Investigation of Geotechnical properties of lateritic soil from Iwo road located in Ibadan, Oyo State, Southwestern Nigeria.

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Abstract: Laterite is a highly weathered material, rich in secondary oxide of iron, aluminum or both. This study reports an investigation of lateritic soils on the geotechnical properties. Test such as Sieve analysis, Atterberg limit, Compaction, California Bearing Ratio for the soil was conducted for the sample collected. The sample soil were collected at 0.25m deep at different locations in Iwo road area of Ibadan Oyo State. All analysis were carried out in accordance with the British standard. The liquid limit ranged from 18.1% to 55%, plastic limit ranged from 10.3% to 28.57% while plasticity index is of the order of 5.3% to 28.85%. The maximum dry density (MDD) ranged from 1.71mg/m^3 to 2.32mg/m^3 while the optimum moisture content (OMC) varied from 7.1% to 21.2%. The unsoaked California bearing ratio values (CBR) ranged from 0.69% to 35%. The evaluation reveals that the lateritic soils present throughout the study areas is suitable for use as subgrade, subbase and base materials since the geotechnical properties are fairly within the regulatory standards of Nigeria.

Keywords; Laterite, California bearing ratio, Compaction, Subbase, Subgrade.

1.0 INTRODUCTION

Lateritic soils have wider applications in the Nigeria construction industry, especially in road construction where they are used as sub-grade, sub-base and base materials. One of the major causes of road accident is bad road which is usually caused by wrong application of constructional materials especially laterite as base and sub – base materials by construction companies [9], [7]. Lateritic soils are highly weathered and altered residual soils formed by the in – situ weathering and decomposition of rocks in the tropical and sub – tropical regions with hot, humid climatic conditions. For a material to be used as either a base or sub base course depends on it strength in transmitting the axle – load to the sub soil or sub grade.

The mineralogical composition of the lateritic soil has an influence on the geotechnical parameters such as specific gravity, shear strength, swelling potentials, atterberg limit and bearing capacity.[1].

Laterite are rich in iron oxides, aluminum oxides and low silicates but many contain appreciable amounts of kaolinite and due to the present of iron oxides; lateritic soils are red in colour [2]. Omotoso [10] worked on laterite soils in connection with construction of road, highways and airfields. Considerable studies have been carried out on the geotechnical properties of laterite soil by various researchers [12], Amadi et al, 2015.

Laterite may occur as surface deposits of unhardened clayey soils, gravels and as hard span [5]. Hence, there are no available data on the geotechnical and engineering properties of lateritic soil in the study area, therefore, the aim of this investigation is to obtain geotechnical characteristics of lateritic soil in the study area to assess it suitability for road constructions, engineer's planners, designers and contractor.

2.0 LOCATION AND GEOLOGY OF THE STUDY AREA

The soil samples used in this study were obtained from Iwo road area of Ibadan, Oyo State Nigeria within latitudes $7^0\ 26^I 10^I$ and $7^0\ 26^I 30^{II}$ N and longitude $30^0\ 51^I 20^I$ and $3^0\ 51^I 50^{II}$E, using the method of disturbed sampling.

Geology of Ibadan and environs, including the study area, falls within the pre – Cambrian rocks of southwestern Nigeria. The major rock types are schist – quartzite's, granite – gneiss, and migmatites.[6], while minor rock types such as pegmatite, apilite, quartz vain and dolerite dykes. The study area is typified by banded and migmatite gneiss which generally strikes NW – SE and dip to the east. The migmatite – gneiss complex comprises of biotite and biotite gneiss and quart schist [11].

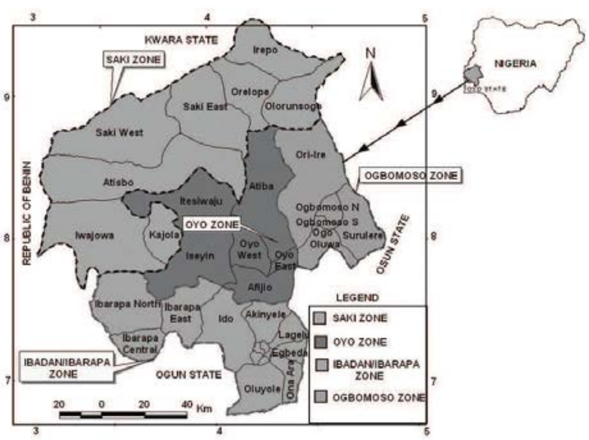

Fig.1: Map of Oyo State showing the study area.

3.0 METHODOLOGY

Samples collected were prepared in accordance with BS1377 of 1990 the materials were air –dried and broken into smaller fragments, care being taken not to reduce the sizes of the individual particles. The materials used during the collection of the samples were sample bags, global positioning system (GPS), masking tape for labeling.

Test procedures ; the following tests were carry out (i) Sieve analysis (ii) Atterberg limit (iii) compaction (iv) California bearing ratio on each of the disturbed samples.

(i) Sieve analysis ; 400g sample was used for the test after washing the sample with sieve BS 200 and the fraction retained on the sieve was air dried and used for the sieve analysis. The sieving was done by mechanical method using an automatic shakers and a set of sieves.

(ii) Atterberg limit; soil sample passing through 425µm sieve, weighing 200g was mixed with distilled water to form a thick homogeneous paste. The paste was collected inside the casangrade's apparatus cup with a grove created and the number of blows to close it was recorded. Also moisture contents were determined. The plastic limit was determined by rolling the sample to form a ball, the ball was rolled on a glass plate until the thread cracks at approximately 3mm diameter, the sample was place in the oven at 105^{0}C to determine the plastic.

(iii) Compaction and specific gravity test; the determination of compaction and specific gravity test followed the standard as outline in BS1377 of 1990.

(iv) California bearing ratio; a portion of air – dried soil sample was mixed with about 5% of its weight water. This was put in CBR mould in 3layers with each layer compacted with 56 blows using 2.5kg hammer at drop of 450mm (standard proctor test). The compacted soil and mould was weighed and place under CBR machine and a seating load of approximately 4.5kg were applied. Load was recorded at penetration of 0.625, 1.9, 2.25, 6.25, 7.5, 10.0 and 12.5m.

4.0 Result and Discussion

The results of the laboratory analysis are summarized in table 1. According to[4], the lateritic soil samples are suitable for subgrade, sub base and base materials as the percentage by weight finer than sieve 200 BS test is less than 35% except location 2, 3, 4, 5, 10 and 11(figure 2). The liquid limit value ranged from 18.1 to 55% while the plastic limit value varies from 10.3 to 28.57% and plasticity index from 5.3 to 28.85% (table 1).[4] recommend liquid limit of 50% maximum for sub base and base materials. All the soil samples fall within this specification, thus making them suitable for subgrade, sub base and base materials except samples 4 and 12. The plot of liquid limit, plastic and plasticity index against the samples is shown in (figure 3).

The maximum dry density for the soil samples ranged between 1.71 mg/m^3 and 2.32 mg/m^3while that of optimum moisture content ranged between 7.1% and 21.2% according to [8] the range of value that may be anticipated when using the standard proctor test methods are : for clay, maximum dry density(MDD) may fall before 1.44 mg/m^3 and 1.685 mg/m^3 and optimum moisture content(OMC) may fall between 20 – 30%, for silty clay (MDD) is usually between 1.6 mg/ m^3 and 1.845

mg/m^3 and (OMC) range between 15% to 25%; for 1.76 mg/m^3 and 2.165 mg/m^3 and OMC between 8 and 15%. Therefore, base on the samples result, it could be noticed that they are sandy clay except sample 2 and 4 which are silty clay.

The moisture content from the compaction test is ranged from 7.1% to 18.5% with an average value of 12.8% (table1 and figure 4) indicating that the soil is generally poorly graded and sandy clay with other determined geotechnical parameters, thus making the soil samples suitable for subgrade, subbase and base materials.

The unsoaked California bearing ratio value for the lateritic soil sample range from 0.69% to 35%, the plot of CBR value against sample soil is shown in (figure 5). Federal ministry of works and housing recommendations for uses as subgrade, subbase and base materials are ; ≤ 10% ≤ 30% and ≤ 80% respectively for unsoaked soil. This indicating that sample soil 2, 3, 4, 5, 6 with value less than 10% are excellent subgrade materials, all location having value less than 30% and 80% are good materials for subbase. Thus, all the location have their unsoaked CBR value less than 80% which is the maximum value recommended for soil to be used as base ma terials. (Federal ministry of works and housing, 1997).Therefore, the lateritic sample soils are suitable materials for subgrade, subbase and base materials.

Table 1. Summary of Laboratory Results

Sample Number	Depth of Sample	Particle Size Analysis	Compaction Test		Atterberg Limit			Unsoaked CBR
		% Passing	OMC %	MDD mg/m2	LL	PL	PI	
1	0.25	22.5	9.26	2.32	24	14.81	9.19	15.31
2	0.25	48.87	16	1.84	47.1	25.81	21.31	5.23
3	0.25	54.25	11.4	2.02	26.4	20.5	5.9	5.38
4	0.25	74.5	21.2	1.71	55	28.57	26.43	5.77
5	0.25	41.6	12	2.07	20	11.32	8.68	0.69
6	0.25	30.5	10	2.1	22	14	8	1.43
7	0.25	30.2	11	2.11	35	16.4	18.6	23.39
8	0.25	11.5	7.1	2	18.1	10.3	7.8	35.05
9	0.25	26.7	14.1	2.01	35	26	9	30.63
10	0.25	38.5	12.2	2.14	44.3	15.5	28.8	10.06
11	0.25	51.2	18.5	2.18	24.3	19	5.3	22.52
12	0.25	34.5	12.1	1.9	54	27.4	26.6	34.17

ISSN 2229-5518

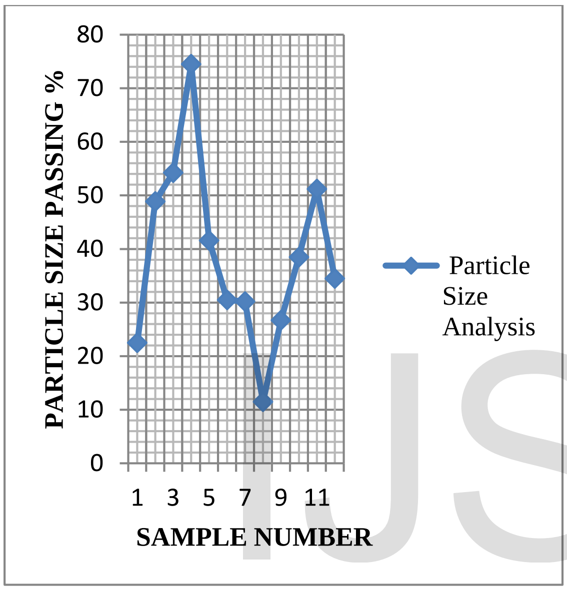

Fig. 2. Graphical display of particle size percentage passing

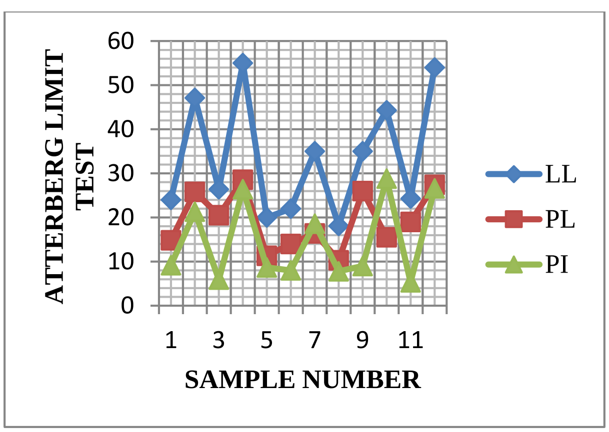

Fig. 3. Graph of Atterberg Llimit test for all samples.

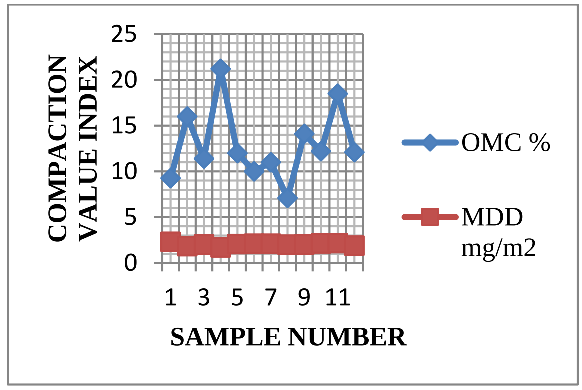

Fig.4. Graph of Compaction Values Index

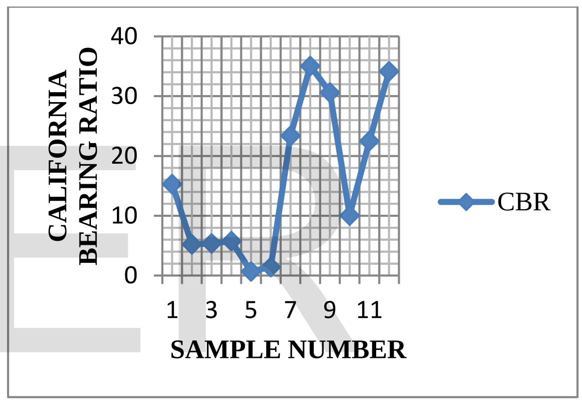

Fig. 5. Graph of California Bearing Ratio

5.0 Conclusion

Geotechnical properties of laterite from Iwo road area of Ibadan Oyo State southwestern Nigeria has been carried out in compliance with BS 1377 and Nigeria federal ministry of work and housing for read construction (1977). The result showed that the studies soil samples are classified as clay, silty clay and sandy clay easily compactable with good drainage. The soil sample test from the study area indicate a general cohesive nature with low moisture content, high granular materials which is suitable for road construction. The data obtained from geotechnical investigation can be useful for civil engineers in the design and construction of road and utilization of laterite in Iwo road and environs for maximum durability and efficiency.

REFERENCE

[1] Amadi A.N, Eze, C.J., Igwe, C.O., Okunola I.A and Okoye, N.O (2012). Architect's and Geologist's view on the causes of building failures in Nigeria. Modern Applied Science, 6(6), 31-38.

[2] Amu, O. and Adetuberu, A. (2010). Characteristics of bamboo leaf as stabilization on lateritics soil in highway construction. International journal of engineering technology. 2(4). 212-219.

[3] British Standard. BS 1377 -3 : 1990 methods of test for soils for civil engineering purposes.

[4] Federal ministry of work and housing (1997). General specification for road and bidges, volume II, Federal highway Department, FMWH; Lagos, Nigeria,317p.

[5] Fookes, G. (1997) :Tropical residual soil, A geotechnical society engineering group working party revised report, pp21-33. Publ. Geol. Soc., London, Tulsa, New south Australia, Delhi, Tokyo.

[6] Jones, H.A and Hockey, R.D. (1964); The geology of the part of southwestern Nigeria.

[7] Nwankwoala, H.O, Amadi, A.N, Vshie, F.A and Warmate, T. (2014). Determination of Subsurface Geotechnical Properties for Foundation Design and Construction in Akenfa community, Bayelsa State, Nigeria. Americal Journal of Civil engineering and Architecture, 2(4), 130 – 135.

[8] O'Flaherty, C.A.(1988) Highway Engineering volume 2, Edward Anold publishers, London UK.

[9] Oke, S.A; Amadi, A.N, Alacaka A.E, Nwosu, J. and Ajibade, S.A (2009). Index and compaction properties of laterite deposites for road construction in Minna area, Nigeria. Nigeria Journal of construction Technology and Management, 10(1&2), 28:35.

[10] Omotoso (2010). An inverstigation into the geotechnical and engineering properties of some lateritics of Eastern Nigeria. Journal of Nigeria Mining Geology and Metallurgical Socienty; 1:10-110.

[11] Oluwafemi, O. (2012). Electrical resistivity imaging survey for shallow site investigation at university of Ibadan Campus Southwestern Nigeria. ARPN journal of Engineering and Applied Science. 7(2) : 187 – 196.

[12] Ojo, G.P; Igbokwe, U.G; Nwozor, K.K and Egbuachor, C.J.(2016). Geotechnical properties of lateritics overburden materials on the charnockite and gneiss complexes in Ipele – Owo area, Southwestern Nigeria. American journal of engineering research (AJER) vol. 5, issue 9, pp53-59.