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SUITABILITY OF AFAKA BORROW PIT FOR SUBGRADE AND BASE MATERIALS

Abimiku J., Pogu J.H. and Bala A. B.

Department of Civil Engineering
Kaduna Polytechnic, Kaduna State
E-mail: ubbe.eggon@yahoo.com, joshpogu@yahoo.co.uk, abdullahibala50@gmail.com

Abstract: The Afaka Mando borrow pit in Kaduna metropolis was investigated for its engineering properties with respect to its suitability as subgrade and base materials in road construction. This was achieved by carrying out laboratory tests on the soil samples for engineering properties such as the natural moisture content, specific gravity, sieve analysis, Atterberg limits, compaction and California bearing ratio. Particle size analysis shows that the percentages passing sieve No 200 range from 0.3 to 0.8%.The liquid limit ranges between 17.31 and 29.2%, plastic limit ranges from 10.56 to 12.43% and the plastic index ranges between 5.6 and 16.77%.The California bearing ratio (unsoaked) ranges from 12.72 to 33.23%. The Specific gravity ranges between 2.37 and 2.4 which is not good, while the maximum dry density ranges between 1.76 and 1.98g/cm^3 with their optimum moisture content ranging from 9.0 to 17.24% while the natural moisture content was 17.25 to 21.38%. From the result, and according to the Federal Ministry of Works and Housing Specifications for roads, this lateritic material can be used for subgrade because the C.B.R. is not less than 10% but cannot be used for base course because the C.B.R. is less than 80%. The result also shows that the lateritic samples are classified as silty or clayey gravel sand (A-2-4).

Keywords: Laterite, Engineering Properties, Subgrade, Base, Roads.

INTRODUCTION

Roads remain the major means of transportation of goods and services in Nigeria, and generally everyone travels by road. This shows how roads are of paramount importance to the Nigerian economy. The development of good road network in Nigeria plays a vital role on the economic growth of the country. Studies conducted by Ighodaro (2009) revealed that good roads clearly contribute to poverty reduction by improving the living conditions of people, augmenting the opportunities available for trade and employment, and helps to build and maintain the society thereby leading to economic growth. The Nigerian government has been implementing deliberate policies targeted towards providing good quality roads all over the country to ensure connectivity to all habitations. These roads come about by planning, `design, construction and maintenance, mostly financed by the government. The construction of any road requires quality control of works by carrying out series of laboratory tests on the construction materials and ensuring good workmanship. Lateritic soils are generally used for road construction in Nigeria. These soils are usually obtained from either other cut sections along the road or from a borrow site where suitable materials that meet the required standard are present. Lateritic soil in its natural state generally have low bearing capacity and low strength due to high content of clay (Ogunribido, 2012). Amu *et al* (2011) noted that in the road construction industry, there is much need for soil materials in the construction of pavements, and when a section of the road is to be filled with soil, the material is either obtained from other cut sections along the road or from a borrow site where suitable material that meets the required standards is present.

Various researchers define laterite in various ways. Bello and Adegoke (2010) defined laterite as products of tropical weathering with red, reddish brown or dark brown colour with or without nodules or concreting and generally (but not exclusively) found below hardened ferruginous crust or hard pan. Quadri *et al* (2012) reported that in this tropical part of the world, lateritic soils are used as road making material and they form the sub grade of most tropical roads. They are used as sub base and bases for low cost roads and these carry low to medium traffic. According to Osuolale *et al* (2012), laterite soil is one of the commonest materials that are widely used in the construction of roads with the subgrade, subbase, and base layers mostly constructed using laterite soil. Omotoso *et al* (2012) stated that engineering properties of soils play a significant role in civil engineering construction works particularly in road construction, foundations, embankments and dams, thereby making the testing of soil for the foundation imperative. The general failure of Nigerian roads within few years or even months after construction is worrisome, considering the huge sum of money spent on the construction of these roads. This situation calls for a more critical and exact examination of the engineering properties of all lateritic materials used in road construction and quality control during all stages of construction. Ogunribido (2012) observed that failures on Nigerian highways are generally due to poor geotechnical properties of the underlying soils which constitute the base or sub grade material for the entire road configuration. Since for different kinds of road work, lateritic soils are widely used as borrow filling materials for the sub grade, the durability of such roads will be ensured by carrying out, laboratory tests on the soil samples to assess their engineering properties and hence suitability for the proposed road work. The aim of this study is to investigate important geotechnical properties of the borrow soil that would reveal the suitability of the materials for use in the construction of subgrade and base.

MATERIALS AND METHODS

The lateritic soil samples used for this study were collected from Afaka borrow pit along Mando road in Kaduna. Three samples were collected from three different locations of the borrow area whose soil strata has been exposed and were labelled A, B and C. They were packaged in air tight polythene bags and taken to the soil and geology laboratory of Civil Engineering Department, Kaduna Polytechnic, Kaduna, for testing to determine their suitability for use as filling materials in road construction.

TESTING PROCEDURES

All the laboratory tests carried out on the soil samples are in accordance with BS 1377 (1990). The tests include: natural moisture content test, particle size distribution test, Atterberg limits tests, compaction test, California bearing ratio (C.B.R.) test, and specific gravity test.

RESULTS AND DISCUSSION

From the laboratory tests and analyses the summary of results obtained are hereby presented as follows;

TABLE 3.1.: NATURAL MOISTURE CONTENT (NMC)

Sample No.	NMC Value %	Average %
A	20.90	19.5
B	21.38	
C	17.25	

TABLE 3.2.: SPECIFIC GRAVITY (GS)

Sample No	Specific Gravity, Gs	Average
A	2.41	2.4
B	2.37	
C	2.38	

TABLE 3.3.: ATTERBERG LIMITS

Sample No	Liquid Limit %	Plastic Limit %	Plasticity Index %	Shrinkage Limit %
A	29.2	12.43	16.77	5.0
B	17.31	11.71	5.60	8.0
C	21.0	10.56	10.44	4.0
Average	22.5	11.57	10.94	5.67

TABLE 3.4.: PARTICLE SIZE DISTRIBUTION (TOTAL PERCENTAGE PASSING)

B.S Sieve	Sample A	Sample B	Sample C	Average %
7	21.43	33.48	20.47	25.13
10	15.17	23.47	16.18	18.27
14	11.71	17.61	12.82	14.05
18	9.41	13.27	10.43	11.04
25	7.05	9.97	8.50	8.51
36	5.74	7.36	6.74	7.61
52	4.53	5.41	5.63	5.19
60	3.90	4.32	4.50	4.24
100	2.36	2.93	3.97	3.09
150	0.94	1.68	0.98	1.2
200	0.00	0.80	0.30	0.37

TABLE 3.5.: COMPACTION TEST

Sample No.	MDD(g/cm3)	OMC (%)
A	1.98	12.51
B	1.76	17.24
C	1.76	9.00
Average	1.83	12.92

TABLE 3.6.: CALIFORNIA BEARING RATIO (CBR)

Sample No.	Top at 2.5mm	Top at 5.0mm	Bottom at 2.5mm	Bottom at 5.0mm	C B R value %	Average %
A	14.11	19.11	16.67	16.56	33.23	
B	5.71	7.05	6.38	6.30	12.72	
C	7.73	11.41	11.38	13.51	21.99	22.65

TABLE 3.7.: SOIL CLASSIFICATION (AASHTO)

Sample No	Liquid Limit %	Plastic Limit %	Plastic Index	% Passing Sieve 200	Classification
A	29.2	12.43	16.77	0.00	A-2-6 Granular material silty or clayey granular sand excellent to good
B	17.31	11.71	5.6	0.80	A-2-4 Granular material silty or clayey gravel sand excellent to good
C	21.00	13.24	7.76	0.3	A-2-4 Granular material silty or clayey gravel and sand excellent to good

TABLE 3.8.: SUMMARY OF TESTS RESULTS

Sample No	AASHTO Classification	NMC %	Gs g/cm³	MDD g/cm³	OMC %	CBR %	% Sieve Analysis Passing sieve 200	L.L %	P.L %	P.I
A	A-2-6	20.9	2.4	1.98	12.51	33.23	0.00	29.2	12.43	16.77
B	A-2-4	21.38	2.37	1.76	17.24	12.72	0.8	17.31	11.71	5.60
C	A-2-4	17.25	2.38	1.76	9.00	21.99	0.30	21.0	10.56	10.44
Average		19.5	2.4	1.83	12.92	22.65	0.37	22.5	11.57	10.94

DISCUSSIONS

Natural Moisture content

The natural moisture content of the soil sample was computed to be 19.5%

Specific Gravity Test

The specific gravity of samples A, B, and C are 2.4, 2.37 and 2.38 respectively with an average of 2.4. According to the specification, a good lateritic soil should have specific gravity ranging from 2.5 to 2.75. The values obtained for this test fall below specification, and thus, not suitable for use as sub grade and base material.

Particle Size analysis

From the result, the percentage passing sieve 200 ranges from 0 to 0.8% with an average of 0.37% which implies that the studied soil samples are classified as silty or clayey sand. The Federal Ministry of Works and Housing (F.M.W &H) clause 6201 specifies that for a soil sample to be used as both subgrade fill and base material, the percentage by weight passing No.200 sieve shall be less than but not greater than 35%.. This result indicates that the lateritic material is suitable as subgrade and base fill since the percentage passing sieve 200 is not greater than 35%.

Atterberg Limits Test

The liquid limit values range from 17.31 to 29.2% with an average of 22.5%, the Plastic limit values are between 10.56 and 12.43%, averaging 11.57%.The Plastic index ranges from 5.6 to 16.77%, having an average of 10.94%. The Federal Ministry of Works and housing Vol.II (1994) for roads and bridges stipulates liquid limits of 80% maximum for subgrade and 35% maximum for base materials. It also recommends Plastic index of 55% maximum for subgrade and 12% maximum for base materials. These results fall within specification, thereby making the soil samples suitable for use as subgrade and base materials.

Compaction Test

The maximum dry density for the soil samples varies from 1.76 to 1.98g/cm^3 and having an average of 1.83g/cm^3 while the optimum moisture content ranges between 9.0 and 17.24% with an average of 12.92%. This result indicates that the lateritic soil is sandy silt and has affinity to absorb more water and swell on drying which is not good for road subgrade and base.

California Bearing Ratio Test

The California bearing ratio values for the unsoaked soil samples range between 12.72 and 33.23% with an average of 22.65%. From the results, the lateritic material can be used for subgrade but cannot be used as base course. This is because the Federal Ministry of Works and Housing Specification for Roads recommends that the CBR values (unsoaked) for subgrade and base courses should not be less than 10% and 80% respectively.

CONCLUSION

The engineering properties of Afaka Mando borrow material has been investigated for its suitability in road construction. Following the investigation, the following conclusion can be made:

(a) The lateritic soil sample has its specific gravity to be 2.4 which is lower than the specification of 2.5.

(b) The lateritic is suitable as sub grade and based fill since the percentage passing sieve 200 is not greater than 35%.

(c) The Atterberg limit test result fall between specification thereby making the soil sample suitable for use as sub grade and base material.
(d) The California bearing ratio values for the unsoaked soil sample fall between 12.72 and 33.23%, indicating that lateritic material can be used for sub grade but cannot be based course.

RECOMMENDATION

Based on the test carried out during this study, the following recommendations are made:

- Laboratory test should be carried out on borrow pit materials that are intended to be used for road construction in order to know their suitability for the proposed work.

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Biographical Note

Pogu Joshua Hirpaya was born on 8th march, 1977 in Chibong local government of Borno state in Nigeria. He holds Bachelor of Engineering (B.Eng) in Civil Engineering from University of Maiduguri, Nigeria. He has been working with Kaduna Polytechnic since 2008 to date as a Lecturer in the Civil Engineering Department. He has co-authored several research papers.

Engr. Bala, Abdullahi Balarabe was born on 15th April, 1966 in Kaduna North of Kaduna state. He holds Higher National Diploma in Soil and Water from Kaduna Polytechnic and Bachelor of Engineering (B.Eng) in Civil Engineering from Bayero University Kano(BUK). He worked with the Department of Engineering Services, Logistics and Design Unit, of the Federal Capital Development Authority (FCDA), Abuja for eight years and joined the Department of Civil Engineering Kaduna Polytechnic as a lecturer since 2000 to date. He is a COREN registered engineer and has been practicing in the field of civil engineering.

Engr. Abimiku Joshua was born on 12th July, 1960 in Nasarawa Eggon Local government of Nasarawa State of Nigeria. He holds bachelor degree (B.ENG) in Civil Engineering from Ahmadu Bello University Zaria (ABU) . he worked with P&P Construction Company for six years and joined the Department of Civil Engineering Kaduna Polytechnic as a Lecturer since 1995. He is an NSE and COREN registered engineering and has practicing in the field of civil engineering.