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Properties of lateriticsoilat Lader in Borrow pit for road pavement construction in Abeokuta, Ogun State, Nigeria.

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ABSTRACT
This paper examined the engineeringproperties of lateritic soil used for roads and buildings construction at Oke-Ilewo, Abeokuta, Ogun State. The studies investigated the sub-surface condition of a soil along and at the borrow pit to determine the suitability of the available material for pavement and foundation structure construction. Tests carried out on the samples include the Atterberg limit, sieve analysis, compaction, and California Bearing Ratio (CBR). All the laboratory tests were carried out in accordance with the requirement of relevant British Standard (BS) and American Association of State HighwayTransportation Official(AASHTO) specification. The result of the tested materials showed the classification characteristics, liquid limit (LL) of 35%, average plastic limit (PL) of 24% and average plasticity index(PI) of 7%, the average moisture content of the sample was 30.8%, the compaction characteristics of the soil was 12.5% optimum moisture content (OMC) and 1.87 g/cm^3 maximum dry density (MDD), the california bearing ratio (CBR) value of the soil was 17.2% and which is fair for sub-grade construction as prescribed by general rating of soil material.Results drawn from the tested materials revealed the materials as A – 2 – 6 based on the (AASHTO) specifications, silt and sandy soil in nature. It was concluded that the sample is suitable materials for pavement and foundation structure construction.

Keywords: Lateritic soil, Tests - LL, PL, PI, OMC, MDD, CBR

I. INTRODUCTION

Lateritic soils are used in the Nigeria construction industry, especially in road construction where they are used as sub-grade, sub-base and base materials. According to Ologun et al., (2019) one of the major causes of road failure is bad pavement structure caused by application of poor constructional materials especially laterite as base and sub – base materials by construction companies. The geotechnical properties of lateritic soil is important for highway engineers, to enable them identify, classify soil, measure its strength, evaluate its drainage properties and help in processing the soil as a highway material (Ojo et al., (2016)). This is an investigation that helps to describe the sub-surface condition of a soil in a location to determine the suitability of the available material for pavement structure construction. The sample obtained from the location contains; mineral and organic particles, moisture and air.The engineers must make certain assumptions regarding the properties of soil. Amadi et al., (2012) reported that the assessment of the accuracy of soil parameter, whether they are determined in the laboratory, on the field or are assumed by the engineers must have a good grasp of the basic principle of soil mechanics. At the same times, they must realize that natural soil deposits on which foundation are constructed are not homogenous in most cases. Thus, the engineers must have a thorough understanding of condition. Foundation engineering is a clever combination of soil mechanics, engineering geology of the area, i.e the origin, nature of soil stratification and also the ground water geology and proper judgment derived from past experience (NPTEL (2012)). The lateritic soils are found in the tropical environment where there is an intense chemical weathering and leaching of soluble minerals. According to Brainy encyclopaedia (2005), laterites are reddish brown, well graded and found almost everywhere in the

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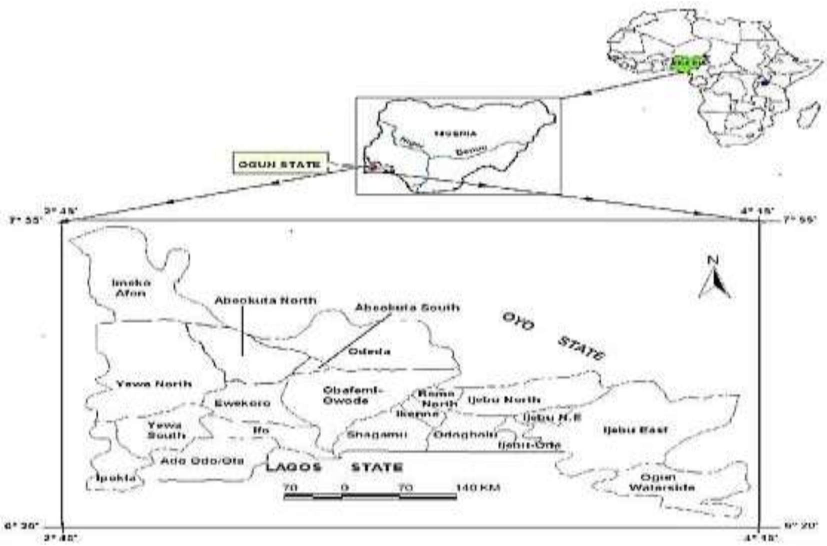
tropics, with wide application in the construction industries. This paper investigated the engineering properties of lateritic soil used for roads and buildings construction. Laboratory tests carried out on the samples include the Atterberg limit, soil classification, compaction and California bearing ratio (CBR). The work examined the sub-surface condition of the soil along and at the location to determine the suitability andavailability of the material for pavement structure construction.

II. DESCRIPTION OF THE STUDY AREA

The study area is located in the Abeokuta south local government area of Ogun State; situated in the southwest of Nigeria. It covers an approximate area of about 71km (27sq ml). It lies between latitude 7^0 09' 00" N and 7^0 15' 00" N and longitudes 3^0 21' 00" E and 3^0 26' 00" E. The study location can be reached by going along Babangida boulevard road and MoshoodAbiola express road all in Abeokuta south local government bounded by Abeokuta North, Odeda and ObafemiOwode local government respectively.

The geology in the western upland where Abeokuta South Local government is situated is underlay by rocks of the basement complex which forms a part of the African crystalline shield.

The basement is composed predominantly of folded gneises, schists and quartzite of the precambrian age to which have been emplaced by c harnockitic rocks from older granite by extrusion and replacement (Bello and Oriaje (2019)).



Source: https://www.researchgate.net
Fig 1: Google map showing the study area.

III. METHODOLOGY

The soil sampleusedfor thisstudywas collected andbrought from Laderin borrow pit used atOkeilewo site. The disturbed samplewasairdriedbefore testinginthelaboratory fortheengineeringpropertiestests.

Methodoftest

Preliminary classificationtests wereperformedonthe soilinaccordancewithFMW&H&BS1377P art 1 (1990). (i) Sieve Analysis (ii) Atterberg limit (iii) Moisture Content (iv) Compaction (v) California bearing ratio on the disturbed samples

(i) Sieve analysis:The grainsize distributionof soilsamplewasdeterminedby passingthrough astackofsieveofdressedmeshopening sizeand bymeasuringtheweight retainedon each sieve. The analysiswasperformed indryconditions.

(ii) Atterberg limit: This is the combination of Liquid limit, plastic limit and plasticity index.

(a) Liquid Limit:This isexpressedintermsofwater content asapercentage.Soil sample waspassedthrough 425 µmsieve weighing200 gramsmixedwithwatertoformathickhomogenous paste putinsidethecasangrade'sapparatuscupwithagro ovecreatedandthenumber ofblowstocloseit wasrecorded.Also,moisturecontentsweredetermi

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ned.

(b) Plastic Limit: This representsthemoisturecontent atwhichsoilchangefromplastictobrittle state.Itistheupperstrengthlimitofconsistency.Soil sampleweighting200 grams wastaken fromthematerial passingthe425 µmtestsieveandthen mixedwithwatertillit becamehomogenousand plastictobeshapedtoball.Thesimplemethod for plastic limittestis byrollingathread ofsoil onaglass plateuntilit crumblesatadiameterof3 mm.

(c) Plasticity Index**:** This is defined as a range of water content where the soil is plastic. Therefore, it is numerically equal to the difference between the liquid limit (LL) and the plastic limit (PL)i.e. (LL - PL).

(iii) Moisture Content:This is defined as the mass of water divided by the mass of soil solids or the ratio of the mass of water to the mass of soil. Mathematically it is given as

$$M_c = \frac{M_W}{M_S} \times 100 \quad \text{.............................. (1)}$$

M_c = moisture content, M_w = Mass of water and Ms = Mass of solid. This method is based on removing soil moisture by oven-drying a soil sample until the weight remains constant.

(v) Compaction: This was carried out to determine the optimum moisture content (OMC) and maximum dry density (MDD). The process involves the removing the air from the air voids.

(vi) California bearing ratio(CBR): This is carried out to estimate the CBR% of the soil used in subgrade and base course using the California bearing ratio (CBR) machine. The CBR% is a strength–based method of pavement design which uses the load deformation characteristics of the roadbed soil, aggregate, sub-base and base materials and an empirical design chart to determine the thickness of the pavement, base and other layers. The value can be used and in design of the base and the sub-base material for pavement.

IV. RESULT AND DISCUSSION

Sieve Analysis

The result of sieve analysis carried out on the soil sample shown below, Table 1 and fig. 2. The reddish-brown lateritic soil result showed that the soil is sandy silt clay. The result indicates the percentage passing through different sieve sizes. Percentage passing sieve number 200 (75 µm) is 4.3% being the least of the sieve sized used. According to AASHTO,specification requirement, for a sample to be used as both subgrade fill and base, the percentage by weight passing No.200 sieve (75 µm) shall be less than but not greater than 35%. Sequel to the above, the samples under review were good samples because percentages by weight passing sieve No.200 for both soils do not exceed 35% requirement.

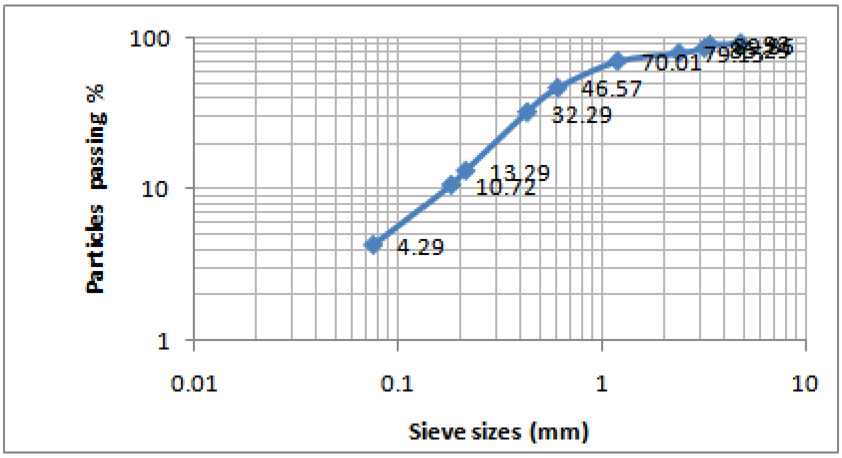

Fig. 2: Particle size distribution curve

Table 1:Summary ofLaboratory Results

Sample No.	Sieve Analysis		Compaction Test		Atterberg Limit %			CBR %
	Sieve Opening	Percentage Passing %	Moisture Content	MDD g/cm^3	LL	PL	PI	

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	(mm)		%					
1.	4.75	92.0	5	1.49	38.5	33.3	5.2	
2.	3.35	89.9	10	1.79	36.4	27.2	9.2	
3.	3.15	85.3	15	1.79	33.3	20.0	13.3	17.2
4.	2.36	79.2	20	1.68	15.0	14.3	0.7	
5.	1.18	70.0						
6.	0.600	46.6						
7.	0.425	32.3						
8.	0.212	13.3						
9.	0.180	10.7						
10.	0.075	4.3						

Table 2:Consistency limit

Number of bumps	18	23	28	34
Moisture content, w = $\frac{m2-m3}{m3-m1}$ x 100%	38.46	36.37	33.33	15.0

Atterberg limit test

The consistency limit result Table 1, 2showed the liquid limitfig. 3 measured at 25 bumps count, plastic limit and plasticity index results. The value for liquid limit is 35%, plastic limit 24% and the plasticity index 7%. The plastic limit against liquid limit on the plasticity index chart showed the Atterberg limits was a zone of the granular material (35% or less passing number 200 sieve) is of excellent silt and sandy soil. According to FMW&H, the sample are fit to be used in roads and buildings construction since both liquid limits and plastic limits value are within the stipulated value as shown in the group classification of "A - 2 - 6". Therefore, the soil sample is suitable for the construction of road structures.

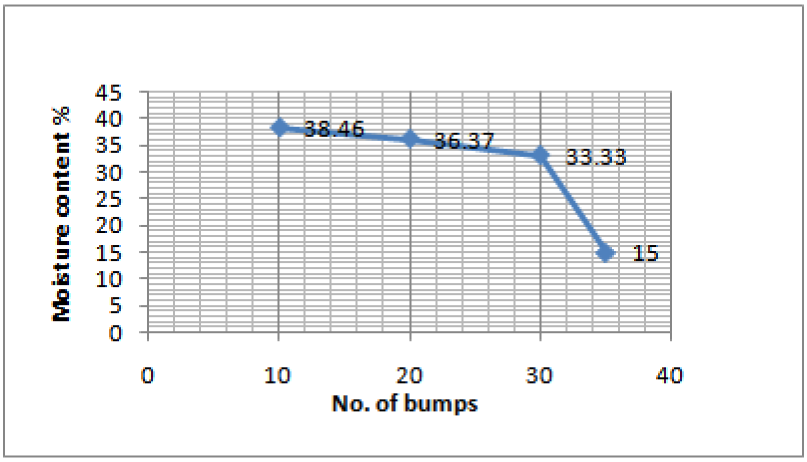

Fig. 3: Liquid limit test curve

Moisture Content

Theresultofmoisturecontent testonthesoilsamplewasshowninTable 2 and fig. 3,fourtests werecarried outonthesoilsamples,themoisturecontentwas determined inpercentageswith averagemoisturecontentof 30.8%.

Compaction

The result of compaction test Table 1 and fig. 4at 5%, 10%, 15% and 20% of water addition, the moisture content was6.35%, 9.21%, 12.17% and 13.24% respectively. The dry density also increases from 1.49 g/cm^3 to 1.79 g/cm^3 respectively and later dropped to 1.68 g/cm^3. The graph of the compaction in figure 4 showed that there is an increment in the maximum density (MDD) of 1.87 g/cm^3 and optimum moisture content stands at 12.5%.

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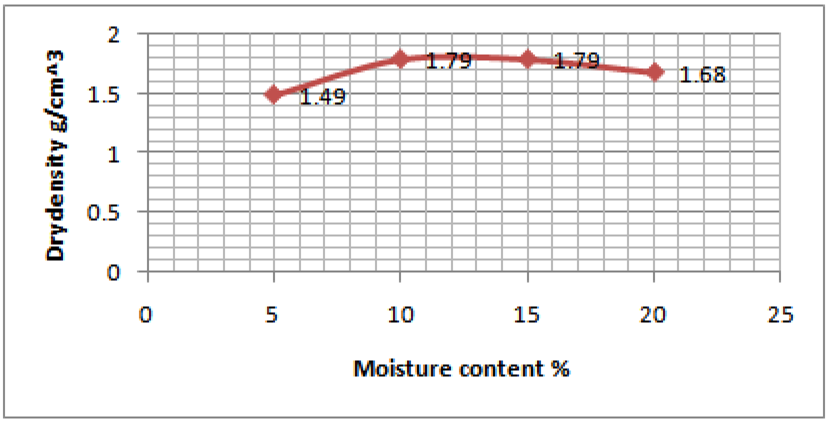

Fig. 4: Compaction test curve

California bearing ratio (CBR)

The result of California bearing ratio Table 1 and fig. 5. The CBR values of the tested soil are 17.2% for CBR at 2.5 mm penetration and 12.4% for CBR at 5.0 mm penetration. The higher of the two was 17.2% which represent the CBR value of the soil. The trend at which the CBR value increases was shown in fig.5, the increment in the CBR value makes it suitable for road pavement and other purpose.

According to AASHTO, classification system is based on the following three soil properties i.e sieve analysis, Liquid limit and Plasticity index. Since the soil classification belongs to A – 2 – 6 (Granular materials 35% or less passing No. 200) the group index would be calculated as shown below;

GI = 0.01(F200 - 15) (PI - 10)

GI = 0.01(4.29 - 15) (7 - 10) GI = -0.3213

According to Murthy (2007), when the combined partial Group indices are negative, the Group index should be reported as “Zero”

Therefore, GI = 0

The general rating of soil material using CBR values is classified according to Bowles (1990) as a fair material and can be used for sub-grade since thesampleliesbetweenthevaluesof7—20.

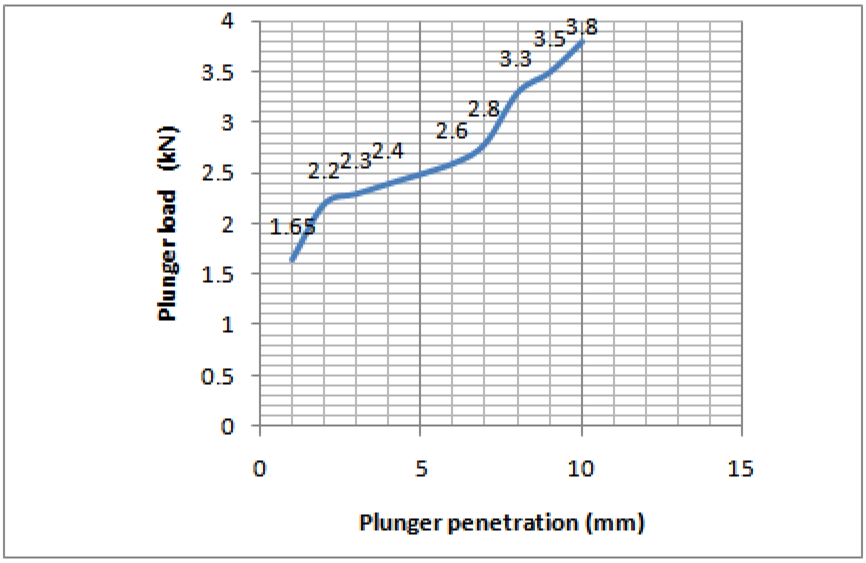

Fig. 5: CBR test curve

V. CONCLUSION AND RECOMMENDATION.

Conclusion

A comprehensive investigation into geotechnical engineering properties of laterites used at Oke-Ilewo Abeokuta had been carried out based on the results of the study, the following conclusions are drawn:

- The sample are sandy silt clay in nature following the results of sieve analyses
- The subgrade sample fall within categories A -

2 - 6 according to AASHTO system classification. This classification revealed the rating of the subgrade and base as good to be used for construction.

- The material tested, percentage passing sieve no. 200 was 4.3%, the liquid limit of 35% and plasticity index value 7% which are still within the stipulated minimum value of 35% and 7% respectively.
- The subgrade samples are suitable as highway construction materials since their percentages passing sieve no. 200 i.e., liquid limits, plasticity index values are not greater than 35%, 50%, and 30% respectively as stated in federal ministry of works and housing (F.M.W. & H.) specification requirements.
- The compaction graph showed the optimum moisture content (OMC) of 12.5% while the maximum dry density (MDD) is 1.87 g/cm^3.
- The CBR value of the tested soil sample was 17.2%; this can be categorized as fair subgrade material based on the general rating of soil material.

Recommendation

It is recommended that the materials be used for construction of pavement sub-structures.

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