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Assessment of Index Properties of Lateritic Soils in Offa for Road Construction Works

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Abstract

Lateritic soils are the most common surface deposits occurring in the tropical and subtropical regions of the world. The index properties of lateritic soil of selected borrow pits in Offa, Nigeria for road construction works has been investigated. Specific gravity, natural moisture content, particle size distribution and Atterberg limits tests were conducted on the samples taken from the borrow pits/lateritic deposits. The results revealed that the specific gravity of the soil samples has been classified as inorganic soils. The natural moisture content of samples A to D, are within the average specified limit for road constructions while sample E does not conform to the specified range (which is an indication of high water adsorption capability of the soil material). The soils of samples A and B; and C and E, fall under group A-6 and A-7-6, respectively, suggesting poor road construction material. However, soil samples D fall under group A-2-7 classification suggesting good road construction material. Soil samples A, B, C, and D are within the maximum standard limit of liquid limit, thereby making them suitable for subgrade, subbase and base materials. While sample E value is above 50% rendering it unsuitable materials.

Keywords: ***Index properties, Lateritic soil, Road, Offa***

1. Introduction

Lateritic soils are the most common surface deposits occurring in the tropical and subtropical regions of the world, enriched in iron and aluminium and developed by intensive and long lasting weathering of the underlying parent rock. Nigeria is the only nation where laterites serve as the perfect soil materials to solve all construction problems especially in construction of earth dams, highways, embankments, airfields and foundation materials to support structures without considering its classification as problem and non-problem types and the actual field geotechnical performance of the soils (Amadi *et al.,* 2015; Ademila, 2017).

Inadequate information on soils and their properties has led to failures of some road construction works. Lateritic soil are found in the six geopolitical zone in Nigeria including the major roads linking local, state, within the country. However, this study investigate the index properties of lateritic soil in Offa Local Government Area of Nigeria for road construction work due to the fact that there is no existing data of most suitable laterite in the study area.

Oghenero *et al.*, (2014) investigated classification and compaction characteristics of lateritic soils of Warri, Delta state, Nigeria. Classification tests (sieve analysis and consistency tests) revealed the Lateritic soils to be A6, A3 and dominantly A-2-4 type characteristics based on the American Association of State Highway and transport Officials (AASHTO) Classification Scheme. Oluyinka and Olubunmi (2018) investigated the geotechnical properties of lateritic soil as subgrade and base material for road construction in Abeokuta, Southwest Nigeria. The liquid limit, plastic limit and plastic index of the study ranges from 12.0 to 40.1%, 10.0 to 22.0% and 2.8 to 20.4% respectively. This implies that lateritic soil present throughout the study area are suitable for use as sub-base and base materials since the geotechnical properties are fairly within the regulatory standards of Nigeria. In the study by Okoyeh *et al.*, (2017) on suitability of Ihiala laterites for use as sub-grade material in road construction, the study recommended that soil samples should undergo appropriate tests to determine their suitability for a particular purposes and strength improved where necessary before it can be used as subgrade material.

2. Study Area

Offa is a city located in Kwara State, North Central of Nigeria. Offa Local Government is a town located on latitude 4.62^0 to 4.74^0 N and longitude 8.11 to 8.22^0 E (Figure 1). Offa is 100% bordered by Oyun Local Government with savanna vegetation and the main occupation in the town is farming (Jimoh and Sholadoye, 2011).

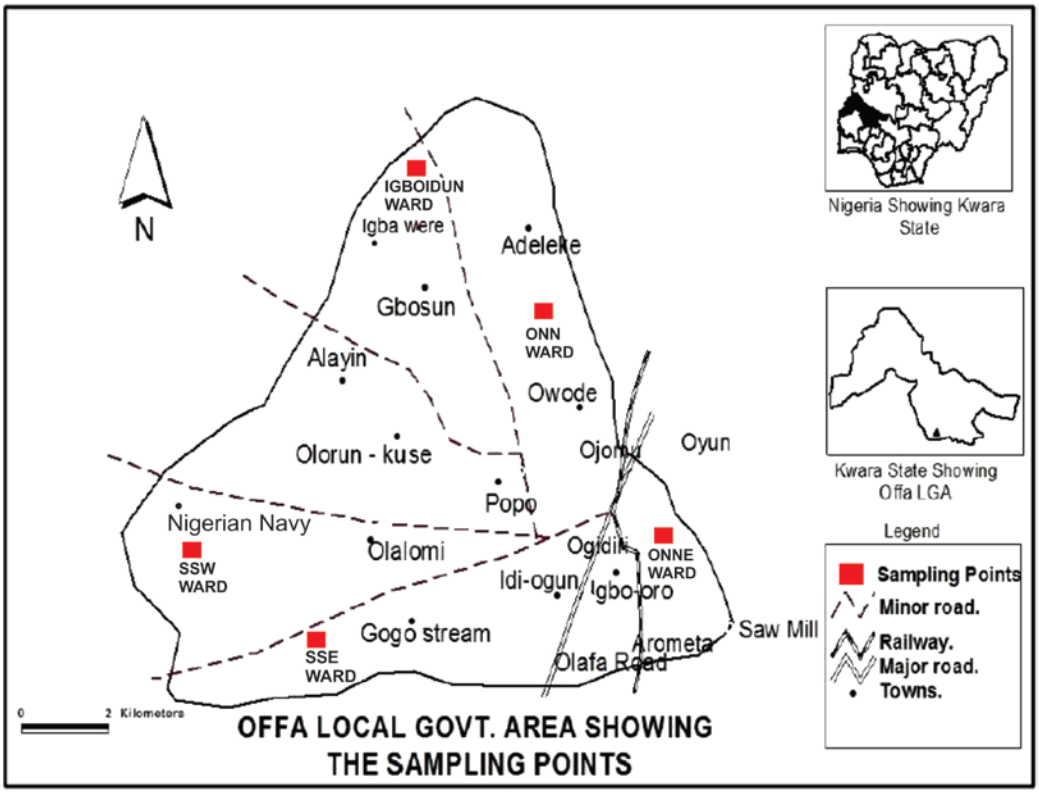

Figure 1: Map of Offa Local Government Area showing Sample points

3. Methods

This study compares lateritic soil from different borrow pit/lateritic deposit in Offa Local Government of Kwara State, Nigeria for road construction works. Specific gravity, natural moisture content, particle size distribution and Atterberg limits (liquid limit, plastic limit and plasticity index) tests were carried out on the samples taken from five different borrow pits/lateritic deposits. The tests were determined in accordance with the Nigerian FMWH (1997) as well as AASHTO (1986) requirements for transportation materials.

3.1 Sampling Approach

The samples from the five lateritic deposits were obtained by auger boring from the following pits:

i. The Federal Polytechnic Offa borrow pit (Temporary site) located at Sawo South West Ward of the Local Government.
ii. Igba-wẹrẹ (Offa – Ojoku Road) borrow pit along permanent site Federal Polytechnic Offa, located at Igboodun Ward of Offa Local Government.
iii. Egunkara borrow pit (Along Igosun Road) Offa, located at Ojomu South ward of the local government.
iv. Alaya off Navy Med. School borrow pit (Along Nowa Nursery and Primary School, Located at Sawo Southwest ward) Offa.
v. Igberiogun off Navy Med. School borrow pit located at Sawo Southwest ward Offa.

Three samples of 30kg (disturbed sample) in a point was obtained from each location at a depth of 1.5m. Igberiogun Off Navy Medical Sch. Offa, Federal Poly Offa, Igbawere-Ojoku Road, Alaya Off Navy Medical Sch. Offa and Egunkara-Igosun Road, Offa were denoted as samples A, B, C, D and E, respectively.

4. Results and Discussion

4.1 Specific Gravity

Specific gravity depends significantly on the factors which are size of samples, position of samples in soil profiles, grading characteristics, mineralogical composition of parent rocks and so on. The specific gravity of lateritic soil falls within a range of 2.60 to 3.40 (Oyelami, 2017). The results of the specific gravity of the soil samples in this study ranged from 2.66 to 2.77 (Table 1) and this has been classified as inorganic soils (Ramamurthy and Sitharam, 2005). These results are in agreement with previous studies by Ademila (2017), Oyelami (2017) and Olofinyo *et al.*, (2019).

Table 1: Specific Gravity of samples A-E

Sample	Borrow Pit	Specific Gravity	Test Conformity
A	Igberiogun Off Navy Medical Sch. Offa	2.77	BS 1377:2 (1990)
B	Federal Poly Offa,	2.66	BS 1377:2 (1990)
C	Igbawere-Ojoku Road,	2.76	BS 1377:2 (1990)
D	Alaya Off Navy Medical Sch. Offa	2.68	BS 1377:2 (1990)
E	Egunkara-Igosun Road, Offa	2.72	BS 1377:2 (1990)

4.2 Natural Moisture Content

The natural moisture content (Table 2) of the selected soil samples were 11.8, 13.8, 14.3, 14.0 and 18.6 for samples A, B, C, D and E, respectively. The natural moisture content of samples A to D, are within the average range of 5 – 15% specified by FMWH (2000) for roads construction. However, sample E does not conform to the specified range. This shows that soils from sample E has high natural moisture content, which is an indication of high water adsorption capability of the soil material. The variation in the natural moisture contents of the lateritic soils (samples A to E) in this study may be influenced by climate, hydrological condition of the area and the topography of the area (Ademila, 2017). The variation in moisture content corresponds to previous findings by Odeyemi *et al.,* (2012), Ademila (2017) and Olofinyo *et al.,* (2019).

Table 2: Natural Moisture Content of samples A-E

Sample	Borrow Pit	Natural Moisture Content (%)
A	Igberiogun Off Navy Medical Sch. Offa	11.8
B	Federal Poly Offa,	13.8
C	Igbawere-Ojoku Road,	14.3
D	Alaya Off Navy Medical Sch. Offa	14.0
E	Egunkara-Igosun Road, Offa	18.6

4.3 Particle Size Distribution

The grain size distribution carried out on the five (5) borrow pits are shown in Figure 2, while the corresponding coefficient of uniformity are shown in Table 3. From Table 3, all the samples from the five (5) borrow pits have values of Cu less than 4.0. Thus, they are all classified as being uniformly graded (ASTM D2487, 2017). Soil samples A, B, C and E had percentage passing No. 200 BS sieve of more than 35% whereas sample D had percentage passing No. 200 BS sieve of less than 35%. The lateritic soil samples D are suitable for subgrade, subbase, and base materials as the percentage by weight finer than No. 200 BS sieve is less than 35% (Amadi *et al.,* 2015; FMWH, 1997). The soils of samples A and B; and C and E, fall under group A-6 and A-7-6, respectively of AASHTO classification suggesting poor road construction material. However, soil of samples D fall under group A-2-7 of AASHTO classification suggesting good road construction material.

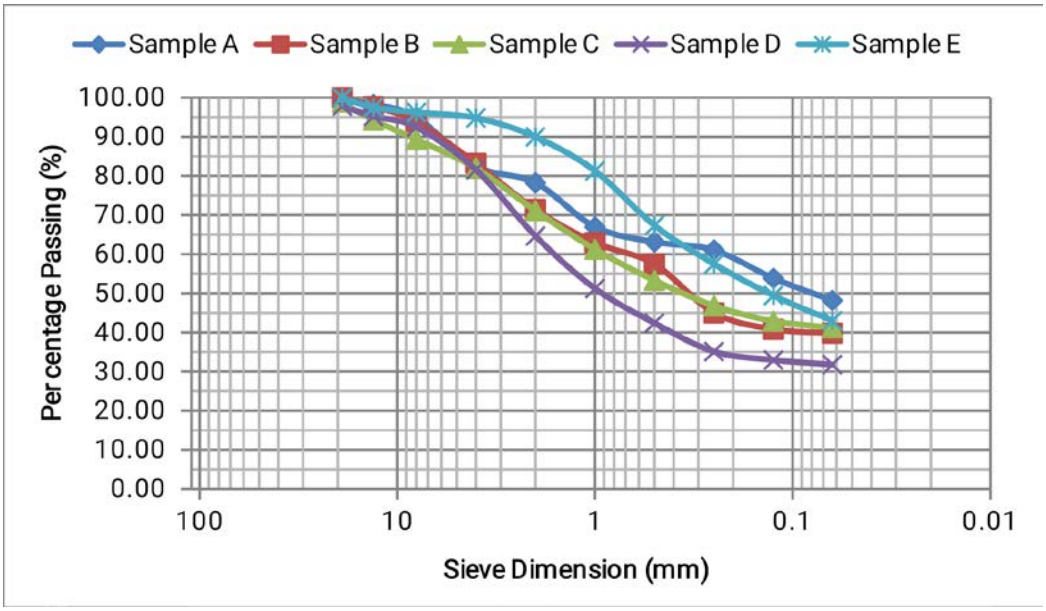

Figure 2: Combined graph for Particle Size Analysis for all Samples

Table 3: Coefficients of Uniformity and Soil Classification

Sample	Borrow Pit	Cu	AASHTO Classification
A	Igberiogun Off Navy Medical Sch. Offa	0.25	A-6
B	Federal Poly Offa,	0.7	A-6
C	Igbawere-Ojoku Road,	1.0	A-7-6
D	Alaya Off Navy Medical Sch. Offa	1.75	A-2-7
E	Egunkara-Igosun Road, Offa	0.3	A-7-6

4.4 Atterberg Limit

Atterberg limits evaluates the settlement and strength characteristics of soils for road construction Olofinyo *et al.*, (2019). The Liquid Limit (LL), Plastic Limit (PL) and Plasticity Index (PI) results of the soils ranged from 36 - 53%, 18 - 22% to 14 - 35%, respectively. FMWH (2000) specification for road works recommend LL of 50% maximum for subgrade, subbase and base materials and maximum PI of 20% for highway subgrade materials. Samples A, B, C, and D are within the maximum standard limit of LL, thereby making them suitable for subgrade, subbase and base materials. While sample E value is above 50% rendering it unsuitable materials. Nonetheless, the PI of samples A, B and D are less than 20% maximum standard limit of PI, thus making them suitable for highway subgrade materials. The combined table and graph were the LL was obtained are as presented in Table 5 and Figure 3, respectively.

Table4: Atterberg limits of Offa Soil

TYPE OF TEST	SAMPLE (A) (IGBERIOGUN) OFFA	SAMPLE (B) (FEDPOFFA) OFFA	SAMPLE (C) (IGBAWERE) OFFA	SAMPLE (D) (ALAYA) OFFA	SAMPLE (E) (EGUNKARA) OFFA
LL (%)	36	38	43	41	53
PL (%)	22	21	20	22	18
PI (%)	14	17	23	19	35

Table 5: Combined Table for Determination of the Plasticity Properties of Material

Sample A		Sample B		Sample C		Sample D		Sample E	
MC	No. of Blows	MC	No. of Blows	MC	No. of Blows	MC	No. of Blows	MC	No. of Blows
43.03	13	43.23	15	49.48	14	48.99	16	60.07	14
36.65	24	36.86	28	43.98	23	39.62	28	56.15	19
32.03	36	34.15	37	39.32	34	34.92	37	50.00	31
29.17	47	32.26	44	37.50	40	32.75	44	44.59	47

MC: Moisture Content

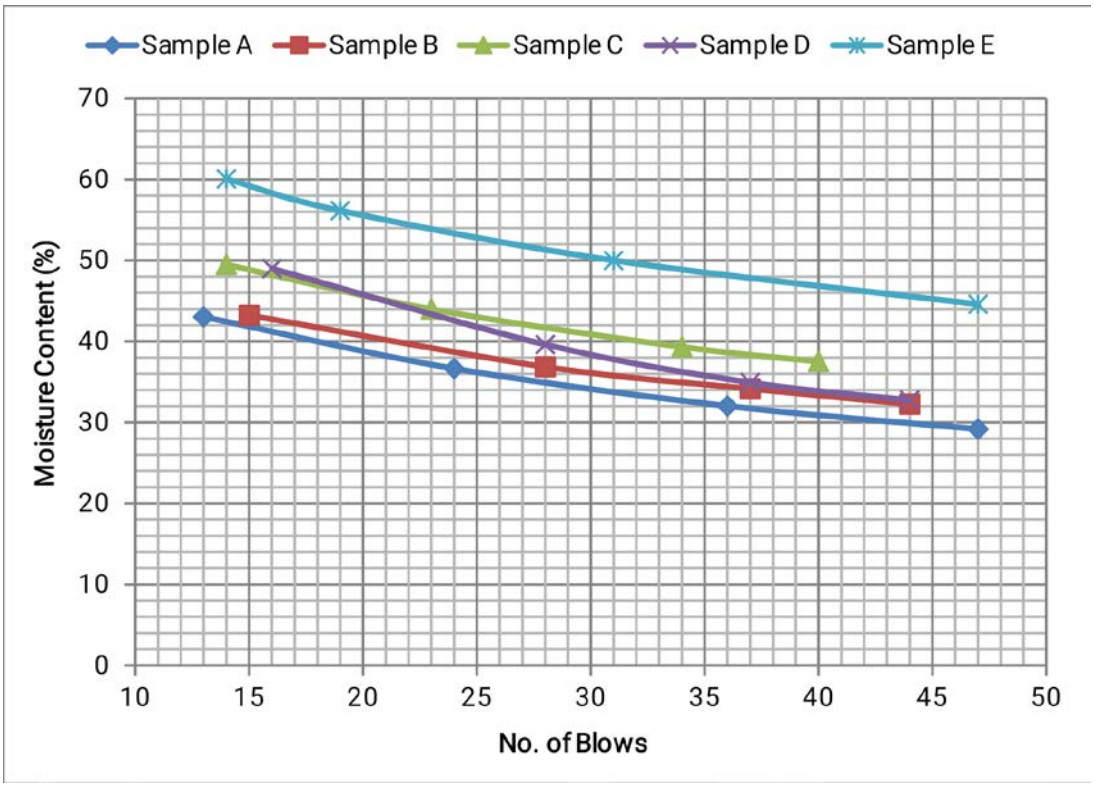

Figure 3: Combined Graph for Determination of the Plasticity Properties of Material

5. Conclusion

The index properties of lateritic soil of selected borrow pits in Offa has been investigated. The results revealed that the ranged of the specific gravity of the soil samples in this study has been classified as inorganic soils. The natural moisture content of samples A to D, are within the average specified limit for road constructions while sample E does not conform to the specified range. This shows that soils from sample E has high natural moisture content, which is an indication of high water adsorption capability of the soil material. The soils of samples A and B; and C and E, fall under group A-6 and A-7-6, respectively of AASHTO classification suggesting poor road construction material. However, soil samples D fall under group A-2-7 of AASHTO classification suggesting good road construction material. Soil samples A, B, C, and D are within the maximum standard limit of LL, thereby making them suitable for subgrade, subbase and base materials. While sample E value is above 50% rendering it unsuitable materials.

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