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Research Paper

Characterization of Marine Clays of the Niger Delta

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ABSTRACT: *Marine clay is a soft soil that can be found in abundance along the coast and offshore. High settlement and instability are common characteristics of this type of soil, as are poor soil properties that are unsuitable for engineering purposes and low unconfined compressive strength. Even with small loads, significant failure can occur, resulting in a flat or featureless surface. The geotechnical and engineering features of marine clay are studied and addressed in depth in this paper. The properties included moisture content, particle size distribution, specific gravity, Atterberg limits and coefficient of variation. The marine clay used in this research was classified as an A-7-5 (Clayey Soil) soil based on the AASHTO classification system. The test revealed that the bulk unit weight ranged from 4332 kg/m^3 to 6289 kg/m^3 while the moisture content from the various locations ranged from 27.3% to 83.7%. The results also showed that the Liquid Limit ranged from 53.9% to 83% while the Plastic Limit ranged from 17.5% to 35.1%. The results showed that the Plasticity Index from all various locations ranged from 21.1 to 49. In addition, this paper serves as a guideline for the design and construction of projects on marine soils.*

KEYWORDS: *Marine Clay, Soft Soil, Coastal Soils, Geotechnical Properties*

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I. INTRODUCTION

Marine clay is a type of soil found primarily along coastal corridors, lowlands, and offshore regions, as well as other locations on the earth. Soft sensitive soils with significant settlement and instability, poor soil qualities unsuitable for engineering applications, performance uncertainty, low unconfined compressive strength of 25 to 50 kPa, and a flat or featureless surface are all characteristics of this type of soil [1]. Rapid urbanization and population increase have prompted the construction of numerous civil engineering infrastructures and facilities on marine soils. As a result, rigorous characterization of marine clays has been essential for understanding the behavior of these marine clays.

Marine clays are made up of soil minerals including chlorite, kaolinite, montmorillonite, and illite, as well as stone minerals like quartz and feldspar, all of which are bonded together by organic matter [2] and [3]. Marine clays can also be found at the bottom of bodies of water and reservoirs such rivers, harbors, and channels. Degraded marine clay is a type of marine clay that is mainly excavated for the aim of widening rivers, managing floods, and gaining access to the harbour and port channel [4]. [5] studied marine clay at a building site in Kedah, Malaysia, and discovered that the soil's undrained shear strength was less than 25 kPa. Working with coastal clay soil is difficult due to the considerable influence of moisture content. It expands when moisture levels rise and contracts as levels fall [6].

The strength and stability of marine deposits are largely determined by the physical qualities of marine clay. Particle size distribution, liquid limit, plastic limit, plasticity index, moisture content, specific gravity, organic content, shrinkage limit, and mineral composition are the primary index parameters that impact the strength and compressibility of marine clay. Therefore, the index properties of marine clay are investigated and evaluated carefully in this paper.

II. METHODOLOGY

The soil samples used in this study were obtained from Eagle Island, Obio-Akpo Local Government Area, Kereken Boue, Khana Local Government Area, Iwofe, Obio-Akpo Local Government Area, New Road (Town), Port Harcourt city, and Choba, Emohua local Government Area all in Rivers State, Nigeria. They were collected as disturbed sample, excavated from depth not less than 1.0 m so as to avoid any organic material. The samples were packaged in sealed plastic bags for use in laboratory. Three borings where taken per site.

Figure 1: Marine clay from Eagle Island

Figure 2: Marine clay site (Eagle Island)

Figure 3: Marine clay from Choba

Figure 4: Marine clay from Iwofe

Figure 5: Marine clay site at Iwofe

Figure 6: Marine clay from Kereken

The following laboratory tests were carried out:

Table 1: Laboratory Tests

Experiments	Parameters	Standard
Sieve Analysis	Particle Size Distribution	BS 1377-2: 1990
Specific Gravity Tests	Specific Gravity table	BS 1377-2: 1990
Atterberg's Limit Tests	Liquid Limit, Plastic Limit and Plasticity Index	BS 1377-2: 1990
Linear Shrinkage	Shrinkage Limit	BS 1377-2: 1990
Standard Proctor Compaction	Dry Density and Moisture Content	BS 1377-4: 1990
Unconfined compressive Strength test	strength	BS 1377-5: 1990
California Bearing Ratio Tests	CBR (Soaked and Unsoaked)	BS 1377-5: 1990

III. RESULTS AND DISCUSSION

Specific Gravity Test

Results showed that the mean specific gravity from the various locations is 2.596 with a coefficient variation of 0.102 which implied a level of confidence of 89.8%. The specific gravity ranged from 2.12 to 2.9, Figure 7.

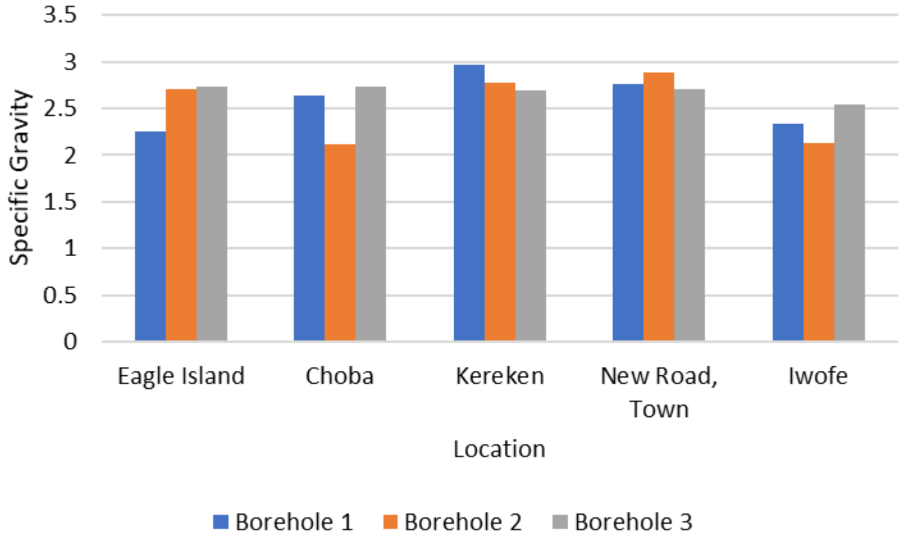

Figure 7 Graph of Specific Gravity

Bulk Density Test

The mean bulk density for the various locations was 5256 kg/m^3 with a coefficient variation of 0.118 which implied a level of confidence of 88.2%. The Bulk density for the various locations ranged from 4332 to 6289 kg/m^3, Figure 8.

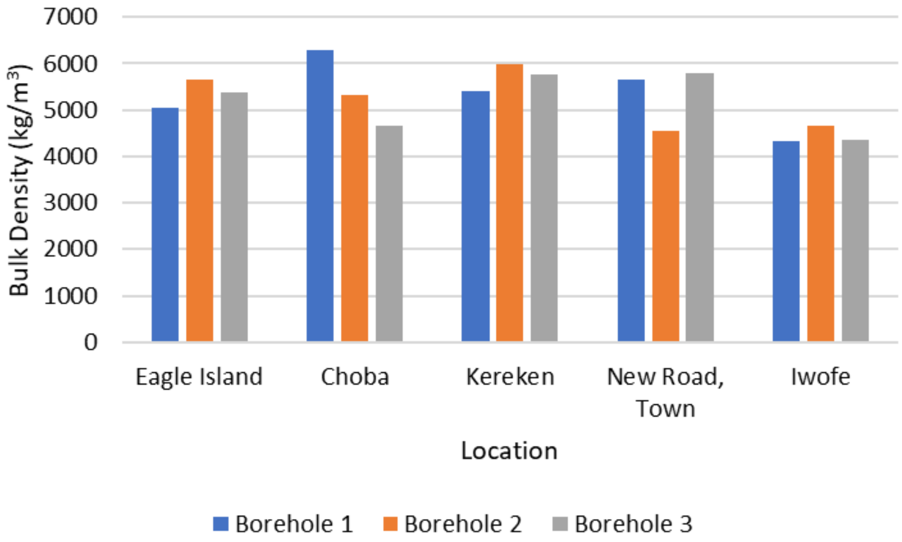

Figure 8: Graph of Bulk Density (kg/m^3)

Natural Moisture Content Test

Results showed that the mean moisture content from the various locations was 53.85% with a coefficient variation of 0.242 which implied a level of confidence of 75.8%. The Moisture Content from the various locations ranged from 27.3% to 83.7%, Figure 9.

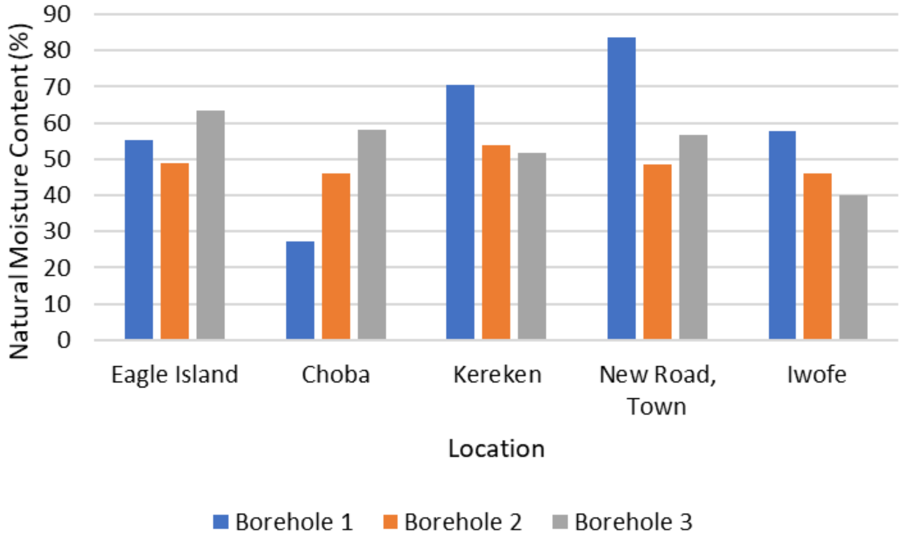

Figure 9: Graph of Natural Moisture Content

Atterberg Limits (LL, PL and PI) Test

Atterberg limits comprise of liquid limit (LL), plastic limit (PL) and plasticity index (PI). These index tests are used in the classification of soil using the AASHTO chart. These tests revealed the soil to be unworkable with such consistency values and belong to the A-7-5 group which is basically clayey soils.

Liquid Limit

Results showed that the mean Liquid Limit from the various locations was 67.33% with a coefficient variation of 0.115 which implied a level of confidence of 88.5%. The Liquid Limit from the various locations ranged from 53.9% to 83%, Figure 10.

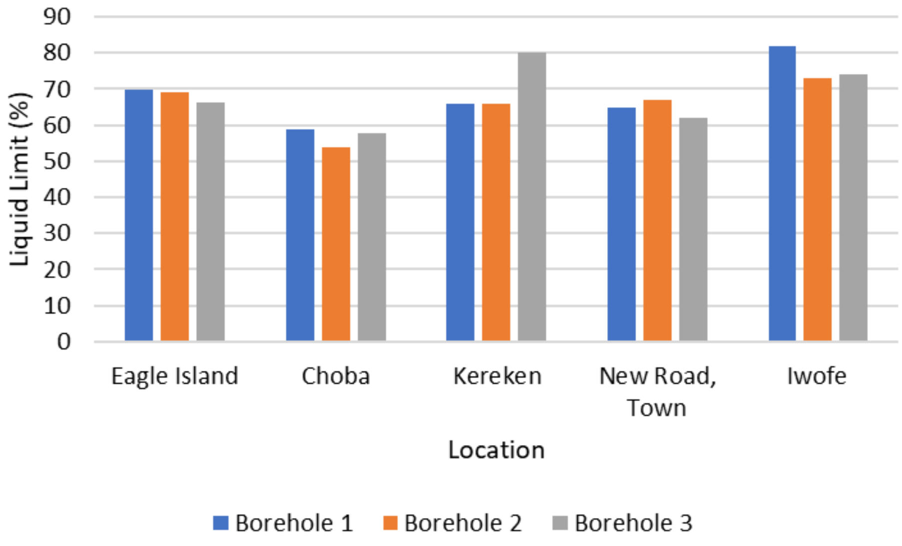

Figure 10: Graph showing the Liquid Limit of all the locations.

Plastic Limit

This result showed that the mean Plastic Limit from all various location was 29.19% having a coefficient variation of 0.170 which implied a level of confidence of 83%. The Plastic Limit ranged from 17.5% to 35.1%, Figure 11.

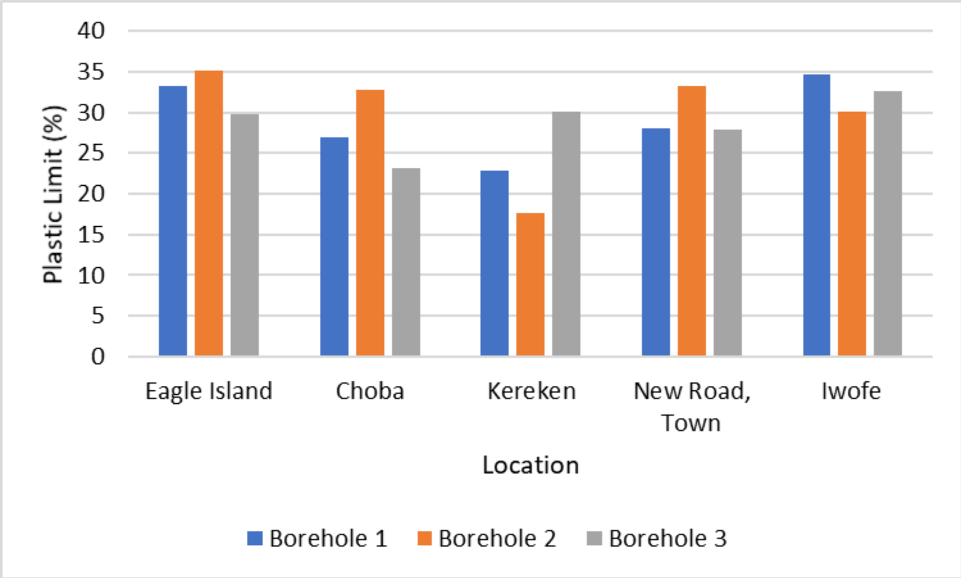

Figure 11: Graph showing the Plastic Limit of all the locations.

Plasticity Index

Results showed that the mean Plasticity Index from all various locations was 37.63% with a coefficient variation of 0.207 which implied a level of confidence of 79.3%. The plasticity index of the various locations ranged from 21.1% to 49%, Figure 12.

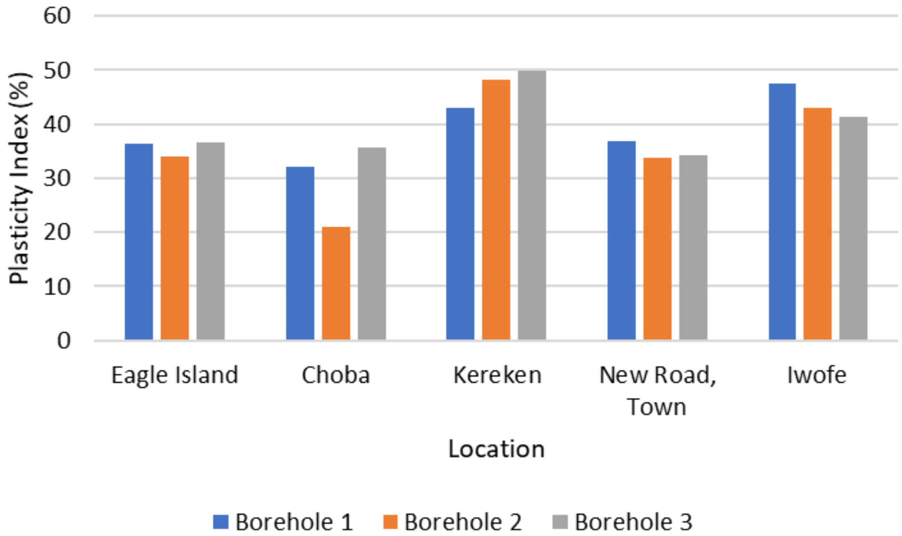

Figure 12: Graph showing the Plasticity Index of all the locations.

Proctor Compaction Test

This laboratory test consisted of compacting soil at known moisture content into a cylindrical mould of standard dimensions using a compactive effort of controlled magnitude. The soil was compacted into the mould of a certain amount of equal layers, each receiving a number of blows from a standard weighted rammer at a specified height and the dry densities were determined for each. The maximum dry density was finally obtained from the peak point of the compaction curve and its corresponding moisture content, also known as the optimal moisture content was determined as shown in Figures 13-17.

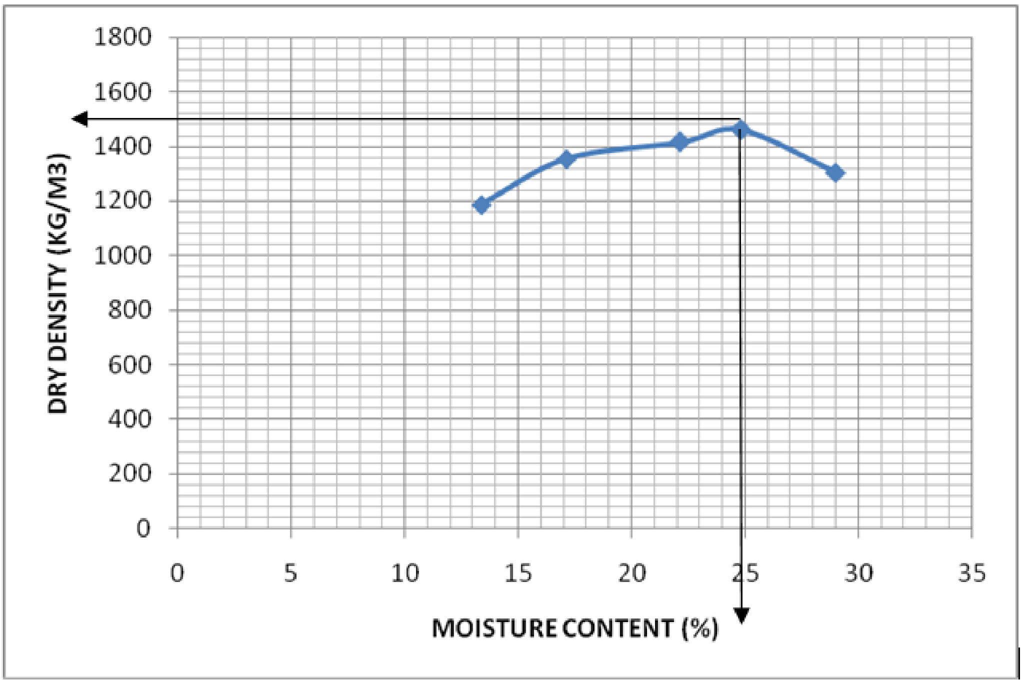

Figure 13: Graph Summary of Compaction Characteristics of Marine Clay Eagle Island.

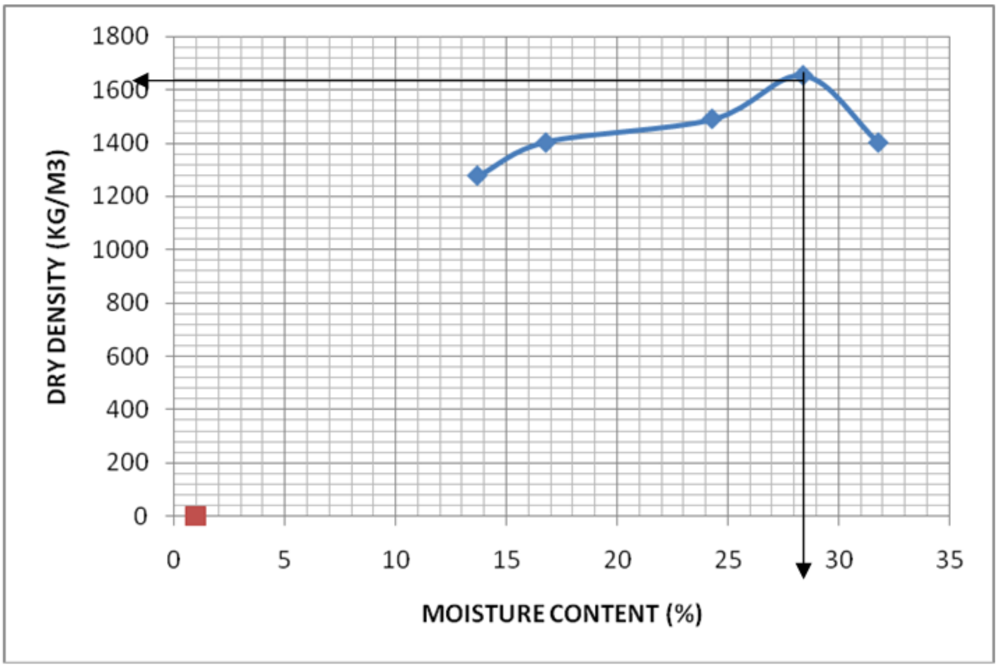

Figure 14: Graph Summary of Compaction Characteristics of Marine Clay Choba.

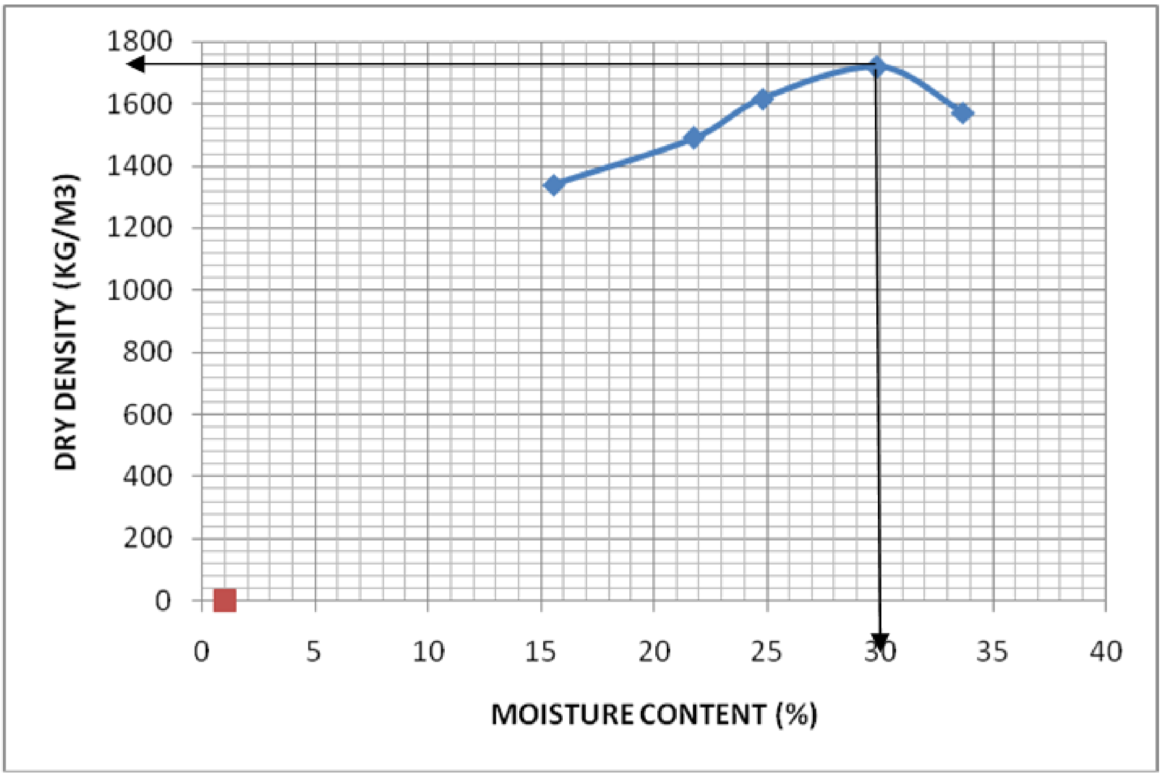

Figure 15: Summary of Compaction Characteristics of Marine Clay Kereken Boue. Khana LGA in Rivers State.

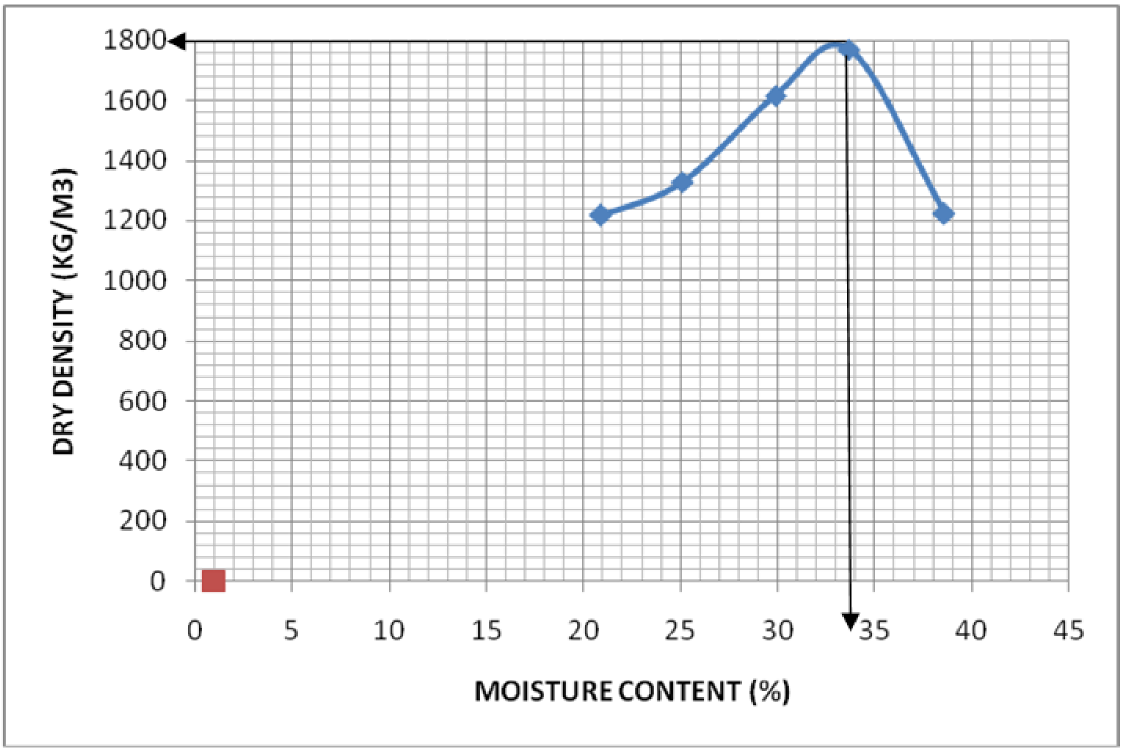

Figure 16: Graph Summary of Compaction Characteristics of Marine Clay, New Road, Town.

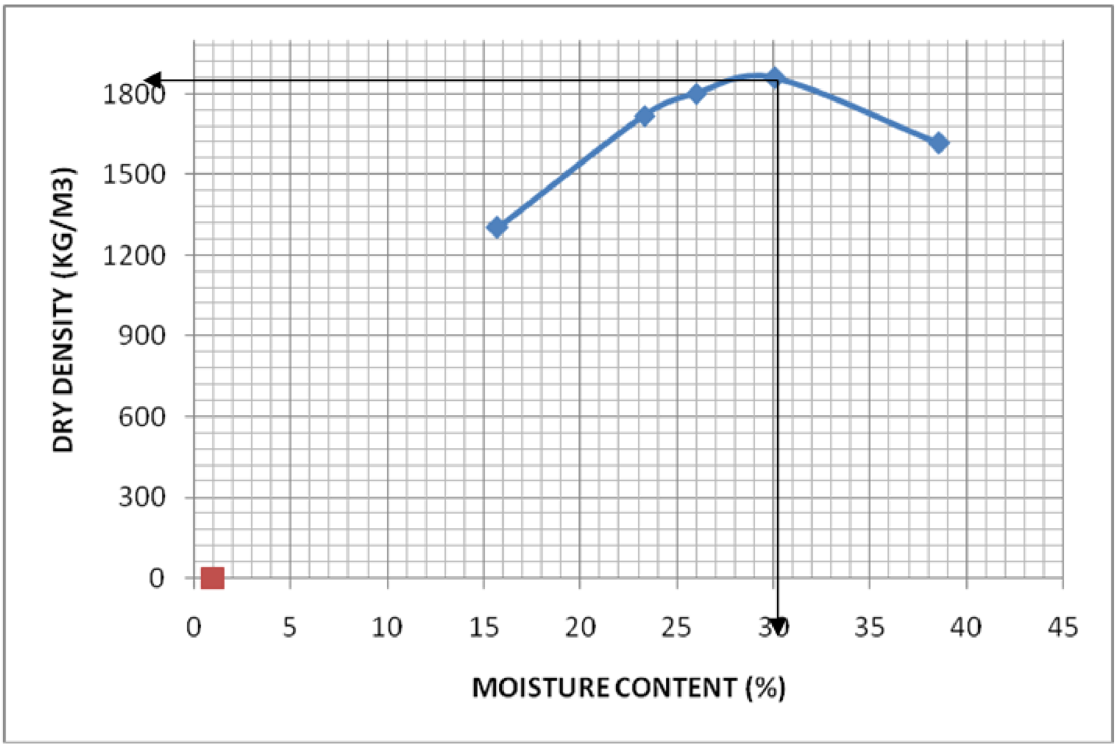

Figure 17: Graph Summary of Compaction Characteristics of Marine Clay Iwofe.

Triaxial test

Results from the triaxial tests carried out is presented in Table 2. Table 2 shows the cohesion (kPa) and angle of internal friction (°) of the soil samples from the various location.

Table 2: Triaxial Test results from all locations

Locations	Boreholes	Cohesion (kPa)	Angle of Internal Friction(°)
Eagle Island	Borehole 1	107	9.2
	Borehole 2	110	5.9
	Borehole 3	97	6.9
Choba	Borehole 1	50	3.5
	Borehole 2	61	6.3
	Borehole 3	61	5.7
Kereken, Boue	Borehole 1	67	3.5
	Borehole 2	100	2.3
	Borehole 3	99	3.4
New road, Town	Borehole 1	115	1.1
	Borehole 2	52	9.2
	Borehole 3	55	9.2
Iwofe	Borehole 1	80	5.8
	Borehole 2	74	6.9
	Borehole 3	101	5.7

IV. CONCLUSION

Based on the laboratory tests conducted on the characterization of marine clays, the following conclusions were drawn. The soils had high liquidity content and its termed as clay of high plasticity. The results showed that the mean specific gravity from the various locations was 2.596 with a coefficient variation of 0.102. The specific gravity ranged from 2.12 to 2.9. The tests revealed that the mean bulk density for the various locations was 5256 kg/m^3 with a coefficient variation of 0.118. The Bulk density for the various locations ranged from 4332 to 6289 kg/m^3. The mean moisture content from the various locations was 53.85% with a coefficient variation of 0.242. The moisture content from the various locations ranged from 27.3% to 83.7%. The results showed that the mean Liquid Limit from the various locations was 67.33% with a coefficient variation of 0.115. The Liquid Limit from the various locations ranged from 53.9% to 83%. Results showed that the mean Plastic Limit from all various location was 29.19% having a coefficient variation of 0.170. The Plastic Limit ranged from 17.5% to 35.1%. The results showed that the mean Plasticity Index from all various locations was 37.63% with a coefficient variation of 0.207. The plasticity index of the various locations ranged from 21.1% to 49%.

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