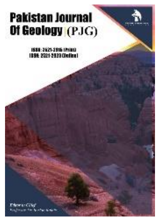
ZIBELINE INTERNATIONAL™ PUBLISHING

ISSN: 2521-2915 (Print)
ISSN: 2521-2923 (Online)
CODEN: PJGABN

Pakistan Journal of Geology (PJG)

DOI: http://doi.org/10.26480/pjg.02.2024.89.97



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RESEARCH ARTICLE

DETERMINATION OF ENGINEERING INDEX PROPERTIES OF SOIL FOR SUITABLE FOUNDATION DESIGN IN AJAH, SOUTHWESTERN NIGERIA

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ARTICLE DETAILS

Article History:

Received 23 June 2024
Revised 09 July 2024
Accepted 23 August 2024
Available online 26 August 2024

ABSTRACT

This research is to determine the engineering index properties of soil for suitable foundation design in Ajah, Southwestern Nigeria. Three samples were acquired from a well bore in the area at depth of 1m, 3m and 5m. The following laboratory tests were carried out on the soil samples collected from the study area (Particle size analysis, Specific gravity, Atterberg limit, Triaxial test, and Compaction). The particle size analysis test revealed the predominance of granular materials ranging from fine to coarse sands in the sample. The specific gravity of the soil shows a gradual increase with depth, from 2.41 (at 1m), 2.50(at 3m) and 2.57(at 5m). The results from the Atterberg limit test showed that the three samples have liquid limit of 20.44%, 23.27%, and 25.61% respectively. The samples are also non plastic in nature, having neither plastic limit nor plastic index. The samples are almost cohesionless, having cohesion of 0.17, 0.95 and 0.76; and having angle of internal friction of about 13.73º, 11.62º, and 11.36º. Further analysis of the soil samples revealed that the optimum moisture content for the samples are 12.4%, 14.2% and 13.2% respectively, from top to bottom, while the maximum dry density for the samples are 1.75g/cm^3, 1.68g/cm^3 and 1.76g/cm^3. The aforementioned properties of the soil proves that the soil is suitable for foundation, having low retention water capacity and relatively high specific gravity and permeability; high percentage of coarser grained fraction and very low percentage of clay minerals.

KEYWORDS

Engineering index properties, Shear stress, Ajah, Foundation

1. INTRODUCTION

It is generally believed that one of the three basic and most important needs of mankind is shelter. The presence of man and growing population worldwide calls for the need of buildings and structures. Engineering geology is one aspect is geology that deals with the analysis and examination of geotechnical properties of materials like soils, for their suitability for constructions and building projects. The strength and durability of every building is determined by the strength of the foundation. The occurrences of building collapse in most places have been attributed to poor quality foundation materials, not suiting the erected structures. Soil is the uppermost part of the Earth's continental crust, formed from the weathering, erosion and transportation processes of preexisting rock bodies. Different soils find use as engineering materials for different purposes, based on its intrinsic property. Basic properties of soil that determines its suitability as foundation includes grain-size distribution, plasticity, compressibility and shear strength. Apeh et al.,2016, in their work "An assessment of foundation design of buildings in Lagos" stated that, That analysis not fewer than thirteen cases of building collapse, were recorded in Lagos State alone while statistics of the previous and subsequent years were not better off either (Mohammad, 2019).

The study in "The Implication of Subsoil Geology in Foundation Failure Using Geotechnical Methods: A Case Study of Lagos Southwestern Nigeria," research was conducted on the areas of Pen-Cinema and Ogudu in Lagos (Ubido, 2017). The study concluded that the subsoil at Pen-Cinema is primarily composed of very hard sandy silty lateritic clay with hard pans at a depth of 2.25 meters, while the subsoil at Ogudu consists of dark grey, stiff, medium-grained clayey sand at a depth of 13 meters. Based on their findings, they recommended that pile foundations are suitable for engineering structures in Ogudu, whereas raft foundations would be more appropriate for Pen-Cinema (Emmanuel, 2017). According to in the study titled "Impact of Sand Mining on Soil and Water Quality along Addo–Baddore Road, Ajah, Lagos State, Nigeria," it was revealed that a thick deposit of well-sorted sand of good construction grade is present along the bay of the Addo-Baddore, Ajah axis in Lagos State, Southwest Nigeria (Ogungbe, 2020). This finding explains the establishment of several sand mining depots along the shore in this area. The study's objective was to examine the geotechnical engineering properties of the soil in the region.

2. DESCRIPTION OF THE STUDY AREA

Ajah is a district within the Eti-Osa Local Government Area of Lagos State, Southwest Nigeria. It is part of the rapidly growing Lekki area, extending from Victoria Garden City (VGC) to Abraham Adesanya Roundabout on the Lekki-Epe Expressway. The district also includes neighborhoods like Badore, Ado, and Langbasa (Wikipedia, 2020). Lagos State, situated in the southwestern part of Nigeria, lies on a narrow plain along the Bight of Benin. It spans approximately 180 kilometers along the Guinea Coast of the Atlantic Ocean. Geographically, Lagos State is located between longitudes 2º 42'E and 3º 22'E, and latitudes 6º 22'N and 6º 27'N. It is bordered to the north and east by Ogun State, to the west by the Republic of Benin, and the Atlantic Ocean to the south (Lagos State Ministry of Science and Technology, 2024). Its territorial extent and political jurisdiction encompasses the city of Lagos and the four administrative divisions of Ikeja, Ikorodu, Epe and Badagry collectively referred to as IBILE and covering an area of 358,862 hectares or 3,577 sq. km. which

Quick Response Code	Access this article online	
	Website: www.pakjgeology.com	**DOI:** 10.26480/pjg.02.2024.89.97

Cite The Article: Ese Anthony Aladin and Andre-Obayanju O (2024). Determination of Engineering Index Properties of Soil for Suitable Foundation Design in Ajah, Southwestern Nigeria. *Pakistan Journal of Geology, 8(2): 89-97.*

represents 0.4% of Nigeria's territorial land mass of 923,773 sq. km (Wikipedia, 2020). Rainy season in Aja occurs in the months of May, June, July, September and October. February has an average maximum temperature of 35ºC (95ºF) and is the hottest month of the year. The coolest month is August with an average maximum temperature of 29ºC (83ºF). June tops the wettest month list with 245mm (9.6in) of rainfall. December is the driest month with 21mm (0.8in) of precipitation. December is the sunniest month with an average of 193 hours of sunshine (CCKP, 2021). The major water bodies in the region include the Lagos and Lekki Lagoons, as well as the Yewa, Ogun, Oshun, and Kweme Rivers. Additional notable water bodies are Ologe Lagoon, Kuramo Waters, and the Badagry, Five Cowries, and Omu Creeks. As Ajah continues to grow in popularity, it provides numerous shopping opportunities to meet the needs of its residents. Traditional fishing remains a significant occupation for the local community and other areas of the state (Lagos State Ministry of Science and Technology, 2024).

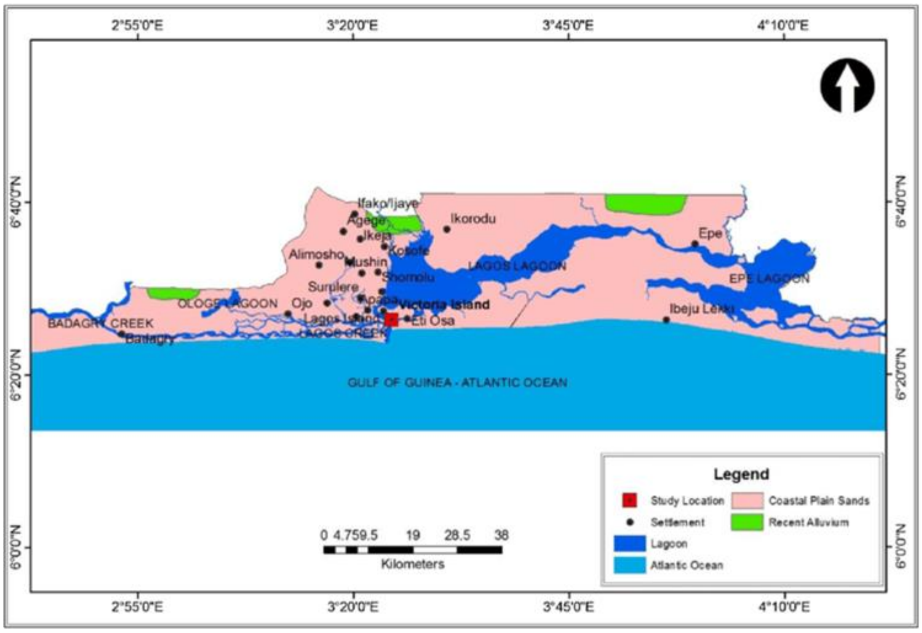

Figure 1: Map of Lagos showing the study location

3. General Geology of Ajah

Ajah is a neighborhood located within the Lekki Peninsula in Lagos, Nigeria. The geological features in Ajah are generally consistent with the broader geology of Lagos. Ajah, like much of the coastal region of Lagos, is characterized by the presence of Coastal Plain Sands. The predominant geological feature in Ajah is the deposition of Coastal Plain Sands. These sands were primarily formed during the Holocene period, which began approximately 11,700 years ago (Adepelumi and Olorunfemi, 2000). As sea levels rose after the last glacial period, rivers transported sediment from the hinterland and deposited it along the coastal plain. Over time, these sediments accumulated and formed the unconsolidated Coastal Plain Sands that characterize the area. They are important for construction purposes and serve as a significant aquifer for groundwater supply in the area (Adepelumi and Olorunfemi, 2000). Ajah is situated along the coastline of the Atlantic Ocean and is influenced by the presence of barrier islands and sand spits. These natural landforms act as a buffer between the ocean and the mainland. Movement of sediment along the coastline is driven by longshore drift. Waves approaching the coast at an angle result in the transport of sediment along the shoreline. This process plays a significant role in the formation and maintenance of the barrier islands, sand spits, and other coastal landforms found in Ajah. Similar to other coastal areas of Lagos, Ajah is subject to coastal erosion. While sediment deposition is an ongoing process, coastal erosion is also a natural part of the coastal system.

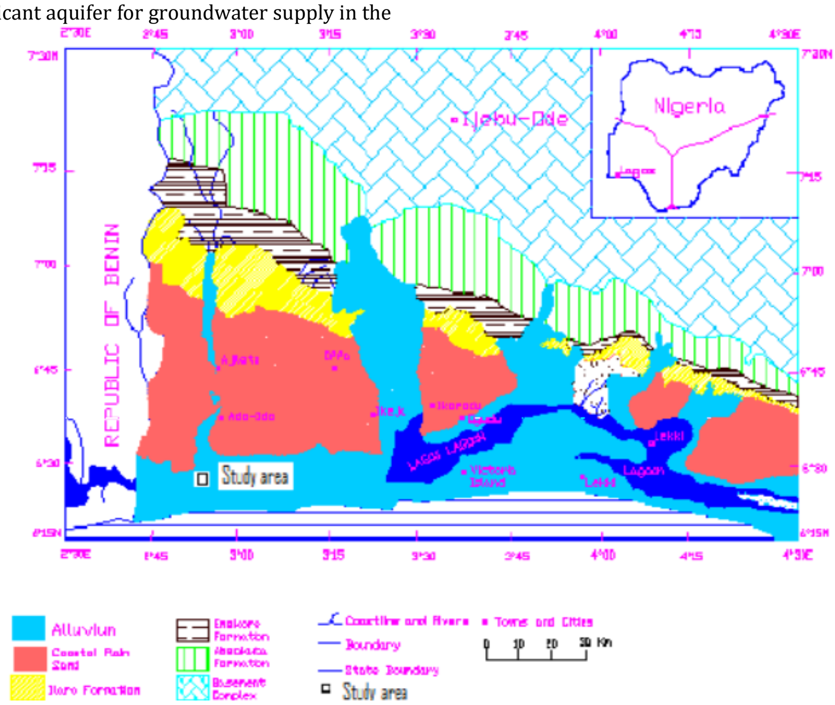

Figure 2: Lagos Geological Map (Adegoke, 1969)

4. Materials and Methods

4.1 Materials

To effectively conduct this research, a range of materials and laboratory equipment was utilized to determine the geotechnical characteristics of the soil in the study area. The following section provides a detailed list of the apparatus and equipment employed for the various tests.

4.2 Method

Once the soil samples were collected, they were transported to the laboratory for analysis. Various tests were conducted to evaluate the soil's engineering properties, including: Determining the distribution of particle sizes within the soil sample; Measuring the density of soil particles relative to the density of water; Determining the natural moisture content of the soil; Assessing the soil's consistency and plasticity through tests for the plastic limit, liquid limit, and plasticity index; Evaluating the soil's compaction capability and determining the maximum dry density under controlled conditions and Assessing the shear strength and stress-strain behaviour of the soil sample under varying confining pressures.

4.2.1 Atterberg Limit

The atterberg limits are crucial in soil mechanics for understanding soil consistency and behaviour. the moisture content at which the soil transitions from a solid to a semi-solid state is known as shrinkage limit (SL). Plastic limit (PL) is when the moisture content of the soil transit from a semi-solid to a plastic state. Liquid limit (LL) is when the moisture contents the soil transit from a plastic to a liquid state. Plasticity index (PI) is differences between liquid limit and plastic limit, calculated as PI = LL - PL. Soil activity is used to determine the plasticity index and the percentage of particles finer than 2µm, which indicates the soil's potential for shrinkage and swelling. The test involves using various tools, including a balance, casagrande's liquid limit device, a grooving tool, mixing dishes, a spatula, and an oven. These help measure and determine the soil's atterberg limits, which are essential for classifying soil and predicting its behaviour under different moisture conditions.

4.2.2 Triaxial Test

Triaxial testing is a key method for evaluating the shear strength and mechanical behaviour of soils under controlled conditions. Here's a brief overview of the process and equipment involved: Triaxial testing assesses soil behaviour under simulated in-situ conditions by applying confining pressures from all sides, which mimics the stress conditions of the soil in its natural environment. This helps in understanding how the soil will perform under load and ensuring that it is suitable for supporting structures. Equipment used to carry-out the triaxial test are triaxial cells, brass or stainless-steel fittings, low-friction piston, triaxial control panels, pore pressure transducer, triaxial data acquisition software, vacuum pump and de-airing tank

The Mohr-Coulomb strength theory describes the shear strength of materials based on the stress state and the material's properties. In triaxial testing, it is commonly expressed as:

$$Ꚍ = C + n \tan Ø \quad (1)$$

Where Ꚍ stand for shear strength, C is cohesion, n is normal stress and Ø is frictional angle

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

$\sigma_1$and σ_3 is cell pressure

Table 1: Undrained Shear strength classification of Clays (Akpokodje, 2001, Andre-Obayanju 2023)

Consistency	Undrained shear strength (kN/m²)
Very stiff or hard	Over 150
Stiff	100 – 150
Firm to Stiff	75 - 100
Soft to Firm	40 – 50
Soft	20 – 40
Very Soft	Below 20

4.2.3 Specific Gravity

Specific gravity is a fundamental property of soils and other construction materials. This dimensionless unit is the ratio of material density to the density of water and is used to calculate soil density, void ratio, saturation, and other soil properties. Applications include the foundation design for structures, calculations for the stability of soil embankments, and estimations of settlement for engineered soil fills, determining specific gravity of soil.

Procedure: Calibration of the pycnometers is the first phase for the ASTM/AASHTO method. The process is time-consuming but can be performed for up to six pycnometers at a time. The calibration procedure only needs to be performed once unless the mass of the pycnometer deviates from the calibrated value by 0.06g or more. Each clean and dry pycnometer is weighed five consecutive times. The standard deviation of the averaged weights must not exceed 0.02g.

The pycnometers are filled with de-aired water, placed in an insulated container, and allowed to come to thermal equilibrium for at least three hours. Locate the container near the balance to minimize handling. One pycnometer at a time is removed from the container, handling only by the rim, and the water level adjusted to the calibration mark. If additional water is needed, it must be de-aired and thermally equilibrated, along with the water in the pycnometer. Excess water can be removed using a small suction tube or a paper towel. Measure and record the mass of each pycnometer to the nearest 0.01g. Measure and record the temperature in each pycnometer to the nearest 0.1°C. Repeat the above procedure five times for each pycnometer, with a three-hour thermal equilibration period between each step. Calculate and record the calibrated volume for each pycnometer.

4.2.4 Particle Size Distribution

Particle size distribution (PSD) of solids or dispersed particles is essential for ensuring the functionality and efficiency of foundation soils. This involves determining the distribution of particle sizes within samples from the study area. The choice of PSD analysis technique depends on factors such as particle shape, approximate particle size, and the type of sample matrix. In cases where particles vary significantly in size, two different techniques might be necessary. For instance, larger particles can be separated through sieving, and then analyzed using appropriate techniques for each size range. Grain size distribution affects soil engineering properties, and analyzing this distribution is crucial for soil classification. ASTM D 422 (Standard Test Method for Particle-Size Analysis of Soils) is observed. Equipment used to carry-out the PSD test are weight balance; set of sieves; cleaning brush; sieve shaker; mixer (blender); 152h hydrometer; sedimentation cylinder; control cylinder; thermometer; beaker and timing device.

Procedure for Sieve Analysis (Wet Sieving**)**: Record the weight of each sieve and the bottom pan; Weigh 100 grams of the soil sample and soak it in water; Wash the soaked sample through the 425-micron and 75-micron sieves. Dry the sieved samples for 24 hours; Weigh and record the weight of the dry soil sample. Assemble the sieves in ascending order (#4 sieve on top, #200 sieve on the bottom) with the pan placed below the #200 sieve; Pour the soil sample into the top sieve, cover it with the sieve cap, and place the stack in the mechanical shaker. Shake for 10 minutes; Remove the stack from the shaker. Weigh each sieve with its retained soil and record the weights. Also, weigh and record the bottom pan with its retained fine soil.

5. Interpretation of Results

5.1 Particle Size Distribution

The particle size distribution indicates a higher volume of granular materials, ranging from fine to coarse sands, with a greater proportion of coarser fractions. This results in the soil having relatively high permeability, which ensures good drainage and makes it suitable for building foundations. According to the Unified Soil Classification System (USCS), the soil samples are classified as uniformly graded to well-graded, as detailed in Table 2. The particle size distribution curves are illustrated in Figure 3-5. According to Unified Soil Classification System (USCS), adopted by Casagrande, 1948 and according to Aladin, (2024), the Coefficient of Uniformity (Cu) and Coefficient of Curvature (Cc) are used to describe the grain size and grading of soil samples.

$$\text{Coefficient of Uniformity (Cu): } Cu = D60/D10 \quad (3)$$

When, 3Cu > 4 Cu > 4 Cu> 4: Well-graded soil; Cu < 2 Cu < 2 Cu< 2: Uniform soil and Cu between 2 and 4: Poorly graded soil

Coefficient of Curvature (Cc): $Cc = (D30)^2 / (D60\times D10)$ (4)

When, 1<Cc<31 < Cc < 31<Cc<3: Well-graded soil and Cc<1C_c < 1Cc<1: Possibly uniformly-graded soil

Table 2: Summary of PSD and USCS of Soil samples of the study area								
BH Sampling Points	Depth (m)	D10	D30	D60	C_U	Classification	C_C	Classification
1	1	0.22	0.28	0.5	2.2727	Uniformly graded	0.7127	Uniformly graded
2	3	0.2	0.25	0.35	1.75	Uniformly graded	0.8929	Uniformly graded
3	5	0.21	0.32	0.65	3.0952	Well graded	0.7502	Uniformly graded

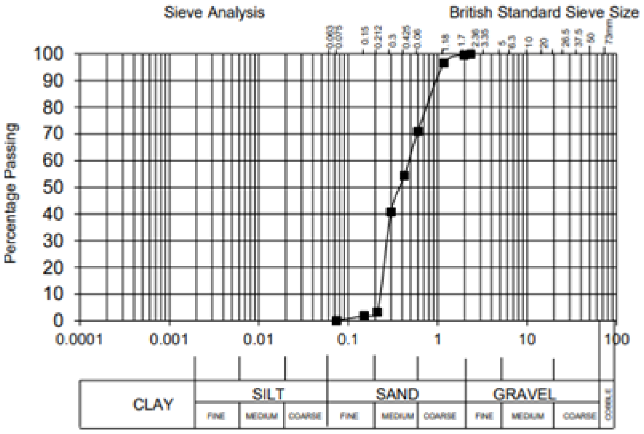

Figure 3: Graph of particle size distribution for sample1

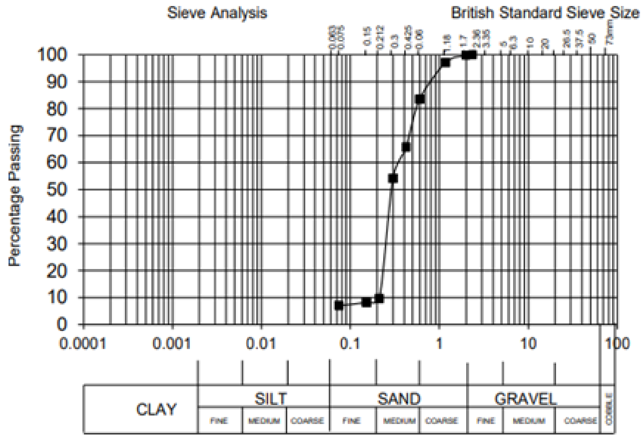

Figure 4: Graph of particle size distribution for sample 2

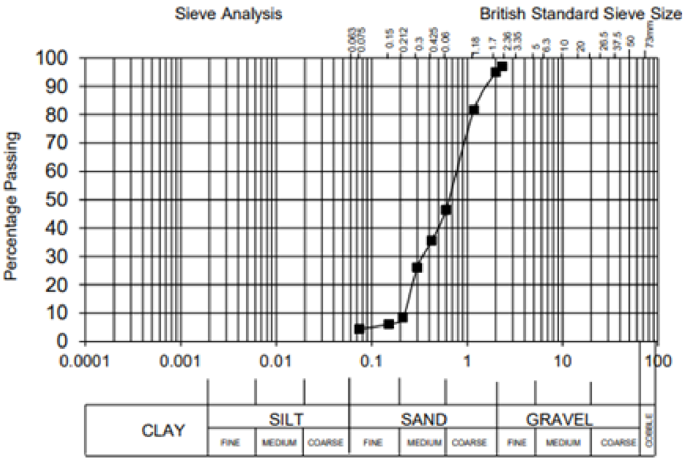

Figure 5: Graph of particle size distribution for sample 3

5.2 Specific Gravity

The specific gravities of the three soil samples taken from depths of 1m, 3m, and 5m are 2.41, 2.50, and 2.57, respectively, as shown in Table 3. The sample from the greatest depth (5m) exhibits the highest specific gravity. Given that the soil is cohesionless, this higher specific gravity indicates a higher unit weight and, consequently, a higher bearing capacity. Therefore, foundations placed at the depth of the third sample (5m) will have a high bearing capacity, making it suitable for supporting substantial loads.

Table 3: Specific gravity of the soil samples												
S/N	DEPTH (m)	BN	B+W	B+S+W	B+S	B	AD.W	WWAS	WS	WOWDS	GS	AV. GS
1	1	FCT	44.97	54.82	34.08	17.18	27.79	20.74	16.9	7.05	2.4	2.41
		BT	50.75	61.53	37.89	19.49	31.26	23.64	18.4	7.62	2.41	
2	3	910	37.62	45.96	25.87	11.96	25.66	20.09	13.91	5.57	2.5	2.5
		BED	37.87	46.97	26.87	11.74	26.13	20.1	15.13	6.03	2.51	
3	5	1112	38.97	49.15	29.41	12.74	26.23	19.74	16.67	6.49	2.57	2.57
		BO13	38.64	49.11	29.05	11.95	26.69	20.06	17.1	6.63	2.58	

GS: Specific gravity, Av. GS: Average Specific gravity

5.3 Atterberg Limit Test

The liquid limit of sample 1, 2 and 3, are 20.44%, 23.27%, 25.61% respectively, and the soils are considered to be non-plastic. Hence, has neither a plastic limit nor a plastic index as shown in Table 4, 5 and Figure 6-8.

Table 4: Liquid limit, plastic limit and linear shrinkage of					
S/N	Moisture Content Of Liquid Limit (LL)				
1	8.21	11.46	14.73	22.1	24.4
2	7.51	12.33	16.84	22.9	27.23
3	12.62	16.36	21.23	23.61	29.25

Table 5: Classification of Clays according to Liquid Limit (Akpokodje, 2001; Andre-Obayanju O, 2024).	
Qualifying term	Ranges of Liquid limit
Low plasticity	Under 35
Intermediate plasticity	35-50
High plasticity	50-70
Very High plasticity	7-90
Extremely high plasticity	Over 90

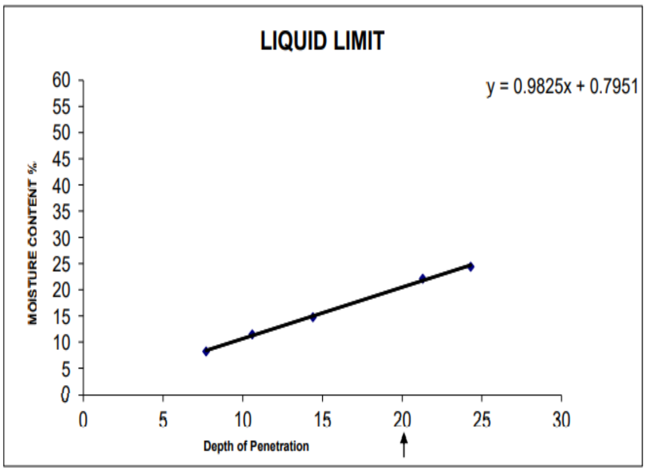

Figure 6: Graph of liquid limit of Sample 1

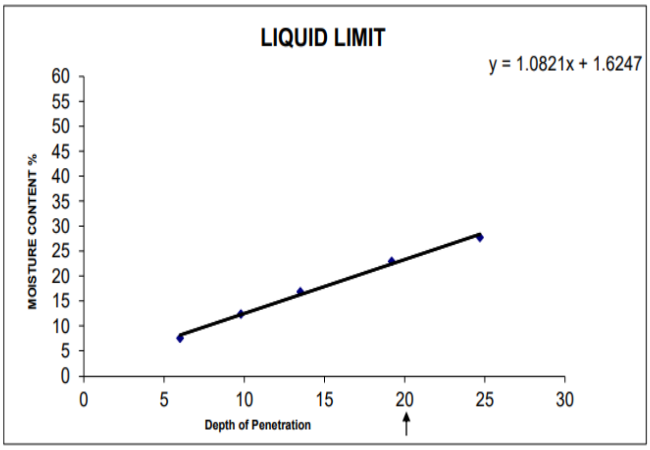

Figure 7: Graph of liquid limit of Sample 2

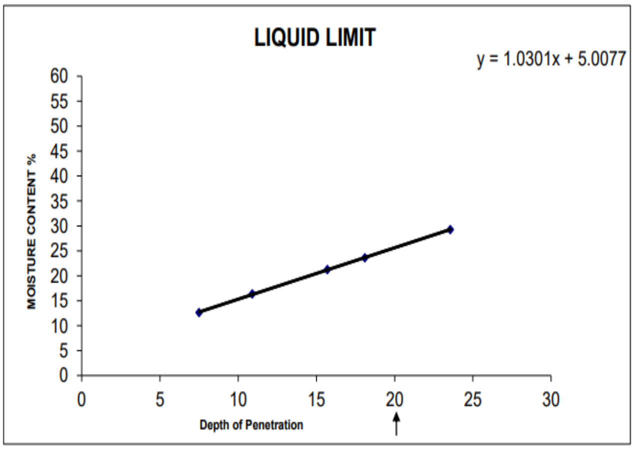

Figure 8: Graph of liquid limit of sample C

5.4 Triaxial Test

The values of the cohesion: 0.17, 0.95 and 0.76, are relatively low, close to zero; and also having angle of internal friction of about 13.73º, 11.62º, and 11.36º as shown in Table 6 and Figure 9-11. This shows that the soils are almost cohesionless and therefore suitable for foundation.

Table 6: Triaxial Test results of the study area

S/N	Load kg	Sample 1			Sample 2			Sample 3		
		Shear Stress KN/m²	Normal Stress KN/m²	DD kg/m³	Shear Stress KN/m²	Normal Stress KN/m²	DD kg/m³	Shear Stress KN/m²	Normal Stress KN/m²	DD kg/m³
1	5	1.4	4.91	2120	1.9	4.91	1710	1.71	4.91	1840
2	10	2.52	9.81		3.09	9.81		2.81	9.81	
3	15	3.8	14.72		3.92	14.72		3.68	14.72	

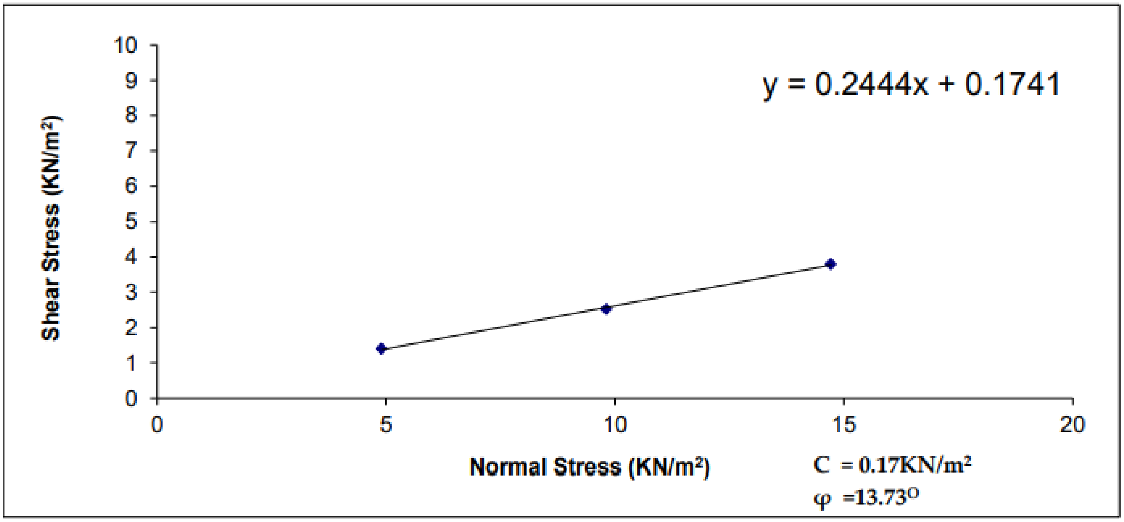

Figure 9: Graph of shear stress against Normal stress for sample 1

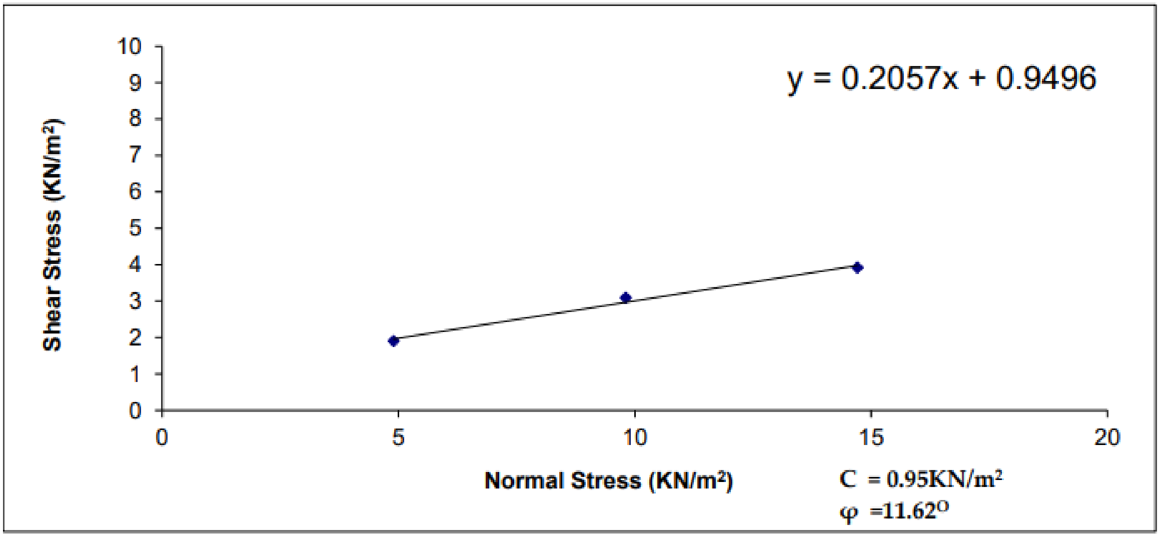

Figure 10: Graph of shear stress against Normal stress for sample 2

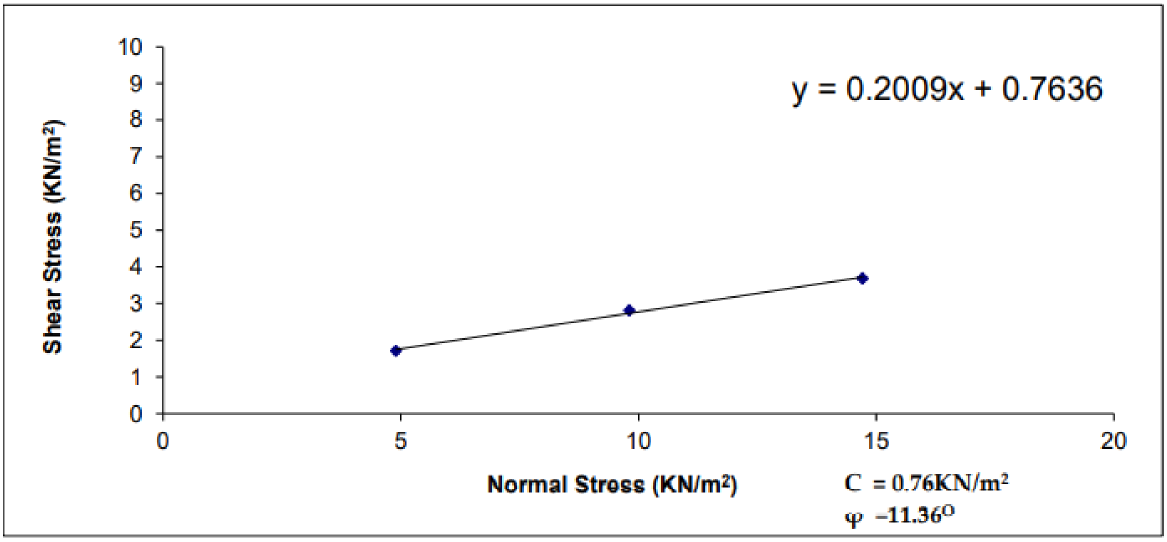

Figure 11: Graph of shear stress against Normal stress for sample 3

5.5 Compaction

The results shows that the optimum moisture content for the samples are 12.4%, 14.2% and 13.2% respectively from top to bottom, while the maximum dry density for the samples are 1.75g/cm3, 1.68g/cm3 and 1.76g/cm3. These values are indicative of good cohesionless soil that has good bearing capacity for loads. The relatively low optimum moisture content shows low retention capacity. The lower the retention capacity of a soil, the better its suitability for foundation as shown in Figure 12-15.

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

Project...**Building Site at Ajah Ogombo Area of Lagos State** Sample No: **BH1, 1m** Date: **09/08/2023...**

MDD: **1.75g/cm³** OPT.MC: **12.4%**

B.S. / C.B.R. Mould......**3285g**

Wt. of mould & wet Soil (W2) g	4820.00		4920.00		5020.00		5080.00		5140.00		5110.00		5040.00	
Wt. of mould (W1) g	3285.00		3285.00		3285.00		3285.00		3285.00		3285.00		3285.00	
Wt. of wet soil (W2-W1) g	1535.00		1635.00		1735.00		1795.00		1855.00		1825.00		1755.00	
Bulk Density (Pb) (W2-W1)/x g/cm³	1.63		1.74		1.85		1.91		1.97		1.94		1.87	
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 939.82cm³														
Container No.	PA	AB	UK	OZ	JA	OB	NP	GL	OB	AI	BL	IP	IV	MU
Wt. of wet soil & container (g)	44.60	41.40	42.10	39.40	46.50	50.70	52.30	60.10	68.40	40.80	48.50	55.20	53.40	55.60
Wt. of Dry soil & container (g)	43.40	40.50	40.30	38.10	43.70	48.10	48.60	56.20	62.40	36.90	44.30	50.40	48.50	50.20
Wt. of Container (g)	17.00	18.00	12.60	17.70	12.50	18.30	13.80	18.20	18.00	7.10	16.60	19.00	18.20	17.20
Wt. of dry soil (Wd) g	26.40	22.50	27.70	20.40	31.20	29.80	34.80	38.00	44.40	29.80	27.70	31.40	30.30	33.00
Wt. of Moisture (Wm) g	1.20	0.90	1.80	1.30	2.80	2.60	3.70	3.90	6.00	3.90	4.20	4.80	4.90	5.40
Moistur Content 100(Wm/Wd) %	4.55	4.00	6.50	6.37	8.97	8.72	10.63	10.26	13.51	13.09	15.16	15.29	16.17	16.36
Average Moisture Content (m) %	4.27		6.44		8.85		10.45		13.30		15.22		16.27	
Dry Density = Pb/1+ (m/100) (g/cm³)	1.57		1.63		1.70		1.73		1.74		1.69		1.61	
C.B.R. (mseen of top & bottom) %														

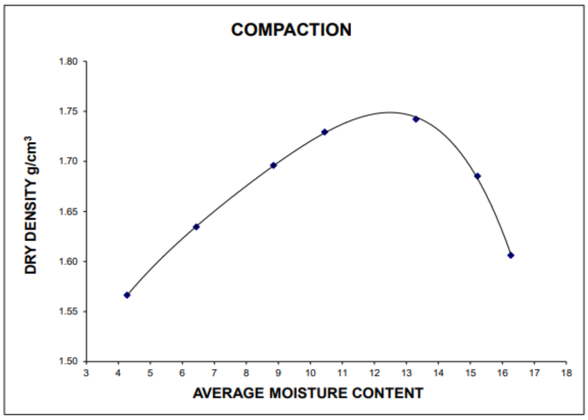

Figure 12: Graph of dry density against Average moisture content sample1

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

Project...**Building Site at Ajah Ogombo Area of Lagos State** Sample No: **BH1, 3m** Date: **09/08/2023...**

MDD: **1.68g/cm³** OPT.MC: **14.2%**

B.S. / C.B.R. Mould......**3285g**

Wt. of mould & wet Soil (W2) g	5015.00		5050.00		5090.00		5071.00		5058.00					
Wt. of mould (W1) g	3285.00		3285.00		3285.00		3285.00		3285.00					
Wt. of wet soil (W2-W1) g	1730.00		1765.00		1805.00		1786.00		1773.00					
Bulk Density (Pb) (W2-W1)/x g/cm³	1.84		1.88		1.92		1.90		1.89					
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 939.82cm³														
Container No.	RE	V	VI	PA	BH	PI	AM	OH	VO	AH				
Wt. of wet soil & container (g)	47.10	43.50	43.40	51.70	52.20	64.00	49.00	73.80	68.00	58.20				
Wt. of Dry soil & container (g)	43.70	40.50	40.20	47.70	47.90	57.70	44.40	66.40	61.30	52.70				
Wt. of Container (g)	17.50	17.40	16.40	17.60	17.70	15.60	14.20	18.00	18.20	17.40				
Wt. of dry soil (Wd) g	26.20	23.10	23.80	30.10	30.20	42.10	30.20	48.40	43.10	35.30				
Wt. of Moisture (Wm) g	3.40	3.00	3.20	4.00	4.30	6.30	4.60	7.40	6.70	5.50				
Moistur Content 100(Wm/Wd) %	12.98	12.99	13.45	13.29	14.24	14.96	15.23	15.29	15.55	15.58				
Average Moisture Content (m) %	12.98		13.37		14.60		15.26		15.56					
Dry Density = Pb/1+ (m/100) (g/cm³)	1.63		1.66		1.68		1.65		1.63					
C.B.R. (mseen of top & bottom) %														

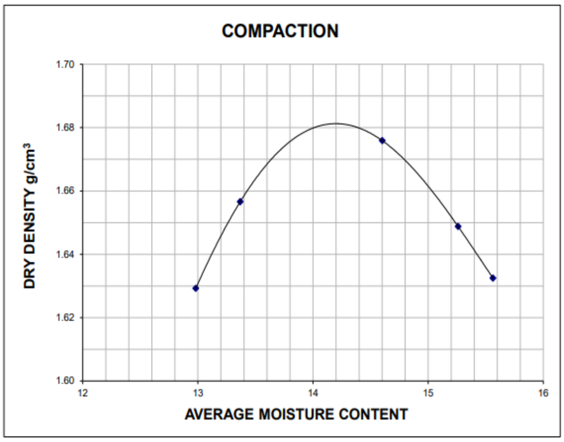

Figure 13: Graph of dry density against Average moisture content sample2

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

Project...**Building Site at Ajah Ogombo Area of Lagos State** Sample No: **BH1, 5m** Date: **08/08/2023...**

MDD: **1.76g/cm³** OPT.MC: **13.2%**

B.S. / C.B.R. Mould......**3363g**

Wt. of mould & wet Soil (W2) g	5110.00		5212.00		5246.00		5226.00		5103.00	
Wt. of mould (W1) g	3363.00		3363.00		3363.00		3363.00		3363.00	
Wt. of wet soil (W2-W1) g	1747.00		1849.00		1883.00		1863.00		1740.00	
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.86		1.97		2.00		1.98		1.85	
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 939.82cm^3										
Container No.	BI	OO	XC	II	VT	VI	RR	VB	OI	IH
Wt. of wet soil & container (g)	56.60	47.00	58.40	52.80	55.10	55.90	67.40	53.10	71.80	70.30
Wt. of Dry soil & container (g)	53.50	44.70	54.60	49.40	51.30	51.80	61.10	48.80	64.50	63.10
Wt. of Container (g)	22.80	21.80	23.10	21.90	23.30	21.80	21.40	21.30	24.00	24.00
Wt. of dry soil (Wd) g	30.70	22.90	31.50	27.50	28.00	30.00	39.70	27.50	40.50	39.10
Wt. of Moisture (Wm) g	3.10	2.30	3.80	3.40	3.80	4.10	6.30	4.30	7.30	7.20
Moistur Content 100(Wm/Wd) %	10.10	10.04	12.06	12.36	13.57	13.67	15.87	15.64	18.02	18.41
Average Moisture Content (m) %	10.07		12.21		13.62		15.75		18.22	
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.69		1.75		1.76		1.71		1.57	
C.B.R. (mseen of top & bottom) %										

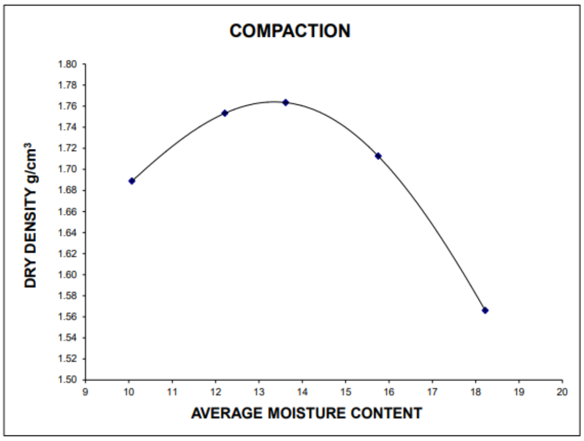

Figure 14: Graph of dry density against Average moisture content sample3

6. Conclusion

The laboratory tests and analysis of sands from the Ajah area in Lagos reveal their qualities, suitability as foundation materials, and load-bearing capacity. Soil samples collected from various depths at the boring location demonstrate relative uniformity and homogeneity in the rock layers, suggesting that a similar geological process contributed to the formation of these soils. The particle distribution indicates a predominance of granular materials, ranging from fine to coarse sands, resulting in relatively high permeability. The specific gravity of the soil increases with depth, measured at 2.41 at 1 meter, 2.50 at 3 meters, and 2.57 at 5 meters. The liquid limits of the three samples are 20.44%, 23.27%, and 25.61%, respectively, and they are non-plastic, indicating low clay mineral content. The samples exhibit minimal cohesion, with values of 0.17, 0.95, and 0.76, and angles of internal friction of approximately 13.73°, 11.62°, and 11.36°. Further analysis shows that the optimum moisture content for the samples ranges from 12.4% to 14.2% from top to bottom, and the maximum dry density varies between 1.75 g/cm^3 and 1.76 g/cm^3.

Recommendation

I recommend that thorough geotechnical survey should be carryout in the study for proper planning and foundation design for high-rise buildings. It helps in making informed decisions that enhance the safety, stability, and longevity of the structure, as well as protecting surrounding properties.

References

Adebisi, N. O., Osammor, J. and Oyedele, K. F., 2016. Nature and engineering characteristics of foundation soils in IbejuLekki area of Lagos, SourhwesternNogeria. Ife Journal of Science vol. 18,(1)

Adepelumi, A.A., and Olorunfemi, M.O., 2000. Engineering geological and geophysical investigation of the reclaimed Lekki Peninsula, Lagos, South West Nigeria. Bulletin of Engineering Geology and the Environment. Vol. 58, Pp. 125–132.

Aladin, A.E., Ogueh, D.E., 2024. Influence of Selected Soil Properties on Groundwater Flow around Ariaria Dumpsite, Aba, Southeast, Nigeria. J. Appl. Sci. Environ. Manage. Vol. 28 (3), Pp. 649-658.

Andre-Obayanju, O., Ese Anthony, A., Osisanya Olajuwon, W., 2023. Enhancing the Engineering Properties of Lateritic Soils using Anthills, specifically Mold soils, in certain parts of the Benin Metropolitan City in Southern Nigeria. Journal: Pakistan Journal of Geology (PJG). Vol. 7 (2), Pp. 48-55.

Apeh, A., Tiza, M., Omale, J., Iorwua, B.M., 2016. An assessmentoffouindation design of buildings in Lagos. Journal of multidisciplinary engineering science studies. Vol.2(6)

Ariye, Y.K., Adigun, A.O., 2020. Evaluation of Shallow Foundation Soils around Lagos Using Results from Cone Penetration Test. The International Journal of Engineering and Science. Vol.9 (6). Pp.21-26.

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

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

ASTM [D 421]. 2007. Standard Test Method for Dry Preparation of Soil Samples for Particle Size Analysis. Page 2.

ASTM D4318. 2007. Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils. TEX-105-E: Determining plastic limit of soils

ASTM [D 698]. 2007. Standard Test Method for Laboratory Compaction Characteristics. Pages 117 – 121.

Climate change Knowledge Portal. 2021. https://climateknowledgeportal. worldbank.org / country / Nigeria /climate-data-historical.

Ubido, E. O., Ogbonnaya, I., Bernadette, U. U., and Ibrahim, G. I., 2017. The Implication Of Subsoil Geology In Foundation Failure Using Geotechnical Methods:A Case Study Of Lagos Southwestern Nigeria. International Journal of Advanced Research and Publications. Vol. 5, Pp. 165-174. www.ijarp.org

Ogungbe, A.S., Babatunde, O.S., Alabi A.A., and Coker J.O., 2020. Impact of Sand Mining on Soil And Water Quality Along Addo - Baddore Road, Ajah, Lagos State, Nigeria. African Journal of Environment and Natural Science Research.Vol.3(3). Pp.73-91.

Lagos State Ministry of Science and Technology. 2024. https://lagosstate.gov.ng/

Fookes, P.G., Parry, R.H.G., 2020. Engineering Characteristics of Arid Soils.

Shaikh, M. F., Pathak, R., Pandey, A., 2019. Forensic Structural Engineering an overview. AIP Publishing.

Wikipedia. 2020. The Historical Background of Ajah, our People,our Culture,our Voice. 8, Wikipedia.org.