Strength and Eco-Friendly Characterization of Selected Lateritic Soils for Road Pavement

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ABSTRACT: This paper is on the study conducted to reveal the strength and eco-friendly characterization of the lateritic soils from Ofada, Papalanto and Shagamu borrow pits in Ogun State of Nigeria when used as road subgrade, subbase or basecourse during the construction of pavements. Engineering properties of the laterite soils samples were determined through laboratory experimental analyses based upon relative density, wet sieve analysis, Atterberg limits tests, unconfined compression test, coefficient of permeability test, mass-volume relations, moisture-density relationship and California Bearing Ratio (CBR) test. Also, chemical composition, metallic composition and physico chemical properties of the laterite samples were assessed and characterized. The results have shown that the higher the material relative density value of the three samples the higher the value of their void ratio, degree of saturation, porosity, co-efficient of permeability and unconfined compressive strength. The materials contained coarse-grained sizes respectively as 54.46%, 66.975% and 29.63% and they can be classified as A-6(5), A-2-6(1) and A-6(12) which is an indication that the higher the coarse-grained the higher the strength. The CBR values in percentages for unsoaked soil samples respectively are 19.55, 31.5 and 13.106 while for soaked conditions are 13.45, 19.3 and 5.8 is an indication that they are suitable for subgrade. The pH values of 10.05, 13.10 and 11.56 respectively indicated that the materials are alkaline. Cadmium, lead and nickel were not detected in each soil sample and it meant that the materials are not hazardous.

Keywords: Premature, Failure, Subbase, Basecourse, Pavement, pH, Alkali

1. INTRODUCTION

The suitability of the use of laterite as subbase or base for pavement construction of roads in South Western part of Nigeria is worthy of challenge because of the prevailing premature failure of their road pavements. Wikipedia (2014) reported Thurston, Edgar who in 1913 claimed that Francis Buchanan-Hamilton first described and named a weathering product of an underlying parent rock as laterite formation at Southern India in 1807. According to Schellmann (2014) laterites are the products of intensive and long lasting tropical rock weathering which is intensified by high rainfall and elevated temperatures along with chemical reactions between the rocks exposed at the surface and the infiltrated rain water. However, laterite on mafic rock that is basalt and gabbro and those on ultramafic rock that are serpentinite, peridotite and dunite show, lower silica and higher iron contents free of quartz. In addition, they are ferruginous yellowish brown laterite such as nickel limonite found on serpentinite that are generally soft and display a very fine porosity of low bulk density. Laterite on acidic rocks has granites, granitic gneisses, together with many types of sediment of clays, shales and sandstone containing quartz of higher silica and lower iron contents.

In South Western part of Nigeria laterite soils are found as a mixture gravel, sand, silt and clay in various proportions. According to Chambers (2007), gravel is composed of unconsolidated rock fragments that have a general particle size range from granule through cobble to boulder and are categorized into granular and pebble. Granule is a rock or mineral with a grain size between 2 and 4 mm. A cobble is a clastic rock with particle size ranging from 64 mm to 256 mm. Boulder is a rock with grain size of usually not less than 300 mm in diameter. Granular gravel is an irregular shaped fragment of rock between 4 and 64 mm diameter size. Pebbles are small rounded fragment of gravel rock between 4 and 64 mm diameter size. Sand is a naturally occurring granular material composed of finely or loose, unconsolidated accumulations of detrital sediment, consisting essentially of rounded grains of quartz between 0.0625 and 2 mm diameter size. Silt is granular material of an earthy character as a soil or as sediment mixed in suspension with water intermediate in grain size somewhere between sand and clay whose mineral origin is quartz and feldspar. Silt may occur as a soil or as sediment mixed in suspension with water (also known as a suspended load) in a body of water such as a river. It may also exist as soil deposited at the bottom of a water body. Silt

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particles range between 0.0039 to 0.0625 mm, larger than clay but smaller than sand particles. Clay is a residual deposit of a fined-texture sedimentary by accumulation of rock waste resulting from weathering in situ. Weathering is a process of disintegration and decomposition effected in rock minerals as a consequence of exposure to the atmosphere and to the action of frost, rain and isolation. These effects can be partly by mechanical, chemical, organic and for their continuation depend upon the removal by transportation of the products of weathering. Weathering and transportation can both take place and this is known as denudation. Clay is fine-grained sediment of variable composition having a grain size less than 0.0039 mm.

Wright (2003) and Garber (2010) claimed that road pavement structure properly planned, designed, constructed must be capable of carrying volumes of passenger cars and mixed trucks traffic safely. For this reason, pavement structure must be placed economically over adequate subgrade foundation and to possibly consist of subbase, base and surfacing with required designed strength throughout the expected life span of 20 years or more. Subgrade is the foundation structure and usually the compacted natural soil in cut or at embankment section filed in layers that must eventually support all traffic loads that come onto the pavement. Subbase is of granular material or stabilized material for use in areas where frost action is severe or in locations where the subgrade soil is extremely weak or where a construction working table is needed. Subbase may also be used, in the interests of economy, in locations where suitable subbase materials are cheaper than base materials of higher quality. The base is a layer or layers of very high stability and density. Base principal purpose is to distribute or spread the stresses created by wheel loads acting on the wearing surface so that the stresses transmitted to the subgrade will not be sufficiently great to result in excessive deformation or displacement of the foundation layer. The base must also be of such character that it is not damaged by capillary water or frost action. The wearing surface must be capable of withstanding the wear and abrasive effects of moving vehicles and must possess sufficient stability to prevent it from shoving and rutting under traffic loads. In addition, wearing surface serves a useful purpose in preventing the entrance of excessive quantities of surface water into the base and subgrade from directly above.

The aim of this paper therefore is to consider the suitability of three selected borrow pits laterite soils currently in use for road pavements construction in South Western part of Nigeria. Specifically, the following items are the objectives of this study.

1. To carry out the experimental analysis on laterite materials from three borrow pits in use as subbase or base for pavement construction at Ofada, Papalanto and Shagamu environs in Ogun and Lagos States of Nigeria.
2. To determine the engineering properties of the laterite soils samples through laboratory experimental analyses based upon relative density, grain size by wet sieve analysis, Atterberg limits tests, unconfined compression test, coefficient of permeability test, mass-volume relations, moisture-density relationship and California Bearing Ratio test.
3. To carry out laboratory experiments upon chemical composition, metallic composition, pH, sulphate and chloride on the borrow pits laterite soil samples.

Significantly, to consider if the selected lateritic soils are suitable in strength to withstand expected traffic loads when chosen for subgrade, subbase or base and also whether they are environmentally friendly.

Ojuri (2013) concluded that an increase in in-situ density, bulk density, and maximum dry density gave a corresponding increase in the dependent variables of California bearing ratio (CBR) and undrained shear strength c_u. He also claimed that a decrease in optimum moisture content, natural moisture content and group index of soils led to an increase in the dependent variables for the soils. Cokca et al. (2004) observed that cohesion attains its peak value at around the optimum moisture content. Bello (2011) reported that unconfined compressive strength value of lateritic soil must be equal to or greater than 200 kN/m^2 as an acceptable material to be used as hydraulic barrier in containment structures. Moses et.al (2013) claimed that significant increase in hydraulic conductivity may result from flocculation of clay particles due to interaction with electrolyte solution, shrinkage of the soil matrix in the presence of concentrated organic solvents and acid-base dissolution of the soil. George (2011) acclaimed that the grain size

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distribution, compaction and moisture-content have an immense influence on the strength and stiffness of subgrades. He further noticed that an increase in the proportion of silty soil fractions resulted in a decrease in the MDD, increase in the OMC, increase in the voids-ratio, and consequently decrease in the modulus of elasticity or stiffness of soil. Nwaiwu (2006) claimed that lateritic clayey gravels have good workability as engineering construction materials and are rated fair to good as road aggregate materials.

2. MATERIALS AND METHODOLOGY

Samples of lateritic soils from three towns Ofada, Papalanto and Shagamu borrow pits in Ogun State of Nigeria were collected and subjected to laboratory physical and chemical analysis along with their comparative studies. The values of Relative Density, Moisture Content, Bulk Density, Dry Density, Void Ratio, Degree of Saturation, Porosity and Critical Hydraulic Gradient were determined in the laboratory in accordance with the related test procedures as outlined in AASHTO T 100 (2010). Also, values of Hydraulic Conductivity for the three lateritic soils were found individually in the laboratory in accordance with the related test procedures as outlined in ASTM D7664 (2010). The Unconfined Compressive Strength and Shear Strength were determined in the laboratory in accordance with the related test procedures as outlined in AASHTO T 208 (2010) for each of the three lateritic soils.

In order to classify the three lateritic soil samples, wet sieve analysis and Atterberg limits of the materials were determined in the laboratory. The laboratory work in this study does not consider the entire grain-size distribution curve. Therefore, wet sieve analysis was employed in accordance with the standard method AASHTO T 88 (2013). In the process, each 200 g oven dried broken laterite soil passing through 9.5 mm sieve size was washed with water over sieve designated No. 200 whilst combined silt and clay passed through. The materials remaining on sieve No. 200 was later oven dried at (100°C±5°C) for 24 hours and later at laboratory temperature subjected to nest of sieves 4.75, 2.00, 1.18, 0.6, 0.425, 0.212, 0.15 and 0.075 with shaking for 5 minutes. Mass retained on each sieve was measured and cumulative percentages passing were determined.

Atterberg limits were considered in this study by the determination of liquid limit, plastic limit, plasticity index and shrinkage limit of the three soils in the laboratory. Determining the liquid limit of the three soils in the laboratory was by following the standard method AASHTO T 89 (2013). The liquid limit for each material of the three lateritic soils was determined as the moisture content at which soil flew together at the 25 drops by the closure groove of 12.7 mm using the Casagrande's liquid device. Determining the plastic limit and the plasticity index of the three soil samples in the laboratory were done by the standard method AASHTO T 90 (2008). Plastic limit for each soil sample was determined as the amount of moisture content at which the soil material crumbled when rolled into a thread of 3.18 mm diameter. Plasticity index for each soil sample was determined knowing the difference between the liquid limit and the plastic limit. Determining the shrinkage limit of the three soil samples in the laboratory were done by the standard method ASTM D427 (2000). The determination of the shrinkage limit was by knowing the moisture content at which each soil did not undergo any further change in volume with loss of moisture.

Table of Standard Specification for Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes AASHTO M 145 (2012) was employed in this study to classify the three lateritic soil samples. In the process, the three lateritic soil samples were classified based on their wet sieve analysis, liquid limit and plasticity index. The system classified soils into 7 groups of A-1, A-3, A-2, A-4, A-5, A-6, and A-7. The order of the arrangement of A-3 before A-2 is to determine correct group by the process of elimination whilst fitting the correct group classification from the left of the table. Subgroup classification of soils according to the table includes A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5 and A-7-6. The general classification according to Wright (2003) and Hoel (2010) is (i) granular materials (35% or less passing No.200 and (ii) silt-clay materials (more than 35% passing No. 200). However, Das (2007) claimed additional general classification of highly organic soils such as peat, muck etcetera as group 8. Furthermore, soils are finally determined by using an empirical formula to determine the group index (GI). GI value is a useful measure of soil

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strength. The formula for the (GI) is given as follows.

$$GI = (F_{200} - 35)[0.2 + 0.005(w_L - 40)] + 0.01(F_{200} - 15)(I_P - 10) \quad (1)$$

Where

F_{200} = percentage passing No. 200 sieve, expressed as a whole number. The percentage is based only on the material passing the 75 mm sieve.

w_L = liquid limit expressed in a whole number

I_P = plasticity index expressed in a whole number

Compaction tests were performed in the laboratory on the three lateritic soils by the standard Proctor test AASHTO T 99 (2010). The methodology involved using a mould 102 mm in diameter which has a volume of 944 cm^3, a hammer weighing 2.5 kg having a striking face of 51 mm in diameter and a 3000 kg of the lateritic dry soil sample that passes No.4 (4.75 mm) sieve. The soil sample was mixed with water and placed in three layers of about equal thickness and each layer is subjected to 25 blows from the hammer by falling freely through a distance of 305 mm in the mould. The compacted sample was measured and part of it was taking about the centre to oven dry for the purpose of determining the water content. Repeated operation continued by addition of more water in sequence of increment until the density decreases.

The California Bearing Ratio tests were performed in the laboratory on the three lateritic soils by the standard Proctor test AASHTO T 193 (2000). At optimum moisture content, each lateritic soil was compacted in a mould of 152 mm diameter and 152/178 mm high and was put in place for four days with surcharge weight in place. Removing the sample from the water it was allowed to drain for a period of 15 min. The same surcharge was imposed on the sample and immediately subjected to penetration by forcing a 19.4 cm^2 plunger at the rate of 1.25 mm/min into the sample to a depth of 2.5 mm. The total loads corresponding to penetrations of 2.5, 5.0, 7.5, 10, and 12.5 cm were recorded. Oxide, Metallic and physico-chemical composition of the three lateritic soil samples were determined by Mineralogy and Chemical Analysis using the X-Ray Diffraction test and Atomic Absorption Spectroscopy (AAS) test.

3. RESULTS

Basic properties of the lateritic soil samples from Ofada, Papalanto and Shagamu borrow pits for highway purposes are in Table 1 individual relative density, moisture content, bulk density, dry density, void ratio, degree of saturation, porosity, critical hydraulic gradient and permeability respectively. Figure 1 shows the wet sieve analysis grain size distribution curves of laterite soils samples from Ofada, Papalanto and Shagamu borrow pits.

Table 2 shows the values of the results of soil classification for highway purposes of laterite soil samples including percentages of gravel, sand plus combined silt and clay. Other results on Table 2 are liquid limit, plastic limit, shrinkage limit, plasticity index, Unified System of Soil Classification and AASHTO System of Soil Classification. Figure 2 through Figure 4 are the results of compaction Proctor tests and also the moisture-density relationship for Ofada, Papalanto and Shagamu lateritic soils respectively. Table 3 shows soil strength characteristics of borrow pits laterite samples from Ofada, Papalanto and Shagamu for highway purposes. These are unconfined compressive strength uncured, cohesion uncured, unconfined compressive strength cured, cohesion cured, optimum moisture content, maximum dry density (kg/m^3), unsoaked CBR and soaked CBR.

The oxide composition, metallic composition and physico-chemical composition of the three lateritic soils are presented respectively in Tables 4, 5 and 6. Physico-chemical composition of laterite soils samples from Ofada, Papalanto and Shagamu borrow pits of Table 6 shows that the materials have pH values of 10.05, 13.10 and 11.56 respectively. In addition, the materials contained respectively sulphate anions of 30, 85 and 35 plus chloride anions of 60, 80 and 80.

Table 1: Soil Basic Properties for Highway Purposes

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S/No	Parameters	Ofada Lateritic Soil Sample	Papalanto Lateritic Soil Sample	Shagamu Lateritic Soil Sample
1	Relative Density, RD or G_s	2.65	2.7	2.7
2	Moisture Content, w%	16.008	16.191	12.016
3	Bulk Density, (ρ)	1.806	1.844	1.844
4	Dry Density, ρ_D	1.557	1.587	1.646
5	Void Ratio, e	0.421	0.435	0.392
6	Degree of Saturation S_r	0.976	0.984	0.787
7	Porosity, n	0.296	0.303	0.282
8	Critical Hydraulic Gradient i_c	1.103	1.148	1.126
9	Co-Efficient of Permeability	2.238E-05	2.141E-05	4.617E-06

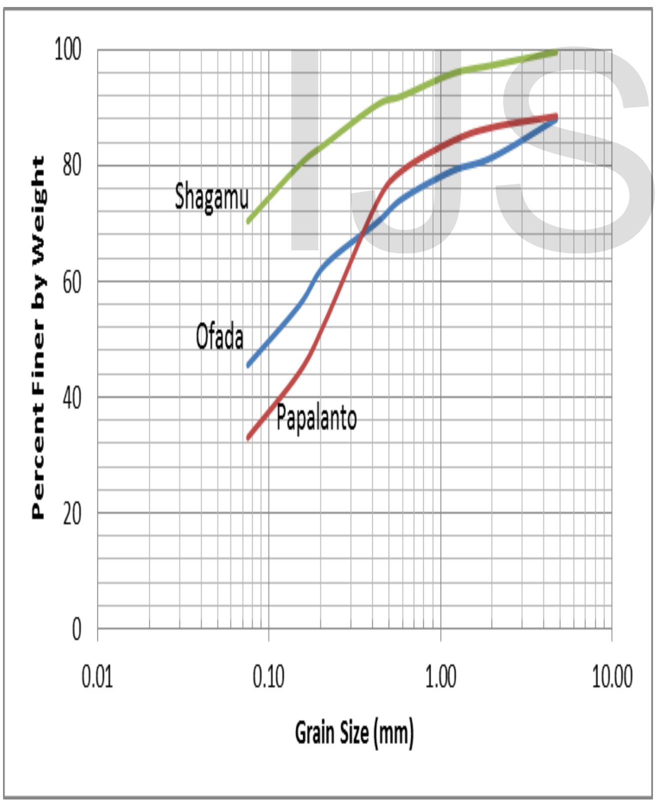

Figure 1: Wet Sieve Analysis Grain Size Distribution Curves

Table 2: Soil Classification for Highway Purposes

S/No	Label	Ofada Lateritic Soil Sample	Papalanto Lateritic Soil Sample	Shagamu Lateritic Soil Sample
1	Percentage of Gravel	12.025	11.505	0.42
2	Percentage of Sand	42.435	55.47	29.21
3	Percentage of Combined Silt and Clay	45.54	33.025	70.37
4	Liquid Limit	34	31	35
5	Plastic Limit	20.827	17.399	20.249
6	Shrinkage Limit	7.813	5.469	7.813
7	Plasticity Index	13.173	13.601	14.751
8	Unified System of Soils Classification	CL	CL	CL
9	AASHTO System of Soils Classification	A-6(5)	A-2-6(1)	A-6(12)

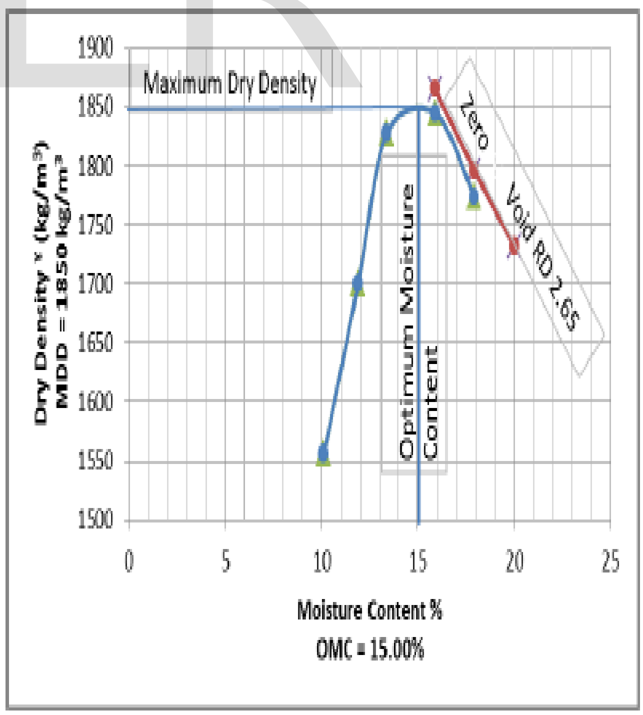

Figure 2: Moisture-Density Relationship for Ofada Lateritic Soil

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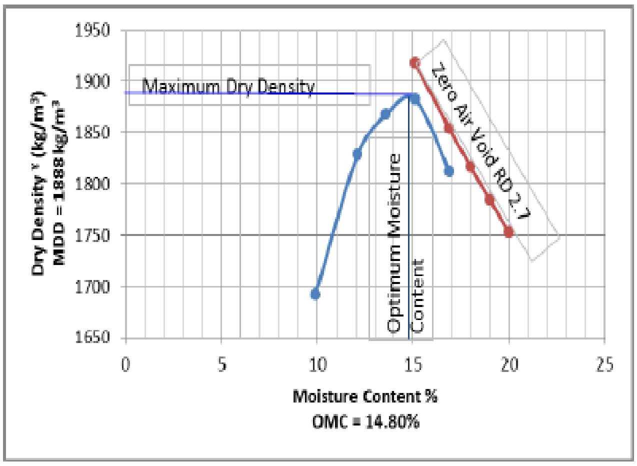

Figure 3: Moisture-Density Relationship for Papalanto Lateritic Soil

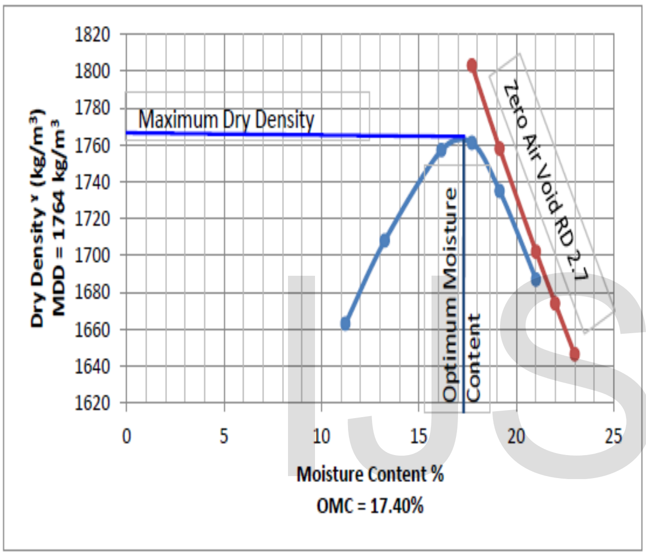

Figure 4: Moisture-Density Relationship for Shagamu Lateritic Soil

Table 3: Soil Strength Characteristics for Highway Purposes

S/No	Label	Ofada Lateritic Soil Sample	Papalanto Lateritic Soil Sample	Shagamu Lateritic Soil Sample
1	Unconfined Compressive Strength uncured	142	190	54
2	Cohesion uncured	71	95	27
3	Unconfined Compressive Strength cured	190	274	84
4	Cohesion cured	95	137	42
5	Optimum Moisture Content	17.8	14.8	17
6	Maximum Dry Density (kg/m³)	1.76	1.88	1.76
7	Unsoaked CBR %	19.55	31.5	13.106
8	Soaked CBR %	13.45	19.3	5.8

Table 4: Oxide Composition of Laterite

S/No	Oxide %	Ofada Lateritic Soil Sample	Papalanto Lateritic Soil Sample	Shagamu Lateritic Soil Sample
1	SiO_2	62.45	62.4	62.42
2	K_2O	0.54	0.52	0.5
3	Na_2O	0.30	0.28	0.26
4	CaO	1.986	1.972	1.970
5	Fe_2O_3	0.080	0.060	0.053
6	MgO	1.247	1.244	1.240
7	MnO	0.008	0.005	0.004
8	Al_2O_3	30.89	30.76	30.70

Table 5: Metallic Composition of Laterite

S/No	Metallic mg/kg	Ofada Lateritic Soil Sample	Papalanto Lateritic Soil Sample	Shagamu Lateritic Soil Sample
1	Aluminium Al	16.35	16.28	16.25
2	Cadmium Cd	Not Detected	Not Detected	Not Detected
3	Copper Cu	0.040	0.020	0.010
4	Manganese Mn	0.006	0.004	0.003
5	Lead Pb	Not Detected	Not Detected	Not Detected
6	Iron Fe	0.054	0.043	0.037
7	Zinc Zn	0.017	0.015	0.013
8	Nickel Ni	Not Detected	Not Detected	Not Detected

Table 6: Physico Chemical Composition of Laterite

S/No	Physico Chemical	Ofada Lateritic Soil Sample	Papalanto Lateritic Soil Sample	Shagamu Lateritic Soil Sample
1	pH	10.05	13.10	11.56
2	Sulphate	30.00	85.00	35.00
3	Chloride	60.00	80.00	80.00

4. DISCUSSION

The relative densities of the three lateritic soil samples being 2.65, 2.7 and 2.7 for Ofada, Papalanto and Shagamu as in Table 1 is an indication that the materials contain clay as mentioned by Terzaghi et al., (1996). Also, in Table 1, the materials bulk density being 1.806, 1.844 and 1.844 while the dry density values being 1.557, 1.587 and 1.646 for the three borrow pits materials respectively suggests that the materials are of fine soils having low

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compressibility as put forward by BS 6031 (2009). Similarly, it could be seen in Table 1 that the three lateritic soils contained dense mixed-grained sand, in so far the material void ratio values are 0.421, 0.435 and 0.392; degree of saturation values being 0.976, 0.984 and 0.787; as well as porosity values being 0.296, 0.303 and 0.282 as discussed by Terzaghi et.al, (1996). Critical hydraulic gradient values of the soil samples are 1.103, 1.148 and 1.126. According to Smith (1980), the higher these values are the later the soils become unstable due to the condition that the soil effective stress becomes zero. Values of the co-efficient of permeability of the lateritic soil samples in mm/s are 2.238E-05, 2.141E-05 and 4.617E-06. According to Smith (1980), the smaller the values the more impervious are the laterite materials.

Wet sieve analysis results of the three lateritic soil samples show in Table 2 that the materials percentages passing sieve size 0.075 mm are 45.54, 33.025 and 70.37. Thus, the laterite samples are respectively silt-clay, granular and silt-clay soils based on AASHTO M 145 (2012) soil classification system. The three lateritic soils classifications by soil group and group index are respectively A-6(5), A-2-6(1) and A-6(12). Significantly, the three constituent materials are respectively clayey soil, clayey-silty-sandy soil and clayey soil. The general rating of the lateritic soils are respectively fair, good and fair for embankments, subgrades and compacted subgrades. Based on Unified Soil Classification System ASTM D3282 (2009), the three lateritic materials are respectively coarse-grained soil, coarse-grained soil and fine-grained soil whilst simply described as silts and clays. The liquid limit of each of the three lateritic soil samples is less than 50 and the respective Plasticity Indexes are 13.173, 13.601 and 14.751 which are all greater than 7 and plotted above line "A" of plasticity chart which confirms the materials to be CL according to Unified Soil Classification System. Obviously, AASHTO M 145 (2012) soil methodology of classification better described the three soils for pavement design than ASTM D3282 (2009). This is because AASHTO distinctly placed soil sample from Papalanto as the best material of the three samples being A-2-6(1) followed by materials from Ofada that is A-6(5) which is better than that of Shagamu that is A-6(12).

Soil strength characteristics of the three lateritic soil samples from Ofada, Papalanto and Shagamu for highway purposes are in Table 3. The soil samples values in kN/m^2 of uncured unconfined compressive strength are 142, 190 and 54 while that of the uncured cohesion are 71, 95 and 27. Also, the soil samples values in kN/m^2 of eight days air-cured unconfined compressive strength are 190, 274 and 84 while that of the cured cohesion are 95, 137 and 42. Obviously, the values of the air-cured unconfined compressive strength of the three samples are higher in values than those of the remoulded clay soil samples. The consistency of the soil material with 54 kPa is medium while the lateritic materials with 142 kPa and 190 kPa are of stiff nature according to Terzaghi et al., (1996).

Also in Table 3, moisture-density relationship based upon AASHTO T 99 (2010) under dynamic compaction along with California Bearing Ratio (CBR) test AASHTO T 193, have been used to judge the classification of the three lateritic soils for highway purposes. The values of OMC in percentages are 17.8, 14.8 and 17 while the corresponding MDD in kg/m^3 are 1.76, 1.88 and 1.76 with evidence that the lower the OMC the higher the MDD. Also, the values of CBR in percentages are 19.55, 31.5 and 13.106 in unsoaked condition while in soaked situation, the values are 13.45, 19.3 and 5.8 with indication that the higher the value of the unsoaked soil material the higher the corresponding soaked value. Actually, the differences between unsoaked and soaked values of CBR for the lateritic soils respectively are 6.1, 12.2 and 7.306. The lateritic soil of A-2-6(1) has a CBR with wider difference of 12.2 between unsoaked and soaked than the other soils of A-6(5) and A-6(12) with differences of 6.1 and 7.306 respectively. This could be attributed to the fact that the former is of granular material while the other soils are of silt-clay materials. This is in conformity to Wright (2003), which claims that granular soils that have better grading and higher densities under the same compactive effort react sharply to small changes in moisture content. Also, the group indexes of the lateritic soils in group A-6 of 5 and 12 respectively by AASHTO soil classification system places material with GI of 5 of higher strength than that with GI of 12.

The values of S_iO_2, K_2O, Na_2O, CaO, Fe_2O_3, MgO, MnO and Al_2O_3 as presented in Table 4 for laterite soils from Ofada, Papalanto and Shagamu burrows pits are similar which is an indication that the three materials are of comparable origin. The values of the percentage composition of oxide in each of the three samples which are 62.45, 62.4 and 62.42 for S_iO_2 and 30.89, 30.76 and 30.70 for Al_2O_3 respectively show that the materials are lateritic soil.

Table 5 is on the metallic composition of the three lateritic soils from Ofada, Papalanto and Shagamu. It could be seen that Cadmium Cd, Lead Pb and Nickel Ni metals were not detected in any of the three lateritic soils and is an indication that they do not contain poisonous substances and so safe health-wise. The presence of iron Fe in the laterite samples is an indication that the lateritic soils are ferruginous.

Table 6 is on physico-chemical composition of laterite from Ofada, Papalanto and Shagamu. The pH values of 10.05, 13.10 and 11.56 for Ofada, Papalanto and Shagamu are respectively greater than 7 which is an indication that the hydrogen ion concentration of each of the lateritic soil material is alkali. The values of chloride present in the lateritic soils are 60.00, 80.00 and 80.00 for Ofada, Papalanto and Shagamu respectively. The values of sulphate present in the lateritic soils are 30.00, 85.00 and 35.00 for Ofada, Papalanto and Shagamu respectively.

5. CONCLUSIONS AND RECOMMENDATIONS

The results have shown that higher relative density values give higher the values of void ratio, degree of saturation, porosity, co-efficient of permeability and unconfined compressive strength, which are basic properties of the lateritic soil samples. Based on the laterite soil samples results basic properties, soil classifications and strength characteristics, Papalanto material is the best followed by Ofada material and lastly Shagamu material. The results have also shown that the lateritic soil from Papalanto is of A-2-6(1) classification and it is the best of the three materials for it could be rated good for subgrade being clayey-silty-sand. On the other hand, classification of materials from Ofada is A-6(5) and that of Shagamu is A-6(12) of which indicates clayey soils and could therefore be rated fair for road subgrade. Since the three lateritic soils are suitable for subgrade and are being used for subbase or basecourse of road pavement, the failure of same prematurely is obvious with early patching. The three lateritic soils are readily available for road pavement construction in particularly subgrade or prepared subgrade but they are not suitable for pavement subbase or basecourse. For these lateritic soil materials to be suitable for subbase or basecourse of road pavements, they should be stabilized. It is worthy to note that Schellmann (2014) claimed that the laterite they worked on is of acidic rocks with many types of sediment of clays, shales and sandstone containing quartz of higher silica and lower iron contents. Laterite worked on in this research study however, is of alkaline origin found of gravel, sand, silt and clayey materials having high silica and alumina with low lime and iron contents.

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