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Technical Note: GEOTECHNICAL EXAMINATION OF THE GEOPHYSICAL PROPERTIES OF OLOKORO BORROW SITE LATERITIC SOIL FOR ROAD WORKS

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Abstract

This present work was carried out to determine the geotechnical properties of Olokoro lateritic soil. Tests were carried out on the sample soil which includes the Atterberg limit tests, particle size distribution analysis; sedimentation test, compaction test using the West African standard and California Bearing Ratio (CBR) test as specified by the Nigerian General specification (1997). The liquid limit, plastic limit and plasticity index were found to fall into A-2-7 soil of AASTO classification and SP group of Unified Classification. The compaction characteristics of the soil were found to be 1.90mg/m^3 and 14.76% for maximum dry density and optimum moisture content respectively on West African Standard. The CBR value was found to be 26%. It was recommended that the soil is good as a filling material in road subgrade and other construction works and require modification to improve its properties for sub-base and road base material.

Keywords: olokoro lateritic soil, particle size distribution, compaction test, geophysical properties, california bearing ratio

1. Introduction

1.1. Lateritic soil

Soil originated from a latin word "solum" which has different meanings to different professional groups. Terzaghi based on this distinction defined soil as natural aggregate of mineral grains which can be separated by such gentle mechanical means as agitation in water [1]. Practically, all soils are products of the disintegration of the rocks of the earth crust. This disintegration or weathering has been brought about by the action of chemical and mechanical forces that have been exerted on the parent rock formations for countless ages. Therefore soil may be classified into two categories such as residual soil e.g. Laterite and transported soil e.g. alluvial soil, aeolin soil, glacial soil etc. [2]. However, the soil name Laterite was coined by Buchanan in India from a latin word "Later", meaning bricks, [3]. Soils under this classification are classified by forming hard impervious and often irreversible pans when dried. Some professionals in this field prefer to use the definitions based on hardening such as "ferric" for iron-rich cemented crusts, "alerete" or "bauxite" for aluminum rich cemented crusts, and "silicrete" for silica- rich cemented crusts [4]. Singh referred Laterite as a ferruginous material produced as a result of tropical alteration suffered by rocks and contains mainly the hydroxides of iron, alumina and manganese, [5].

1.2. Lateritic soil formation

Rock erosion is the basic process that leads to the formation of Laterite and other soil types. Laterite is formed in hot, wet tropical regions with annual rainfall of 750mm to 300mm on a variety of different types of rocks with high iron content. In the first place, calcium, magnesium, sodium and potassium are released, leaving behind a siliceous framework for the formation of clay minerals. During prolonged alkaline attack, the siliceous framework consisting of silica tetrahedral and alumina octahedral is disintegrated. Silica which is soluble at all pH values will be leached slowly, while alumina and ferric oxides (Fe_2O_3, Al_2O_3 and SiO_2) remain together with Kaolin as the end product of clay weathering. The result is a reddish matrix made from Kaolinite, goethite and fragments of the pisolitic iron crust [6].

1.3. Research background

Laterite occurs abundantly in Nigeria and they are widely used for various earth works and engineering constructions such as road pavements, airport pavements, embankments, earth dams etc. So there is need to investigate every source of Laterite to be better placed to take construction and design decision and assumptions.

1.4. Aims and objectives of research

This research is aimed at determining the geotechnical properties of olokoro lateritic soil. The objectives include

1. To adequately classify the soil using the unified classification standard (USC) and AASHTO standards.

2. And to determine the compaction characteristics and the properties that concern the strength as specified by the Nigeria General classification 1997.

1.5. Research justification

Lateritic soil is one of the most important materials used in earth work engineering construction in the tropics and subtropics where it is in abundance like Nigeria. The use of lateritic soil for construction and civil engineering works is very common. Therefore, Umuahia, the capital city of Abia state and its environs have been availed of this wonderful benefit. The borrow site at Olokoro, in Umuahia North Local Government Area of Abia state, Nigeria is one of the major sources of these lateritic soils in Umuahia and its surrounding suburbs. Thus the need to examine this source of Laterite and better understand its properties and qualities in terms of engineering use.

2. Materials and Methods

The material used for this study is a lateritic soil collected from "corner" borrow pit at Olokoro in Umuahia North L.G.A, Abia state, Nigeria. The disturbed sampling method was used. The sample was collected at a depth of about 1.5m. The soil obtained from this location was air dried in trays for four days after which the soil was crumbled. The dried soil was pulverized using a rubber covered pestle in the tray. The rubber cover was to enable the breaking up of the soil aggregates without crushing the individual particles. Distilled water was used for altering the moisture content of the sample and other test were carried out. The compaction test was carried out on the sample soil to determine the maximum dry density (MDD) and optimum moisture content (OMC) by IS by light compaction test (Proctors test on BIS mould).

The apparatus according to [7, 8, 9, 10] are as follows; standard compaction equipment conforming to IS standards, a mould of 100mm diameter and 127.3mm height, IS sieve (4.25mm), balance (capacity = 200mg and sensitivity of 0.01mg), oven (100℃ – 110℃), crucibles, jars (graduated), mixing pan, spatula, scoop etc. the soil was compacted in three layers by the rammer of mass 2.6kg, fall height of 31cm and an evenly distributed blows of 25 on each layer and the result is as shown in Table 1. In much the same way the atterberg limit test was carried out to determine the liquid limit, plastic limit and the plasticity index with the following apparatus, soil sample passing 4.25mm, large glass plate, balance with accuracy of 0.01gm, oven to dry sample at temperature of 105℃ and 110℃, evaporating dishes, desicator etc. it is important to note that soil used for this laboratory examination is not oven dried prior to testing. The result is also as shown in Table 1. The CBR test was also carried out with the lab CBR equipment that meets the essential requirements [11].

3. Results and Discussion

The results of the laboratory examination of the Olokoro lateritic soil are summarized in Tables 1 and 2. From Table 1, it is observed that the plasticity index is greater than 17% which showed that the soil is highly plastic [12]. From the result of the compaction test carried out, the moisture content of Olokoro borrow site lateritic soil was determined with the expression according to [13] thus;

$$wc(OMC) = 100\left(\frac{Ww}{Ws}\right) \quad (1)$$

Where mass of water Ww is given by

$$Ww = W1 - W2 \quad (2)$$

And mass of solid,

$$Ws = W2 - Wc \quad (3)$$

Where, Wc = mass of container and lid, gm; $W1$ = mass of container, lid and moist specimen, gm; $W2$ = mass of container, lid and oven dried specimen, gm is 16.20% and the maximum dry density is 1.91mg/m^3 determined with the expression [8] thus,

$$\varrho d = \frac{\varrho}{1+w} \quad (4)$$

And

$$\varrho = \frac{W1 - W2}{v} \quad (5)$$

Where, ϱd = dry density; v = volume of mould (m^3); $w = wc$ = moisture content; e = bulk density.

Table 1: Geotechnical Properties of Olokoro Lateritic Soil.

Properties	Results
Liquid Limit (%)	39
Plastic Limit (%)	17.96
Plasticity Index (%)	21.04
% Passing Sieve No.200 (0.075mm)	3.69
Coefficient of Uniformity, Cu	3.91
Coefficient of Curvature, Cc	1.01
Group Index	0
MDD (mg/m^3)	1.91
OMC (%)- W.A.S.	16.20
CBR (%)-W.A.S.	26
Olokoro lateritic soil classification on AASHTO	A-2-7

Since the best compaction can be achieved at OMC, its determination will help to carry out compaction in the field by adding that amount of water to the soil during compaction. This has given constructors in Umuahia area of Abia State, Nigeria a clue on the amount of water needed to achieve a dry density of 1.91mg/m^3 for Laterite from the borrow site under investigation.

Similarly, the CBR test was carried out with CBR value corresponding to 2.5mm penetration. From the test result in Table 1, the CBR value of the olokoro borrow site lateritic soil used for major road works in the state of Abia is determined to be 26% and this value gives an idea of the strength of the soil in regard of the pavement design and thickness of the cross section of the pavement to be placed on the compacted olokoro Laterite when used as subgrade material. With the CBR of 26%, the olokoro lateritic soil would need modification to improve the characteristic strength of the soil [14].

Finally, the atterberg limit results show that the soil is of the Kaolinite type of clay with a minimum plasticity index of 21.04 of the clay soils. Soil plasticity has a significant effect on the engineering properties of fine grained soils [15, 16]. So the olokoro borrow site lateritic soil is classified as a plastic soil.

4. Conclusion

AASHTO classification system indicates that the soil belongs to A-2-7 subgroup of A-2 group consisting of granular material and group index of zero. Based on this, [17] concluded that soil of this group is good for subgrade and embankment material. The higher the soil group index, the poorer the soil as a subgrade material. Granular soil is generally preferred for highway and embankment material. On the other hand, the 26% CBR value (Table 2) also indicates that the soil is excellent for subgrade [7, 18]. Since the soil is good for subgrade material but very poor for road base construction, we recommend the modification of the soil using any stabilizing agents or methods which may include a recent research that tried to establish the effect of oil spillage on the geophysical properties of soil. It is established to oil considerably increases the CBR of soils, a property that determines the ability of soil to carry traffic and airfield load though with its reverse effect on the shear strength of the soil [19]. With the foregoing, the soil could be improved to a good subbase material. This same lateritic soil could also be employed in other engineering works apart from the usual road, airfield, embankments and foundation and laterized concrete works thus the use of laterite in the production of laterized sancrete blocks which compressive strength increases by the multivariate function of the proportions of its constituent ingredients thus laterite fines, water, cement and sand [20, 21]. Laterite is fundamentally useful in almost all civil engineering works.

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Table 2: Sieve Analysis (Initial Mass = 60.0g).

Sieve Size (mm)	**Mass Retained** (g)	% **Mass Retained** (g)	**Cum. Mass Retained** (g)	% **Cum. Mass Retained**	% **Passing**
2.00	0	0	0	0	100
1.18	0.7	1.97	1.18	1.97	98.03
0.85	2.8	7.88	5.91	9.85	90.15
0.60	4.5	12.68	13.52	22.53	77.47
0.43	7.0	19.72	25.35	42.25	57.75
0.30	6.8	19.15	36.84	61.40	38.60
0.15	6.1	17.18	47.15	78.58	21.42
.075	6.3	17.75	57.80	96.33	3.67
Receiver	0.3	0.85	58.31	97.18	—

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