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Classification and compaction characteristics of lateritic soils of Warri, Delta state, Nigeria

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ABSTRACT

The research investigated the Classification and Compaction characteristics of lateritic soils of Warri, the economic nerve center of Delta State, Nigeria. Soil samples were collected from eight locations and subjected to Geotechnical test programmes; Sieve analysis, Consistency tests, Compaction and California Bearing Ratio (CBR) Tests. Classification tests (sieve analysis and consistency tests) reveal the Lateritic soils are of A6, A3 and dominantly A2-4 type characteristics based on the American Association Of State Highway and transport Officials (AASHTO) Classification Scheme.CBR values indicate the soils are suitable sub-grade materials (having CBR; 10.10-26.10%) but would require appropriate stabilization to be competent sub-base and base courses for road construction.

Keywords; lateritic soil, compaction, classification and California Bearing Ratio

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INTRODUCTION

Lateritic soils are products of intense weathering which are devoid of gravel sized components and occur under tropical climatic condition resulting in the accumulation of hydrated oxides of iron and Aluminum [Gidigasu,1972; Akpokodje 2001]. They are found in the Flat land/plain and dry deltaic plains of the Eastern and Western Niger Delta respectively.

In recent times, Warri has been witnessing more developmental projects (Land reclamation, construction of roads, Industrial Business Park, houses etc) by government, Multinational Corporation and individuals and these have triggered more exploitation of lateritic soils in the area for construction purposes.The suitability of these soils for earthworks (construction works) depends on their classification and compaction characteristics. It is therefore imperative to investigate these properties for proper design, construction and to prevent road failure.

Several workers have investigated the geotechnical properties of lateritic soils in the Niger Delta [Akpokodje 1986a], [Alabo et al 1984], [Abam and Okogbue 1997], [Olobaniyi et al 2005], [omotosho and eze-uzomaka, 2008], [Ugbe 2011], but there has not been a similar research in Warri, though olobaniyi *et al* [2005], conducted a similar research on the Lateritic soils of Osubi (Outskirt of Warri) and established that the Osubi lateritic soils were of A2-4 and A2-6 type characteristics. A common misconception is to assume that because Osubi and Warri are

neigbouring locations, the engineering geological properties of their Lateritic soils will be the same, which may not be true, hence the rationale for this study.

The focus of this research is therefore to unveil the classification and compaction characteristics of Warri Lateritic soils as this would provide a guide to construction firms, on the suitability and sourcing of lateritic soils for future construction works in the area.

GEOGRAPHICAL SETTING AND GEOMORPHOLOGY

Warri is located in the western portion and coastal zone of the Nigerian Niger Delta (figure 1) some 40 kilometers away from the shores of the Atlantic Ocean.

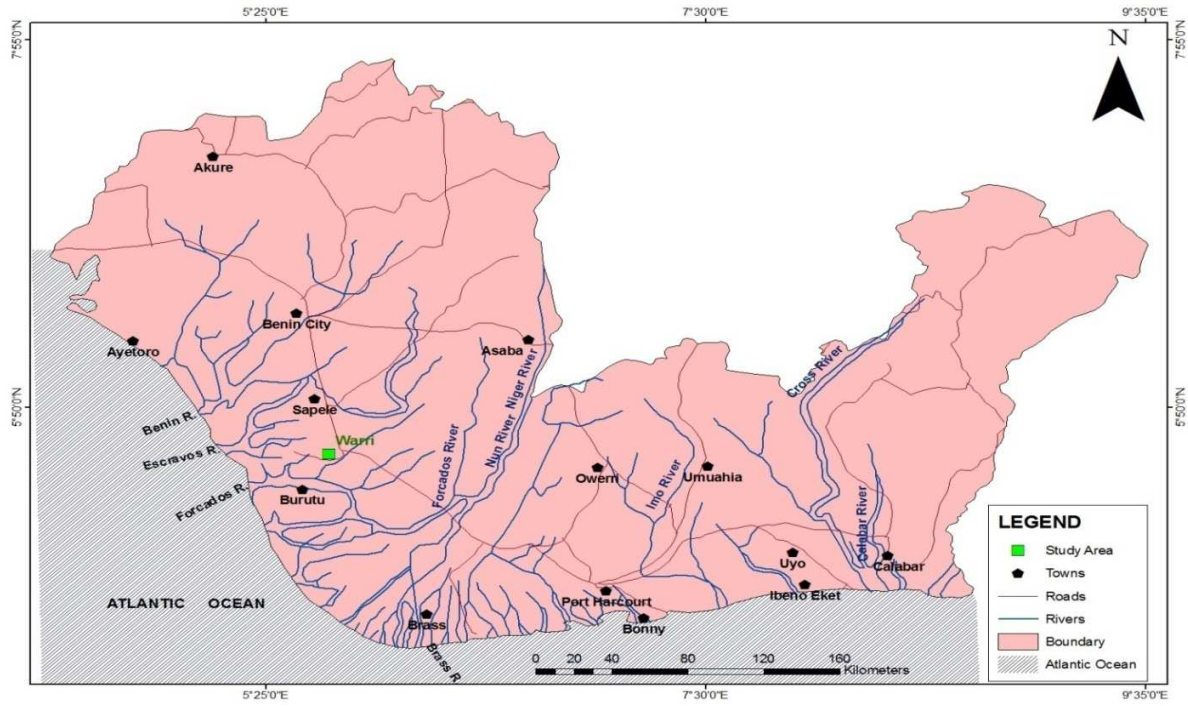

Figure 1: Geographical Map of the Niger Delta Niger Delta, Showing the study location
[Modified after Olobaniyi and Owoyemi 2006]

The area is a prominent centre of commercial activities in southern Nigeria. Warri occupies a low-lying area which is drained by River Warri and its network of tributaries and creeks which empties into the sea. The drainage pattern is dendritic with tributaries branching without a preferred orientation. This signifies a homogeneous underlying material where structural control is lacking. The water table is very close to the ground surface and varies from 0 to 4meters. This limited ground water level fluctuation reflects the high amount of precipitation (about 2000mm annually) recorded in Warri over the greater part of the year.

Warri lies on a flat to gently undulating area with slopes of about $0\text{-}4^0$. In the Niger Delta, various types of depositional environments and morphological units (coastal flats, ancient/modern Sea, rivers and lagoonal beaches etc) are recognized but the Niger Delta can be subdivided into five major geomorphologic units namely:

- Active and abandoned coastal beaches
- Salt water /Mangrove swamp
- Fresh water swamp
- Sombreiro-Warri Deltaic plain with abundant fresh water swamp
- Dry flat land and plain.

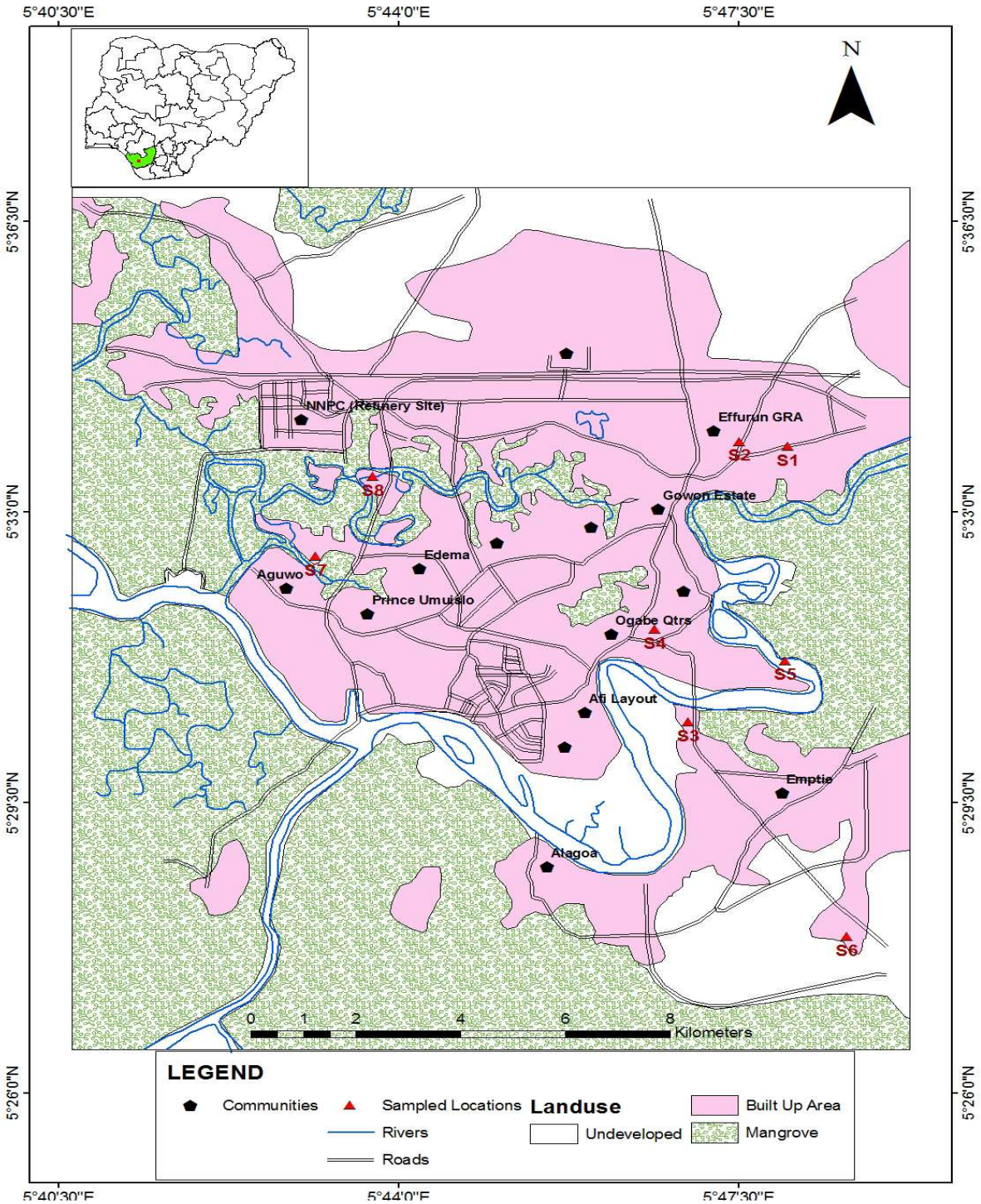

Figure 2.0: Map of Warri showing Sampled Locations
(Inset;Map of Nigeria Showing the Study Location).

1.6 GEOLOGY OF THE STUDY AREA

Warri is underlain by a Quaternary to Recent alluvium known as the Sombreiro-Warri Deltaic Plain sands. This formation consists of sandy silt, brownish lateritic soils (clayey/silty sand) and fine-medium/coarse grained unconsolidated sands. The Formation generally does not exceed 120 meters in thickness and it is predominantly

unconfined while the lateritic unit ranges from 4-5m in thickness. This Quaternary to Recent Formation is then underlain by the three major sub-surface lithostratigraphic units which from bottom to top are; Akata, Agbada and Benin Formations. These are deep marine Shales, Paralic sand and shale sequences and fluviatile sands respectively, that range in age from Palaeocene to Recent [short and stauble,1967].

MATERIALS AND METHODS

COLLECTION/ PREPARATION OF SAMPLES

A total of eight samples were collected by disturbed sampling , two each from four axes of the area [Figure 2.0]. These include Effurun, Enerhen, Edjeba and Udu axes. The samples were prepared in accordance with BS1377 of 1990. Prior to testing, the soil materials were air dried for days and carefully pulverized not to reduce sizes of individual grains.

TEST PROCEDURES

Test programmes conducted on each disturbed sample were sieve analysis, consistency tests (Plastic and Liquid limits), compaction and soaked CBR test. The respective test procedures are discussed as follows.

Sieve Analysis

Representative samples of 200g were used for the test after being washed and oven dried. The sieving was done by mechanical method using a set of sieves and sieve shaker.

Liquid limit Determination

Samples weighing 200g were passed through sieve 0.425mm then mixed with distilled water to form a uniform paste. The paste was placed inside the casangrande apparatus cup with a groove created and the number of blows to close the grove was recorded. The moisture content at each phase was determined then a graph of moisture content against specified number of blows was plotted. Moisture content at 25^{th} blow gave the liquid limit.

Plastic Limit determination.

20g of dry soil sample used in the liquid limit test was mixed with distilled water to form a paste. A portion of the paste was rolled on a glass plate to form a thread until the thread cracked at approximately 3mm in diameter. The moisture content at that point was calculated.

California Bearing Ratio (CBR) Test.

Compaction test were conducted on samples to determine their optimum moisture content (OMC) and maximum dry density (MDD). The OMC and MDD of each sample was used to prepare a specimen for CBR test after 24hrs of soaking. After which, the CBR specimen was weighed and placed under the CBR machine and seating load of approximately 4.5kg was applied. Load was recorded at penetration of 2.5 and 5.0mm.The average CBR for both ends of the moulded specimen was calculated.

RESULTS AND DISCUSSION

CLASSIFICATION CHARACTERISTICS

Classification tests results on Warri Lateritic soils are presented in Table I. Sieve analyses (PSD) show the soils consist of 17.35-41.64% fines and 58.36-82.65% sands. The dominance of sand over fines indicate a non-uniform distribution of grain sizes which implies poor grading (Figure 3.0).Consistency tests show liquid limits and plasticity indices range from 24.90%-37.40% and 5.80-12.10% respectively, this indicates the soils are low-intermediate plasticity soils with low swelling potentials. This is corroborated by the unified soil classification (USC) plasticity chart (Figure 4.0) which further classifies the soils as inorganic clays.

Analysis of these results (PSD and atterberge limits) using the American Association of State Highway and Transport Official (AASHTO) Classification scheme, categorised the soils as granular soils of A2, A3 and clayey soil of A6 type characteristics but the granular soils are dominant. Since the plasticity properties of the A2 soils are similar to typical A4 soils, they are further classified as A2-4 soils.This soil classification (A2-4) agrees with the findings of Olobaniyi *et al* [2005] on the Osubi Lateritic soils except for the presence of A3 and A-6 soil in Warri. The difference in soil classification could be attributed to the local geology and drainage conditions of both areas.

This also confirms the geotechnical properties of lateritic soils could differ in quite a short distance as established by other workers [Adeyemi and Wahab 2008].

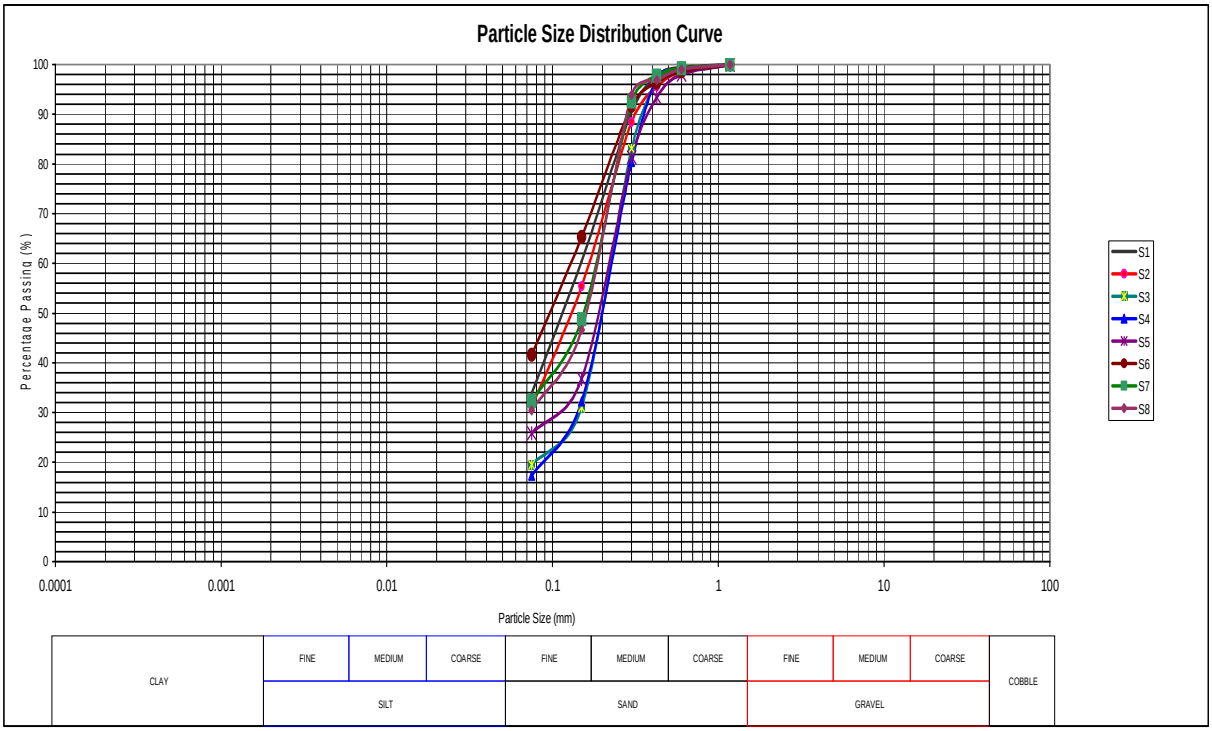

Figure 3.0: Particle Size Distribution curves of Warri Lateritic Soils

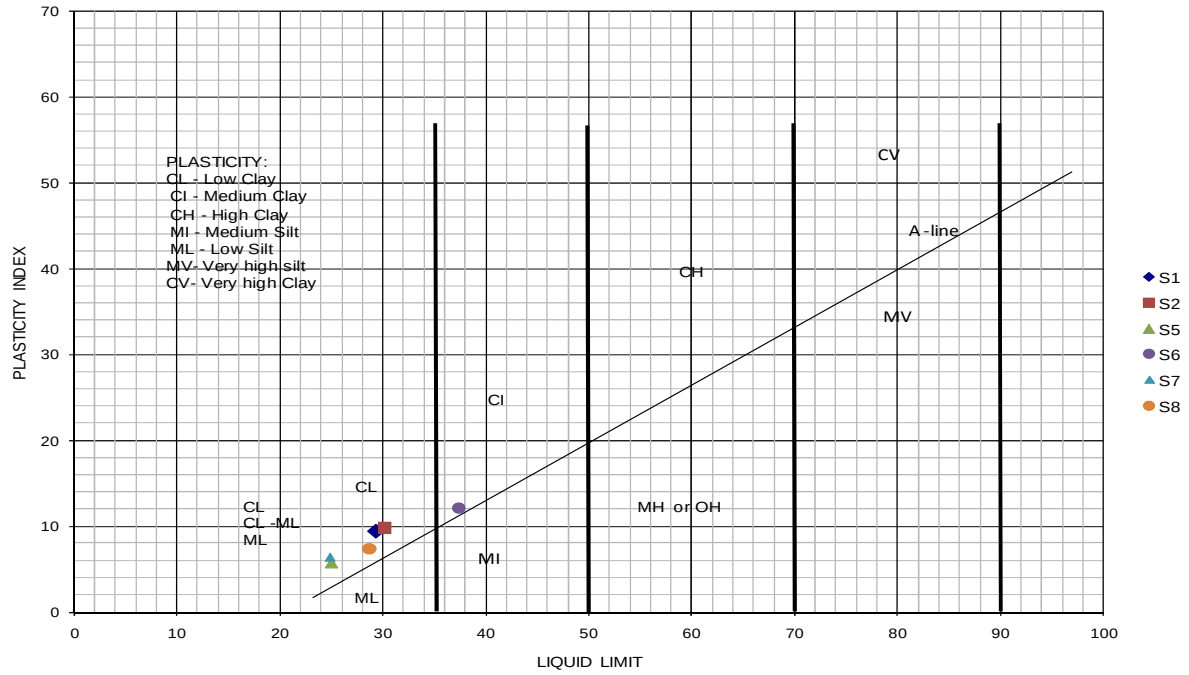

Figure 4.0: Plasticity Chart Of Warri lateritic Soils

Table I: Classification Characteristics of Lateritic soils of the Study Area

Sampled Locations.		S1	S2	S3	S4	S5	S6	S7	S8
Location		PTI road behind first bank	PTI Road by Agofure Park	Urhobo College	Jefia Estate Enerhen	Udu area (SEDCO)	Ujevwu	Ejeba (WIBP)	Ejeba by Chevron
% Moisture content		0.933	7.44	12.25	10.20	8.70	14.05	11.30	12.50
% sand		65.17	68.80	80.52	82.65	74.17	58.36	67.64	69.55
% Fines		34.83	31.20	19.48	17.35	25.83	41.64	32.36	30.45
%Liquid limit		29.30	30.20	NP	NP	25.00	37.4	24.90	28.70
%Plastic limit		19.9	20.40	NP	NP	19.19	25.30	18.50	21.40
Plasticity index		9.40	9.80	NP	NP	5.80	12.10	6.40	7.30
Classification Scheme	USCS	CL	CL	SM	SM	CL	CL	CL	CL
	AASHTO	A2-4	A2-4	A3	A3	A2-4	A6	A2-4	A2-4

NP*= Non- Plastic*
USCS*= Unified soil classification scheme.*

COMPACTION CHARACTERISTICS

The compaction characteristics of Lateritic soils in the western Niger Delta have been found to be dependent on their percentage content of fines [Akpokodje 1986, 1987], [Ugbe 2011]. This is corroborated by the results in table II. The percentage fines, OMC and MDD values of soils at all locations in the area (S1-S8) range from 17.35-41.64%, 10.02-13.8% and 1.935-2.072 g/cm^3 respectively. The soils with the highest percentage of fines (S6) had the highest OMC but lowest MDD which indicates that increase in fines implies greater porosity and requires more water for soil compactions. This in effect, reduces density and consequently lowers the MDD.

Table II: Summary of Compaction and CBR Tests Results on Lateritic Soils in the Area

Sampled Locations	S1	S2	S3	S4	S5	S6	S7	S8
%Percentage fines	34.83	31.21	19.48	17.35	25.83	41.64	32.36	30.45
% Optimum Moisture Content (OMC)	12.50	12.10	10.08	10.02	10.20	13.80	10.20	10.04
Maximum Dry Density(MDD)g/cm^3	1.945	1.960	1.962	2.071	2.058	1.935	2.044	2.068
Califonia Bearing Ratio (CBR%)	15.60	21.50	18.20	17.70	26.10	14.50	10.10	19.20

Furthermore, the soaked California Bearing Ratio (CBR) values of the Lateritic soils range from 10.6 to 26.1%. A comparison of these CBR values with the Nigeria standard [FMW 1997] confirms that the soil could be used as a sub-grade material but unsuitable for use as sub-based and base material in road pavement construction since the CBR values are less than 30% and 80% respectively. This suggests that the soils would fail with time under heavy load, if used in these capacities.

Nevertheless, soil stabilization would be needed to improve their engineering properties and hence remedy these deficiencies. Such stabilization methods are mainly mechanical and chemical stabilization as suggested by several workers [Akpokodje1986], [Omotosho and Eze-Uzomaka 2008].

CONCLUSION

The Lateritic soils of Warri have been found to be of A2-4, A3, and A6 based on the AASHTO classification Scheme, with A2-4 being the dominant soil type.

Compaction Characteristics of the soils are controlled by the percentage fine content while soaked California Bearing Ratios (CBR) have shown they are suitable sub-grade materials but would require appropriate stabilization to be competent sub-base and base courses for road construction.

The classification and compaction characteristics of the warri lateritic soils have therefore provided the necessary preliminary data and information required for assessing and sourcing lateritic soils for future construction works in the area.

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REFERENCES

[1] Abam T. K. S, Okogbue C. O, *JMG*.**, 1997**, 133(1), 15-24.
[2] Adeyemi G.O, Wahab k.A, *Bull.Eng.Geol.Environ*., **2008**, 67, 579-584.
[3] Akpokodje E.G. *Bull.Int.assoc.Eng.Geol*., **1986a,** 33 pp.115-121.
[4]Akpokodje E.G. *Eng. Geol*., **1986**, 23, 193-211.
[5]Akpokodje, E.G . Proc (9th Reg. Conf. soil mech. and foundation Engr. Lagos,**1987)** 751-760**.**.
[6] Akpokodje E.G .*Eng. Geol*., **1989**, 26, 247 – 25.
[7] Akpokodje E.G, Introduction to Engineering Geology,Pam Publishing Coy Ltd, Port Harcourt, **2001**,pp. 239-246
[8] Alabo E.H, FitzJohn W.H, Ogare F.A. *Nigeria journ.Min. Geol*. **1984** , 21, 35-39.
[9] British Standard Institute. Methods for Tests for soils for civil Engineering Purposes. B.S 882. **1992**
[10]Federal Ministry of Work, (F.M.W) Nigeria. General specifications (roads and bridges) 2, **1997**.
[11] Gidigasu M.D. *Eng. Geol* **1972**, 4:79-91.
[12] Olobaniyi S.B, Ugbe, F.C and Akpodavwe, S. Nigeria, *Jour. Pure and Appl. Sci*.**, 2005**, 20,1853-1857.
[13] Olobaniyi S.B, Owoyemi F.B. *African Journal of Science and Technology*, **2006**, 7(1), 73-81.
[14] Omotosho O., Eze-uzomaka O.J. *Journal of South African Institute of Civil Engineering*., **2008**. 50 (2), 10-17.
[15] Short, K.C. and Stauble, A.J .Outline of the Geology of the Niger Delta. **1967**, *Bull. AAPG* 51, 761-77.
[16]Ugbe F.C . *Research Journal of Environmental and Earth Sciences*. **2011**, 3(4), 433-437.
[17] Ugbe F.C . *Research Journal of Environmental and Earth Sciences*,**2011**.3(5), 571-577.