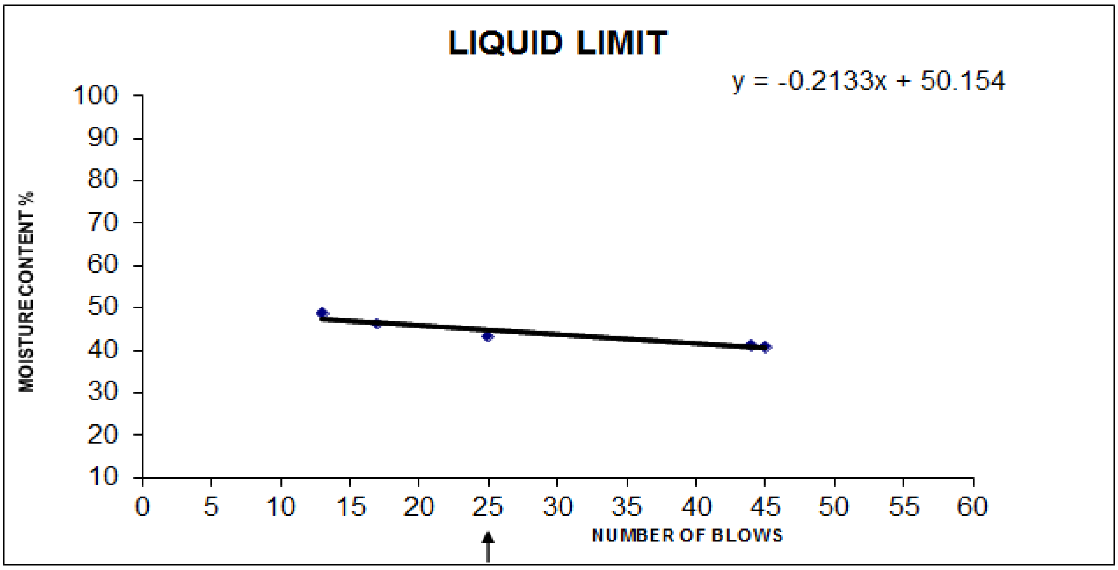
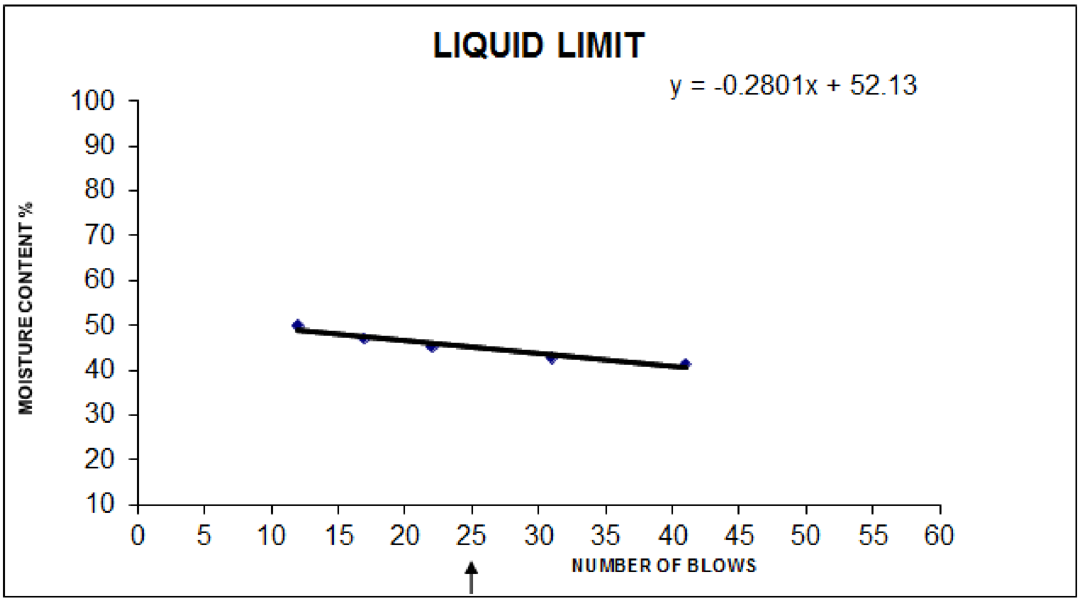


Table 3: Liquid and Plastic Limit, Linear Shrinkage for Sample C

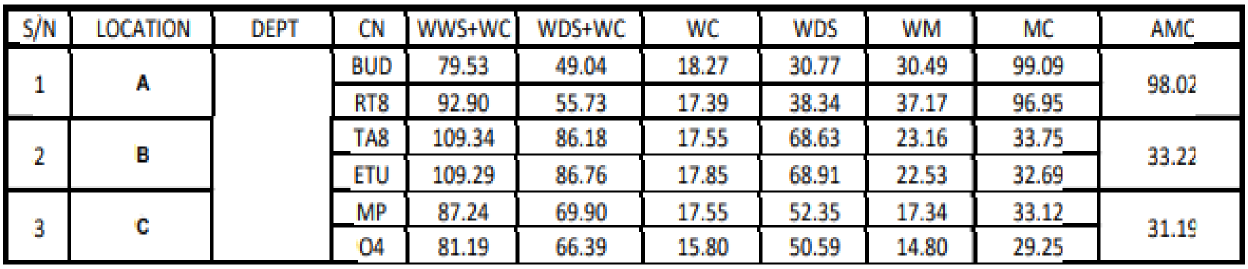
Liquid and Plastic Limit, Linear Shrinkage for Sample C					
Date: 22/11/2022 Liquid Limit: 45.13 Plastic Limit: 33.46 Plastic Index: 11.67					
Proportion of sample retained on No. 36 B.S. Steve = Per cent					
Type of Test	LL	LL	LL	LL	LL
No. of Blows/shrinkage %	41	31	22	17	12
Container No.	S	XP	OI	U	GE
Wt. of wet soil & container (g)	47.54	50.99	48.96	49.83	50.55
Wt. of dried soil & container (g)	39.83	42.97	40.38	40.69	40.85
Wt. of container (g)	21.21	24.23	21.38	21.26	21.37
Wt. of dry soil (Wd) (g)	18.62	18.74	19	19.43	19.48
Wt. of moisture (Wm) (g)	7.71	8.02	8.58	9.14	9.7
Moisture contain 100 (Wm/Wd)	41.41	42.8	45.16	47.04	49.79
Type of Test			PL	PL	PL
No. of Blows/shrinkage %					
Container No.			IT	PA	RT
Wt. of wet soil & container (g)			28.25	27.06	27
Wt. of dried soil & container (g)			25.63	24.65	24.6
Wt. of container (g)			17.87	17.43	17.38
Wt. of dry soil (Wd) (g)			7.76	7.22	7.22
Wt. of moisture (Wm) (g)			2.62	2.41	2.4
Moisture contain 100 (Wm/Wd)			33.76	33.38	33.24



5.2 Natural Moisture Content

The natural moisture content values of soil sample A, B and C are: 98.02%, 33.22%, and 31.19% respectively. Soil sample A has the highest moisture and soil sample C has the least natural moisture capacity. This implies that soil sample A has the highest retention capacity which implies an absence of sands and gravel. The higher the retention capacity the less suitable it is for construction. From the results in Table 4, soil sample B and C is suitable for construction.

Table 4: Natural Moisture Content



S/N	LOCATION	DEPT	CN	WWS+WC	WDS+WC	WC	WDS	WM	MC	AMC
1	A		BUD	79.53	49.04	18.27	30.77	30.49	99.09	98.02
			RT8	92.90	55.73	17.39	38.34	37.17	96.95	
2	B		TA8	109.34	86.18	17.55	68.63	23.16	33.75	33.22
			ETU	109.29	86.76	17.85	68.91	22.53	32.69	
3	C		MP	87.24	69.90	17.55	52.35	17.34	33.12	31.19
			O4	81.19	66.39	15.80	50.59	14.80	29.25	

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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)

5.3 Particle size analysis

According to clause 6201 of Federal Ministry of Works and Housing specification, for a sample to be used as both or subgrade or fill or base, the percentage weight passing through the no 200 sieve (75µm) shall be less than but not greater than 35% and if the percentage passing the no 200 sieve is greater than 35% no need for further tests and material rejected. The soil samples under review have 84.35%, 65.29%, and 59.96% of fine Sand for samples A, B and C respectively passing the 200 sieves. According to Unified Soil Classification System classified the soil samples of A, B and C as Silty Sand (SM) with sand and silt mixture that is uniformly graded. The particle size distribution was analysed and plotted to obtain a grain size curve as shown in Figure 4-6.

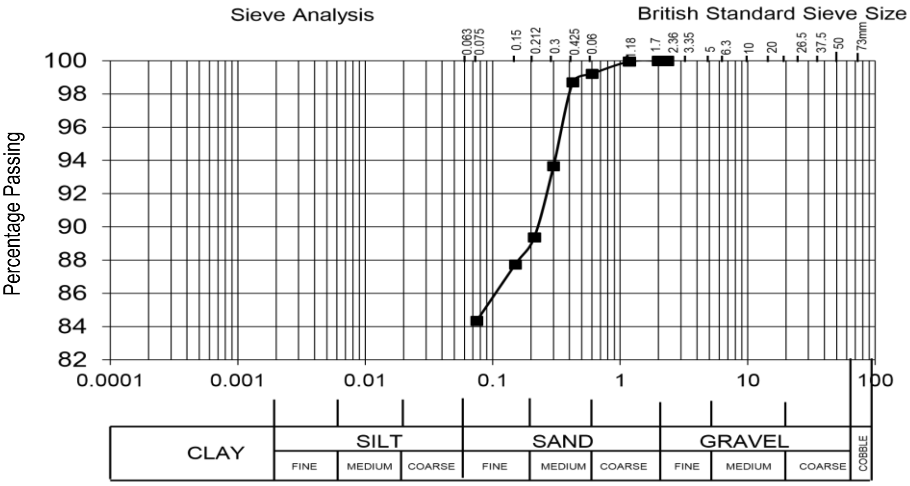

Figure 4: Graph of particle size distribution for sample A

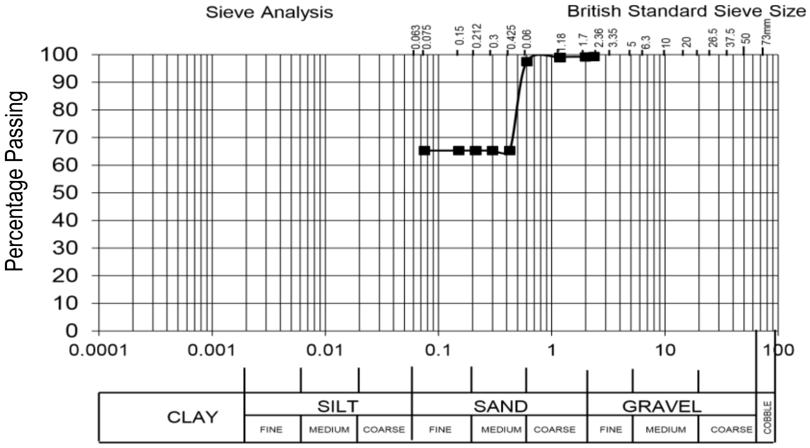

Figure 5: Graph of Particle Size Distribution for Sample B

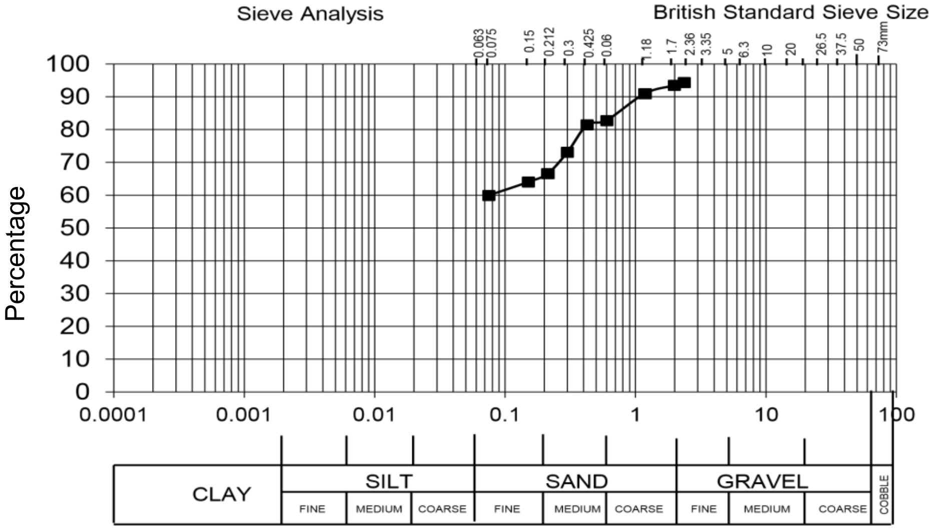

Figure 6: Graph of Particle Size Distribution for Sample C

5.4 Specific gravity determination

The higher the specific gravity of a soil the more suitable it is for construction. The results of the specific gravity analysis (Table 5) are; 2.49, 2.64, 2.55 for sample A, B, and C respectively. Researcher in 1976 stated that a soil is good subgrade if its specific gravity (Gs) range between 2.50-4.60 and all the samples fell in the range of 2.49-2.64 which indicate that it is a fine-grained soil (good subgrade) with fairly high specific gravity mineral and also correlates with the mechanical strength of subgrade (Gidigasu 1976; Mesida, 1981). The specific gravity value of sample A is 2.49, which indicates that the soil sample likely contain Attapulgite minerals while the specific gravity of sample B is 2.64 which indicates that the soil sample likely contain Kaolinite or quartz mineral and the specific gravity value of sample C is 2.55 which indicates that the soil sample contain Halloysite mineral (Akpokodge, 2001). Therefore, sample B with specific gravity value of 2.64 is the most suitable for building and road construction.

Table 5: Specific Gravity Determination

Location	Depth(M)	BN	B+W	B+S+W	B+S	B	Ad. W	WWAS	WS	WOWDS	Gs	AGs
A	0.5	BI	74.65	86.21	49.10	22.67	51.98	37.11	26.43	10.68	2.47	2.49
		IN	76.30	87.42	49.87	23.01	53.29	37.55	26.86	10.69	2.51	
B	0.5	ZH	67.13	83.43	44.23	17.89	49.24	39.2	26.34	10.04	2.62	2.64
		VC	76.88	95.19	53.83	24.52	52.36	41.36	29.31	11.00	2.66	
C	0.5	JA	74.06	91.85	49.67	20.36	53.7	42.18	29.31	11.52	2.54	2.55
		ZC	77.24	93.41	49.63	23.02	54.22	43.78	26.61	10.44	2.55	

B+ W = Wt. of Bottle+ Water (full) W 4

B+ S+ W = Wt. Of Bottle + Soil+ Water W 3

B+ S = Wt. of Bottle+ Soil W 2

B = Wt. Of Bottle W 1

W = Wt. Of Added Water (full) (W 4 - W)

WWAS = Wt. Of Water added to Soil (W 3 - W 2) WS = Wt. Of Soil (W 2 - W 1)

WOWDS= Wt. Of Water Displaced by Soil (W 4 - W 1) - (W 3 - W 2) = W

GS = Specific Gravity (W 2 - W 1)/ W

5.5 Compaction test

From the results obtained, it can be seen that optimum moisture content (OMC) for Sample A, B, and C are: 24.4%, 26.3%, and 27.5% respectively. The maximum dry density (MDD) obtained from the test are; 1.34g/cm^3, 1.17g/cm3, 1.27g/cm^3 for samples A, B, C respectively as shown in Table 6. The compaction curves are shown in Figure 7-9.

The Nigeria specification for road and bridge materials (Nigeria federal ministry of works and housing, 1970) recommends that for a material to be used as fills it should possess maximum dry density (MDD) greater than 0.047 kg/m^3 and optimum moisture content (OMC) less than 18%. Based on the specified requirements for road and bridge materials in Nigeria, all three samples (A, B, and C) are deemed unsuitable for use as fills due to their higher-than-recommended optimum moisture content (OMC). Although the maximum dry densities (MDD) meet the specified requirement, the OMC values exceed the permissible limit, making these samples unsuitable for use in road and bridge construction based on compaction characteristics

Table 6: Compaction Test

Location	Location A		Location B		Location C	
Average Moisture Content (m) %	14.64	17.64	19.87	22.87	24.7	27.53
Dry Density = Pb/1+ (m/100) (g/cm3)	1.18	1.21	1.26	1.32	1.34	1.28
MDD: 1.34g/cm^3 OPT.MC: 24.4% B.S. / C.B.R. Mould……3377g						

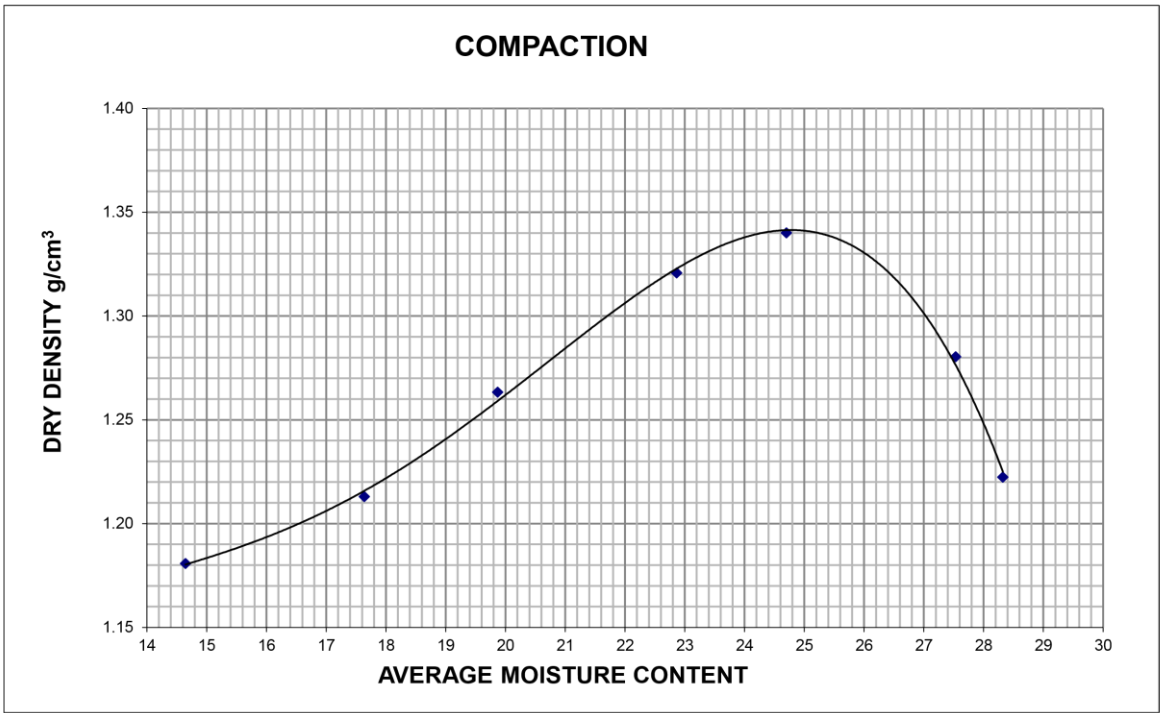

Figure 7: graph of compaction test of sample A

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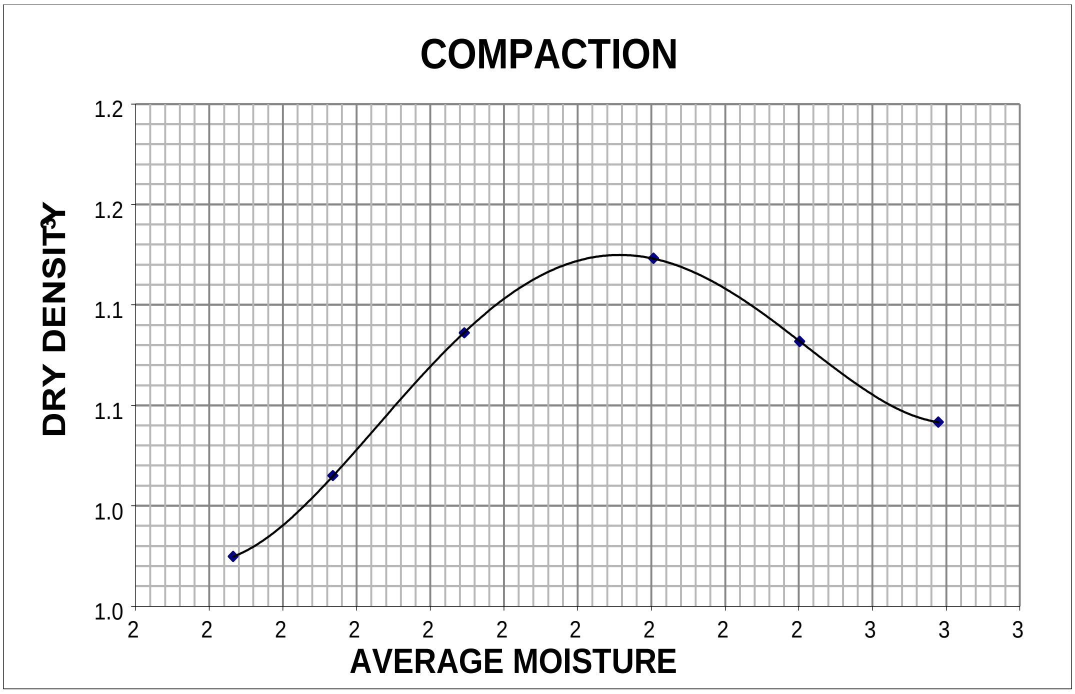

Figure 8: Graph of Compaction Test of Sample B

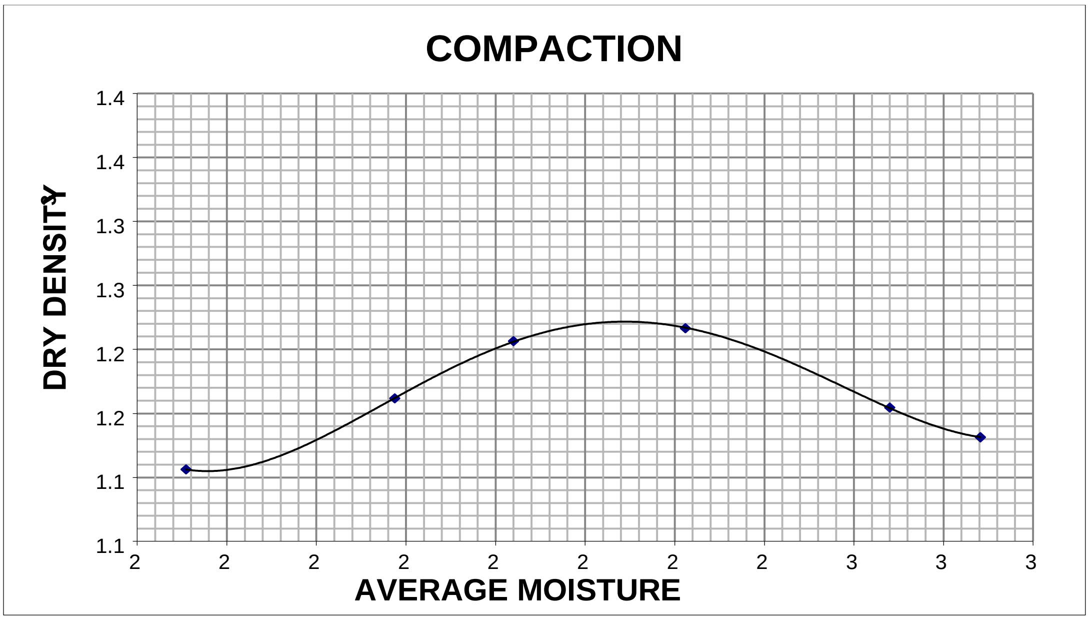

Figure 9: Graph of Compaction Test of Sample C

5.6 Triaxial Compression Test

Triaxial compression test is conducted on a variety of soil types for obtaining the shear strength parameters namely; friction angle and other dependent parameter. From Table 7, the results of triaxial test for sample A, B and C is as follows: Cell Pressure: 100, 205, and 310KN/m^2 respectively; Friction Angle: 7.78º, 9.80̊ and 3.18̊ respectively; Cohesion: 60.0kN/m^2, 3.0kN/m^3 and 3.0kN/m^3 respectively as shown in Table 7. The wet weight of Sample A (140g, 142g, 146g), sample B (165g, 158g,156g), and C (134g, 151g,153g) as shown in Table 7. From Table 7, The wet weight measurements indicate variability but suggest the characteristics of clay classified as Very soft to Firm (Akpokodge, 2001; Andre-Obayanju, 2024). The variation in friction angle and cohesion among the samples can indicate differences in shear strength and soil behavior under different stress conditions. The wet weight measurements suggest the consistency and plasticity of the clay samples, supporting their classification as Very soft to Firm.

The Mohr circles visually represent the shear strength parameters (friction angle and cohesion) and the state of stress for each sample under triaxial compression conditions. The Morh Circe is shown in Figure 10-12. The triaxial compression test results and associated soil characteristics provide insights into the shear strength and behavior of the clay samples (A, B, and C) under varying stress conditions, aiding in their classification and understanding of their engineering properties for geotechnical applications.

Table 7: Triaxial Compression Test

Location	Depth (m)	Wet Weight	Friction Angle	Cohesion (KN/m^2)	Shear strength (KN/m^2)	Undrained shear strength classification of Clay (kN/m^2)
Sample A	1.0	140g,142g,146g	7.78	60.0	73.16	Firm
Sample B	1.0	165g,150g,156g	9.8	3.0	19.27	Very soft
Sample C	1.0	134g,151g,153g	3.18	3.0	8.52	Very soft

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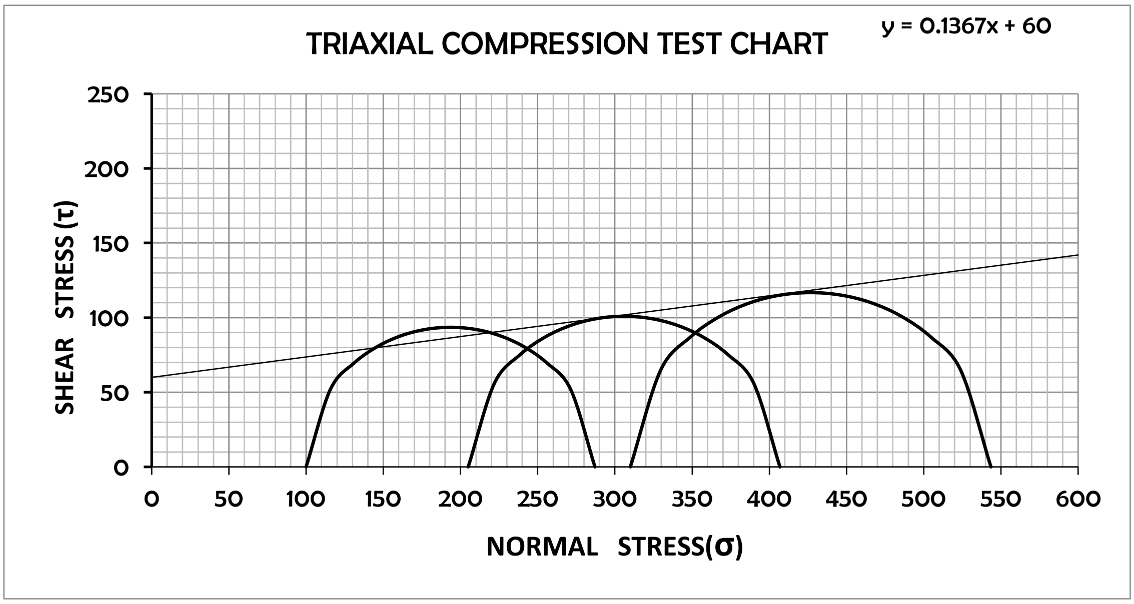

Figure 10: Triaxial compression test of sample A

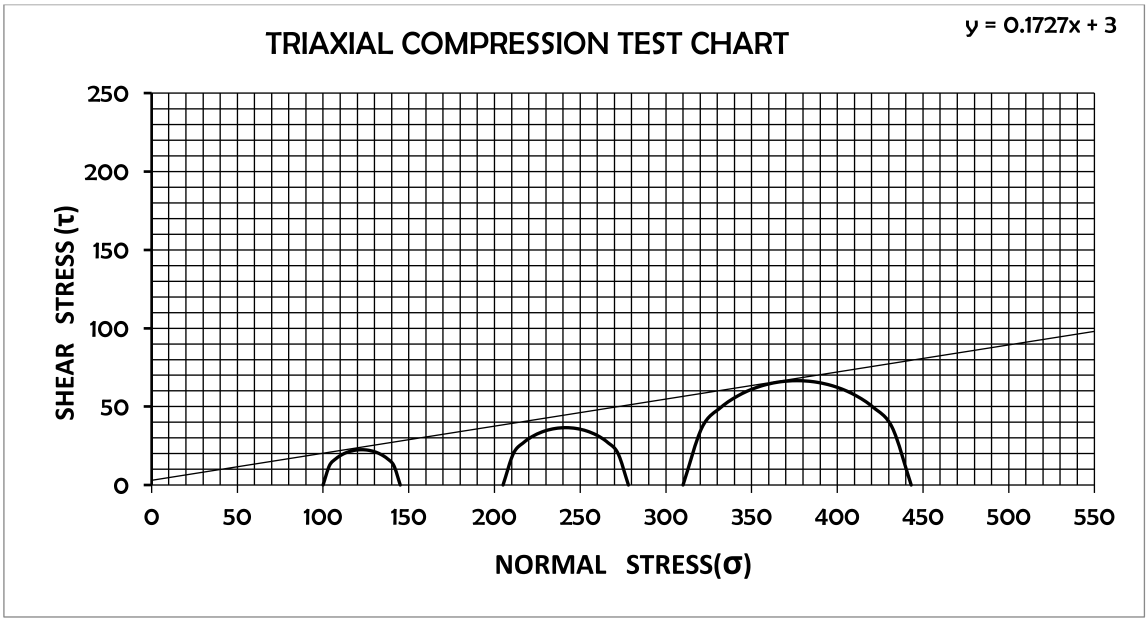

Figure 11: Triaxial compression test of sample B

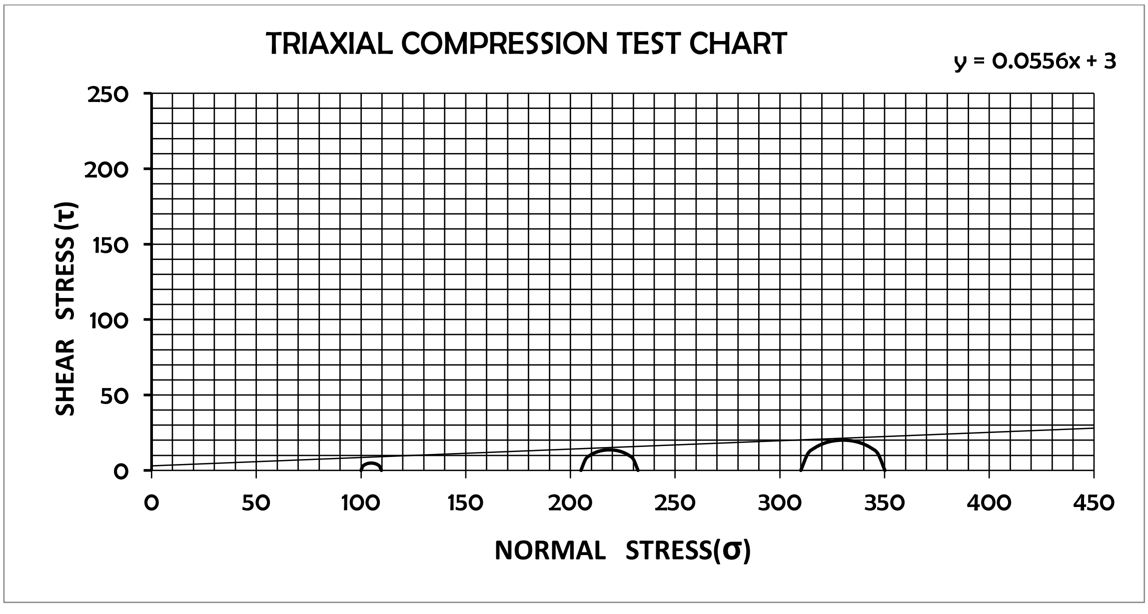

Figure 12: Triaxial compression test of sample C

6. CONCLUSION AND RECOMMENDATION

The results gotten from the analysis of three soil samples in the Iyana-ipaja shows that all the samples are poor construction materials. Sample A which is closer to the canal drainage system is relatively the worst construction material with the highest number of fines and water retention capacity. While Sample B and C which are relatively father away from the canal drainage is the best construction material. Although, all three samples will have to undergo chemical stabilization (preferable cement or lime) in order to be suitable for construction purposes. Based on the collation and interpretation of the result obtained from these tests, it is shown that the soils father away from the canal drainage are better construction materials for engineering projects.

Based on the investigations of this study, the following recommendations can be proffered: the resident engineers and contractors conduct proper analysis and adhere to the code of ethics and ensure that the international set standards are adhered to. Also, suitable stabilization methods should be employed before construction can begin.

REFERENCE

Adegbola, R.B., Oyedele, K.F., Adeoti, L., Adeloye, A.B., 2016. Multichannel analysis of the surface waves of earth materials in some parts of Lagos State, Nigeria. Pp. 82- 83

Adeyemi, 1972. Sedimentology of Lagos lagoon. Unpublished B.Sc. Thesis, Obafemi Awolowo University, Ife-Ife, Osun State, Nigeria.

Ajibola, M. Olusola; Adeleke, Adedapo Muyideen and Ogungbemi, Olayinka Abel (2016). An Assessment of Wetland Loss in Lagos Metropolis, Nigeria. 6 (7), Pp. 1-7.

Andre-Obayanju O, Ese Anthony Aladin and Osisanya Olajuwon Wasiu, 2023. Enhancing the Engineering properties of lateritic soils using Anthills, specifically Mold soils, in certain parts of the Benin metropolitan city in Southern Nigeria. Pakistan Journal of Geology (PJG) 7 (2), Pp. 48-55

Andre-Obayanju, O.O., Ireaja, C.C., 2022. Geotechnical Evaluation of Road Failure Along 20th Street Bdpa, Benin City, Nigeria. J. Appl. Sci. Environ. Manage. 26 (5), Pp. 809-814

ASTM, 2007. Standard Test Method for California Bearing Ratio of Pavement, Subgrade, Base – course and Sub – base materials, D (1883), Pp. 97– 110.

ASTM, 2007. Standard Test Method for Dry Preparation of Soil Samples for Particle Size Analysis, D (421), Pp. 2.

ASTM, 2007. Standard Test Method for Laboratory Compaction Characteristics. D (698), Pp. 117 – 121.

ASTM, 2012. Standard Test for Sieve Analysis of Fine and Coarse Aggregates by Sieving. C (136), Pp. 15 – 17.

Babalola TS, Oso T, Fasina A. S. and Godonu K., 2011. Land evaluation studies of two wetland soils in Nigeria. International Research Journal of Agricultural Science and Soil Science. 1 (6), Pp. 193-204

Bankole, I.S., Schrank, E., Erdtmann, B., 2007. Palynology of the Paleogene Oshosun formation in the Dahomey basin, Southwestern.

Billman, H. G., 1992. Ofshore stratigraphy and paleontology of the dahomey embayment, West African. Niger. Assoc. Pet. Explor. Bull. 7, Pp. 121–130.

British Standard 1377, 1975. Methods of test for soils for Civil Engineering

Purpose. British Standard Institution HMSO London.

Carl C. Trettin, Randall K. Kolka and Anne S. Marsh (2020) Wetland and Hydric Soils.

Coker, S. J. L., 2002. Field excursion guide to tar sand outcrops.

d'Almeida, G. A. F., Kaki, C. and Adeoye, J. A., 2016. Benin and Western Nigeria Ofshore Basins: a stratigraphic nomenclature comparison. Int. J. Geosci. 7, Pp. 177–188

Fajemidagba K. J., 2015. Hydrogeological Characteristics Of Deep Wells In The Coastal Sands Of Alimosho Area, Lagos State

Fasina A.S., 2005. Properties and classification of some selected Wetland soils in Ado Ekiti, Southwest Nigeria. Applied Tropical Agriculture, 10 (2), Pp. 76-82

Gidigasu, M.D., 1976. Laterite Soil Engineering. Elsevier Scientific Publishing Co., New York.

Jones, H.A., Hockey, R.D., 1964. The geology of part of South-Western Nigeria Geological Survey of Nigeria Bulletin No 31.

Longe, E.O., Malomo, S., Olorunniwo, M. A., 1987. Hydrogeology of Lagos metropolis. *J. Afr Earth Sci.* 6 (3), Pp. 163-174.

Mesida E.A., 1981. Laterites on the Highway - Understanding Soil Behaviour. West African Technical Review, November. Pp 112 - 118.

Mohammed S., Opuwari M., and Titinchi S., 2020. Source rock evaluation of Afowo clay type from the Eastern Dahomey Basin, Nigeria: insights from different measurements, Pp. 3-4

Nigeria. Revista Espanola de Micropaleontologia, 39 (1-2), Pp.29-44.

North Carolina Division of Water Resource, 2023. Wetland Soils in North Carolina. *www.ncwetlands.org.*

Nton, M. E., Ikhane, P. R. and Tijani, M. N., 2009. Aspect of rock-eval studies of the Maastrichtian-Eocene sediments from subsurface, in the eastern Dahomey basin southwestern Nigeria. Eur. J. Sci. Res. 25, Pp. 417–427

Olaleye, A.O., 1998. Characterization, Evaluation, Nutrient dynamics and Rice Yields of Selected Wetland soils in Nigeria. PhD Thesis in the Department of Agronomy, University of Ibadan. Pp. 202

Omatsola, M. E. and Adegoke, O. S., 1981. Tectonic evolution and cretaceous stratigraphy of the Dahomey Basin. Niger. J. Min. Geol. Vol. 18, Pp. 130–137

Singh, P., 2008. Engineering and general geology. Eighth Revised Edition. S.K. Kataria and Sons; North Carolina Division of Water Resources.

US EPA, OW (2015). "What is a Wetland?" US EPA. Retrieved 2022-07-08.

Vasilas LM, Hurt GW, Berkowitz JF (eds)., 2016. Field indicators of hydric soils in the United States, Version 8.0. U.S. Department of Agriculture, Natural Resources Conservation Service, Washington, DC, Pp. 55

Wahied Khawar Balwan and Sachdeep Kour, 2021. Wetland-An Ecological Boon for the Environment (2021). East African Scholars Journal of Agriculture and Life Sciences. Sci.

Cite The Article: Andre-Obayanju O., Aladin Anthony Ese* and Okwusi Emmanuel Odinaka(2024). Assessing Geotechnical Properties Of Wetlands Area In Lagos Mainland Western Nigeria. *Earth Sciences Malaysia, 8(1): 79-90.*