Suitability of Lateritic Soil in Oluku Community, South-South, Nigeria As a Borrowed Pit Material For Construction Purposes

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Abstract. Laterite is a highly weathered material rich in secondary iron and aluminium oxides, which is of great use in road and building construction. This material is found in a larger quantity in the Oluku community; however, there is no prior knowledge of the geotechnical properties and suitability of the lateritic soils for construction purposes. This study investigates the suitability of the lateritic soil from the Oluku community as a borrow pit material for construction purposes. Soil samples were collected from 5 different pits within the study area and at different depths of 1.3, 1.4, 1.2, 1.3 and 1.5 m, respectively, by hand auger. Laboratory tests such as particle size distribution analysis, specific gravity, Atterberg limits, compaction test and California Bearing Ratio (CBR) test were conducted on the soil samples by BS 1377.

The particle size distribution test results revealed that the percentage passing of the soil samples ranged from 31.62 to 67.60%, indicating poor materials. The specific gravity results ranged from 2.3-2.8, while the compaction test results revealed that the optimum moisture content (OMC) and maximum dry density (MDD) ranged from 8.10-15.70% and 0.70 Mg/m^3-2.04 Mg/m^3 respectively. The consistency limits results show that liquid Limit, Plastic Limit and plastic index ranged from 19.73 to 28.52%, 11.89 to 19.03% and 6.70 to 9.82%, respectively. The soaked and un-soaked CBR values ranged from 2.24-4.37 % and 10.35% to 22.65% respectively. These results were compared to the specifications established by the Federal Government of Nigeria for roads and bridges (1997) and British Standards Methods of Test for Soil for Civil Engineering Purposes (BS 1377: 1990). Overall, the result revealed noticeable deviations from standards due to the presence of a high content of silty clay. This implies that the soil samples present at the Oluku community are not unsuitable as borrow pit material and, therefore, cannot be used for construction.

Keywords: California Bearing Ratio; Specific Gravity Test; Particle Size Distribution; Atterberg's Limit Test; Compaction Test; Stabilization.

INTRODUCTION

Lateritic soils are formed through intensive and prolonged weathering of the underlying parent rocks, a process known as laterisation. This tropical weathering is a slow, long-term chemical process that breaks down various rock materials, resulting in soils with diverse thickness, grade, chemical composition, and mineralogy [1]. Researchers have reported that lateritic soils are commonly acceptable construction materials, and in this manner, they are widely utilised in construction [2].

Whenever engineering structures are built or constructed on clay soils, there is always a high tendency for deformations due to the additional load on the soil. This is usually due to the deformation of the soil when soaked, wet or even leached with water [3]. The deformations may cause great failures such as cracking, tilting or even total collapsing of the foundation (that is, the earth structures on which the engineering structures are founded). All these problems related to the foundation, including a collapse in road construction projects and the like, are associated with consolidating the clay soil's strata. To this effect, stabilisation is usually employed as a technique in ground improvement to achieve the optimum required performance of the soil.

Soil stabilisation as a geotechnical engineering practice is a general term that refers to any physical, chemical, mechanical, biological, or combination of two or more methods above to alter a natural soil to meet a specific engineering purpose. It includes but is not limited to the increase of the weight, tensile strength, bearing capacity and the overall performance of sands, in-situ subsoils, waste materials and so on to strengthen the soil to be able to resist the external load exerted on it by the road pavements and other engineering structures constructed on it [4]. The basic and major aim of soil stabilisation is to increase the natural soil's bearing capacity to resist the load (structure) exposed without collapsing.

Borrowed materials are essential to a construction project since they affect the road's firmness and structures used [5]. In developing countries like Nigeria, the geotechnical properties of construction materials are often overlooked; they are sourced from any available site without proper evaluation. Assessment of these materials must not be ignored. This act can lead to detrimental failures of these structures, resulting in loss of lives and properties or even disruption in economic activities within the location where the material might have been utilised.

Therefore, this study aims to investigate the geotechnical properties of the lateritic soil in the Oluku community and its suitability as a borrow pit material for construction purposes. Several experimental techniques will be employed to investigate the suitability of lateritic soil as borrow pit material. These techniques include Geotechnical laboratory tests such as particle size distribution, specific gravity test, Atterberg's limit test, compaction test and California Bearing Ratio (CBR) test. All tests would be carried out according to procedures outlined in the British Standard Code (BS 1377: 1990).

The location of the study area. The study area, Oluku community, is one of the communities in Benin City, South-South, Nigeria. Benin City is the capital city of Edo State, the 22nd largest state by area (17,802km^2) in Nigeria. The study area covers an area of 8.16km^2, equivalent to 0.046% of the state's total area, as shown in Figure 1 below. The study area lies within the latitude of 6° 26' 40"N to 6° 27' 40"N of the equator and longitude of 5° 34' 40"E to 5° 37' 20"E of the Greenwich Meridian. The study area contains socio-economic infrastructures that generate a lot of human activities. Also, the area lies within the Ikpoba River basin, and all the rainfall in the study area flows and is ultimately discharged into the Ikpoba River in Benin City. Annual precipitation in Benin City is around 190 mm, with 274.89 rainy days (75.31% of the year). The yearly average temperature of Benin City is 29.75°C. The borrow pit is chosen because of its proximity to several construction sites.

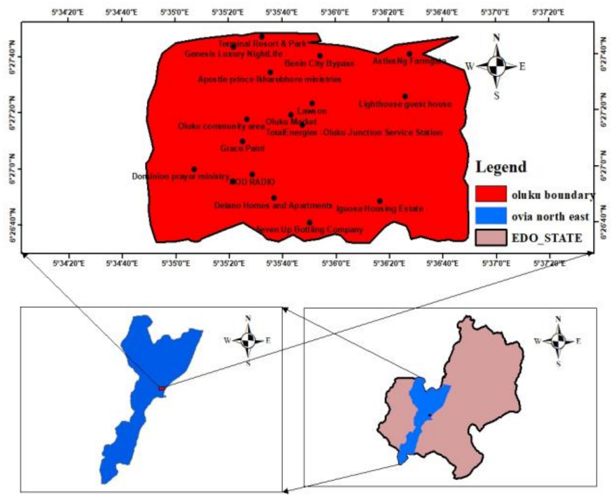

Figure 1 – Location map showing Oluku, in Edo State, South-South, Nigeria

MATERIALS AND METHODS

Lateritic soil samples were collected from five different pits within the community at different depths of 1.3, 1.4, 1.2, 1.3 and 1.5 m, respectively, using a hand drill, then bagged in air-tight polyethene bags. These polyethene bags were clearly labelled as P1, P2, P3, P4 and P5, respectively and transported to the Geotechnical laboratory at the Department of Civil Engineering of the University of Benin, where all the laboratory tests were carried out to determine their suitability for use as borrow pit materials for construction purposes.

Upon arrival at the laboratory, the collected samples were spread separately on clean surfaces within the laboratory and allowed to air-dry for three days. The essence of drying was to allow the soil to lose moisture content. The dried samples were then sieved with a sieve size of 4.75 to remove the debris and other contaminants from the site. These sieved samples were re-bagged to avoid contaminants and then transported to the practical room within the laboratory.

The following Geotechnical laboratory tests were conducted according to procedures outlined in British Standard (BS 1377: 1990): Particle size distribution; Specific gravity Test; Atterberg's Limit Test (Cone Method); Compaction Test; California Bearing Ratio (CBR) Test.

Particle size distribution. Particle size distribution testing is a laboratory method used to determine the distribution of particle sizes in a sample of aggregate. The Particle size distribution of an aggregate is an important factor in the performance of construction materials, as it can affect the material's strength, durability, and workability. This test was carried out using BS sieves of different sizes (ranging from 0.075 mm to 2.36 mm) as shown in Figure 2, a bottom pan and a cover, a mechanical sieve shaker, a sensitive weighing balance weighing up to 0.1g, and an oven.

The method of sieving employed was wet sieving, where a 500 g of soil sample was collected, washed extensively and had a net weight of 200 g. The sample was then oven-dried, and 95 g of the dried sample was taken. The BS sieves were stacked in order, with the largest aperture size at the top and the smallest at the bottom. A receiver was placed underneath to collect samples. The dried sample was poured into the top sieve, covered with a lid, and the stack was placed in a sieve shaker with the clamps fixed. The timer was set between 10 and 15 minutes, and the shaker was switched on. After shaking, the mass of each sieve and the retained material were measured. The sample retained on each sieve was weighed, and the results were then analysed and recorded. The results were then analysed in this paper's next chapter.

Figure 2 – A set of sieves for the Sieve Analysis Test

Atterberg's limit test. Atterberg limit is one of the important geotechnical properties in civil engineering works that describe the consistency of a cohesive soil to provide useful information regarding the soil strength, behaviour, stability, type and state of its consolidation [6, 7]. This test is subdivided into three main limits, namely Liquid Limit (LL), Plastic Limit (PL), and Shrinkage Limit (SL). It should be noted that the two limits are used for soil identification, classification, and strength correlations.

The apparatus and materials used included a cone penetrometer, aluminium containers (moisture cans), a spatula, a 425-micron sieve, evaporating dishes, a mortar and pestle, a digital scale (sensitive up to 0.01 g), and an oven. 400 g of prepared sample was obtained, ground in porcelain mortal and rubber-tipped pestle and then sieved through the 425-micron sieve and a uniform paste of the sample was made by adding distilled water.

The prepared paste was transferred to the cylindrical cup of the cone penetrometer apparatus (the air was let out during the process). The cone was levelled with the cup and placed on the base of the cone penetrometer apparatus, adjusted so that the cone point touched the surface of the soil paste. The initial reading was taken, the vertical clamp was released, which allowed the cone to penetrate the soil paste under its weight for 5 seconds, and the test was repeated 4 times. For the Liquid Limit, the weights of different cans were taken, wet samples were added at varying weights, containers were oven-dried, and the differences in weight before and after drying were recorded. The empty cans' weight was recorded as W1, the weight of the can plus wet soil was recorded as W2, and the weight of the can plus dry soil was recorded as W3.

For the Plastic Limit, clean cans were prepared, ellipsoidal-shaped soil masses were formed and rolled into threads until they crumbled. The crumbled threads were collected, filled into cans, covered, and oven-dried. W1, W2, and W3 weights were recorded similarly to the liquid Limit, and the Plasticity Index (PI) was calculated from the obtained values as shown in Equation 2.

For the Shrinkage Limit, similar steps as the plastic limit test were followed, with the initial length of the crumbled threads (L_o) and the length after oven drying (L) measured, and the difference in length (ΔL) noted. Hence, the equation for calculating the Shrinkage Limit (SL) is presented in:

$$MC = \frac{W2-W3}{W3-W1} * 100 \quad (1)$$

$$PI = LL - PL \quad (2)$$

$$SL = \left(1 - \frac{\Delta L}{L_o}\right) X\ 100. \quad (3)$$

where W1 – the weight of the empty can; W2 – weight of the empty can + the weight of wet soil sample; W3 – weight of the empty can + weight of dry soil sample; ΔL – length of the crumbled thread after oven drying (L) - initial length of the crumbled threads (L_o); MC – Moisture Content; PI – plasticity index; LL – Liquid Limit; PL – Plastic Limit; SL – shrinkage Limit.

The results obtained were analysed, as shown in the next chapter of this paper.

Specific gravity. The specific gravity of soil is calculated by calculating the phase relationships of soils, such as the void ratio, degree of saturation, and density of soil. The specific gravity of the soil depends on the amount of sand, the mineral constituents, and the mode of formation of the soil. The apparatus used in carrying out this test includes a volumetric flask (500 ml), thermometer graduated in 0.5^0C division scale, balance sensitivity up to 0.01g, distilled water, pycnometer, evaporation dishes, spatula, plastic squeeze bottle, and drying oven. The volumetric flask was cleaned, dried and then measured to determine its mass. The flask was then filled with de-aired, distilled water up to 500ml mark. The mass of the flask containing the distilled water was measured and recorded as W1. A thermometer was inserted into the distilled water flask to measure the water temperature, which was recorded as T1. Approximately 100 grams of air-dry soil was placed in an evaporating dish, mixed with de-aired distilled water to form a smooth paste, and soaked for half to one hour (optional for non-cohesive soils). The soil (granular) or soil paste (cohesive) was transferred to the volumetric flask, and distilled water was added to fill it two-thirds full. Air was expelled from the soil-water mixture by gently boiling for 15 to 20 minutes with agitation or applying a vacuum until all air was expelled. Distilled water was added to the volumetric flask until the bottom of the meniscus touched the 500 ml mark and then the outside and inside of the neck above the meniscus. The mass of the volumetric flask containing the soil sample and the distilled water was measured and recorded as W2. The mixture was brought to room temperature and poured into an evaporating dish, and the flask was rinsed to ensure no soil remained. The evaporating dish was dried in an oven to a constant weight, and the dry soil (Ws) mass was determined. The results obtained were analysed, as shown in the next chapter of this paper.

Standard Proctor Compaction test. Compaction is the process of soil densification by reducing air voids, and this is carried out to understand the compaction characteristics of different soils with changes in moisture content. The degree of compaction of a given soil is measured in terms of its dry density. The dry density is maximum at the optimum water content. The apparatus used in conducting this test includes a compaction mould (100 mm diameter x 125 mm high) with a 50 mm high extension collar, No. 4 U.S. sieve, standard proctor rammer (4.5 kg), large mixing pan, jack, steel straight edge, moisture cans, drying oven, spatula, plastic squeeze bottle with water, mould oil, weighing balance(0.1 g sensitivity), graduated jar, and pallet knives.

7 kg of air-dry soil was used for the compaction test; all soil lumps were broken and sieved through a No. 4 U.S. sieve, and 5kg of the material was collected in a large pan and mixed thoroughly with 6% water content to achieve a uniform mixture of the sample required for the test, this sample was further divided into three equal parts. The mould was then prepared by fixing it to the base plate and weighed without a collar; the weight was recorded as W1, after which the collar was lightly oiled to the mould. The first part of the mixed soil sample was filled into the mould in three equal layers, each compacted uniformly with 25 blows by a standard proctor rammer.

The attached collar was carefully removed, and the excess soil was trimmed with a straight edge to level it with the mould's top. The weight of the mould with the base plate and compacted moist soil was recorded as W2. The base plate was removed, and the compacted soil cylinder was extruded using a jack. The mass of the moisture can (W3) was determined, and a moisture sample from the extruded soil was collected in the can, recording the mass of the can plus moist soil (W4). The moisture can with the moist soil was placed in an oven to dry to a constant weight. The rest of the compacted soil was broken down to No. 4 sieve size and mixed with the leftover moist soil in the pan. This procedure was repeated for all five pit samples, and the results obtained were analysed, as shown in the next chapter of this paper.

California Bearing Ratio (CBR) Test. The California Bearing Ratio (CBR) is carried out to measure the strength of the borrowed pit materials to ascertain their suitability for sub-grade material for road construction and use for building construction.

The materials and apparatus used included a CBR machine, a cylindrical (corrosion-resistant) CBR metal mould, a base plate, a 5.0 kg rammer, lubricating oil, screw plugs, a water bottle, a large mixing pan, coarse filter paper, measuring cylinder, weighing balance that is capable of weighing up to 25 kg readable and accurate to 5 g, and metallic surge. 15 kg of air-dried soil sample was sieved through a 4.75 mm sieve, and 8 kg of the sieved sample was collected and mixed thoroughly with the amount of moisture content obtained as the percentage of the product of the optimum moisture content of the sample from the compaction test. The wet sample was filled into a lubricated mould in three layers with filter paper and a spacer disc at the bottom. Each layer received 55 blows from a 5 kg rammer. The top attachment collar was carefully removed, and the excess soil was trimmed with a straight edge to level the compacted soil with the mould's top. The mould with the test specimen was placed on the lower plate of a penetration testing machine, and the penetration piston was placed on the centre of the specimen with the smallest possible load, but in no case over 4 kg, to ensure full contact with the sample. The load and deformation gauges were set to read zero. The load was applied on the piston so that the penetration rate was about 1.25 mm/min. The penetration forces were recorded at the penetration of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, and 7.0 mm for the top and bottom of the sample, while the mould coupled with the collar and the sample was submerged in water in the surge tank for 24 hours. The soaked sample was then loaded on the machine while the penetration forces were equally recorded for the top and bottom as for the un-soaked. The results obtained were analysed after that, as shown in the next chapter of this paper.

RESULTS AND DISCUSSION

The results of all laboratory analyses that were conducted on the borrowed soil samples across the five different pits were based on the soil classification test (Sieve analysis, Atterberg limit and Specific gravity) and the strength test (Compaction and California Bearing Ratio), and these results are presented in the form of tables and graphs as shown below;

Particle Size Distribution Test Result. The sieve analysis results on the soil samples are presented in Table 1 to Table 5 and Figure 3 to Figure 7. The result shows that 0% of the soil samples pass through sieve No. 200 (75 microns), implying 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 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%.

Table 1 – Particle Size Distribution as obtained from the soil samples from Pit 1 at 1.3 m depth

Initial weight = 95 g				
BS Sieve Sizes	Mass Retained in a sieve (g)	Percentage Retained (%)	Cumulative % Retained	Cumulative % Passing
2.36	1.70	1.79	1.79	98.21
2.00	2.00	2.12	3.91	96.09
1.18	4.60	4.84	8.75	91.25
0.6	10.20	10.74	19.49	80.51
0.425	8.50	8.95	28.44	71.56
0.30	35.50	37.37	65.81	34.19
0.212	19.00	20.00	85.81	14.19
0.150	7.00	7.37	93.18	6.82
0.075	6.48	6.82	100.00	0.00
-	0.50	-		

Table 2 – Particle Size Distribution as obtained from the soil samples from Pit 2 at 1.4 m depth

Initial weight = 95 g				
BS Sieve Sizes	Mass Retained in a sieve (g)	Percentage Retained (%)	Cumulative % Retained	Cumulative % Passing
2.36	1.60	1.68	1.68	98.32
2.00	1.900	2.00	2.68	97.32
1.18	4.70	4.95	7.63	92.37
0.6	9.10	9.58	17.21	75.16
0.425	9.60	10.12	27.33	72.67
0.30	36.70	38.63	65.96	34.04
0.212	17.00	17.89	83.85	16.15
0.150	7.80	8.21	92.06	7.94
0.075	7.54	7.94	100.00	0.00
-	0.30	-		

Table 3 – Particle Size Distribution as obtained from the soil samples from Pit 3 at 1.2 m depth

Initial weight = 95 g				
BS Sieve Sizes	Mass Retained in a sieve (g)	Percentage Retained (%)	Cumulative % Retained	Cumulative % Passing
2.36	1.50	1.58	1.58	98.42
2.00	2.33	2.45	4.03	95.97
1.18	4.60	4.84	8.87	91.13
0.6	11.20	11.79	20.66	79.34
0.425	8.53	8.98	29.64	70.36
0.30	35.30	37.16	66.8	33.20
0.212	18.20	19.16	85.96	14.04
0.150	7.00	7.37	93.33	6.67
0.075	6.34	6.67	100.00	0.00
-	0.50	-		

Table 4 Particle Size Distribution as obtained from the soil samples from Pit 3 at 1.3 m depth

Initial weight = 95 g				
BS Sieve Sizes	Mass Retained in a sieve (g)	Percentage Retained (%)	Cumulative % Retained	Cumulative % Passing
2.36	1.64	1.73	1.73	98.27
2.00	2.91	3.06	4.79	95.21
1.18	3.91	4.12	8.91	91.09
0.6	10.23	10.77	19.68	80.32
0.425	7.92	8.34	28.02	71.98
0.30	34.50	36.33	64.35	35.65
0.212	18.00	18.95	83.30	16.70
0.150	7.18	7.56	90.86	9.14
0.075	8.68	9.14	100.00	0.00
-	0.50	-		

Table 5 – Particle Size Distribution as obtained from the soil samples from Pit 3 at 1.5 m depth

Initial weight = 95 g				
BS Sieve Sizes	Mass Retained in a sieve (g)	Percentage Retained (%)	Cumulative % Retained	Cumulative % Passing
2.36	1.8	1.90	1.90	98.10
2.00	2.0	2.11	4.01	95.99
1.18	4.6	4.84	8.85	91.15
0.6	12.5	13.16	22.01	77.99
0.425	9.25	9.74	31.75	68.25
0.30	31.5	33.16	64.91	35.09
0.212	20.4	21.47	86.38	13.62
0.150	6.0	6.32	92.70	7.30
0.075	6.94	7.3	100.00	0.00
-	0.30	-		

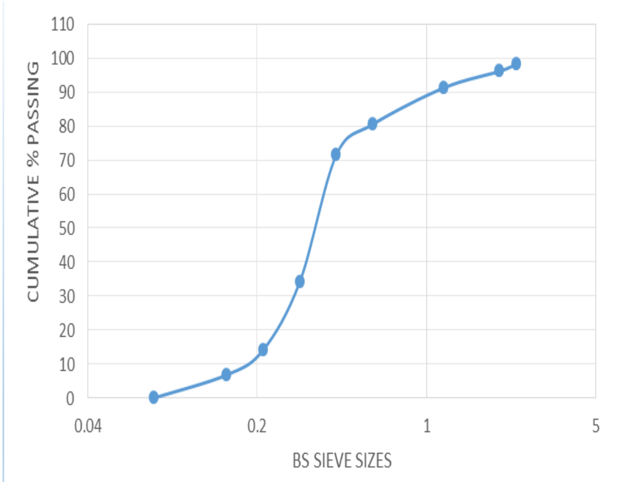

Figure 3 – Particle Size Distribution Curve for Pit 1

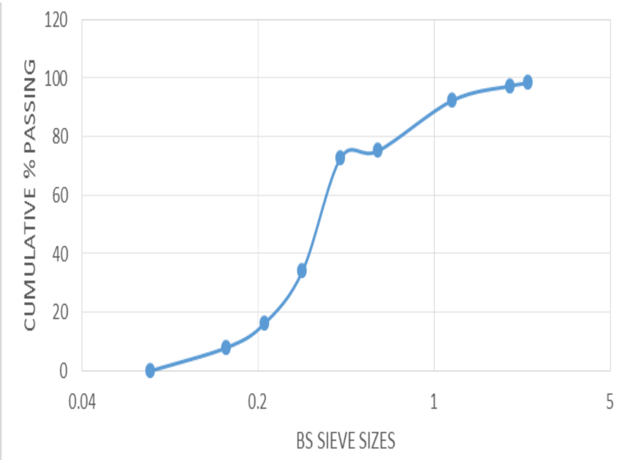

Figure 4 – Particle Size Distribution Curve for Pit 2

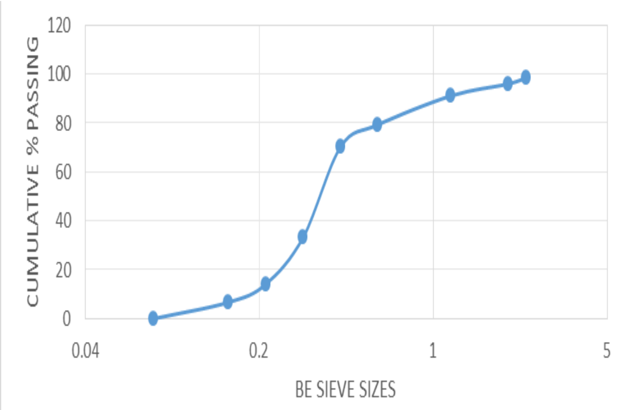

Figure 5 – Particle Size Distribution Curve for Pit 3

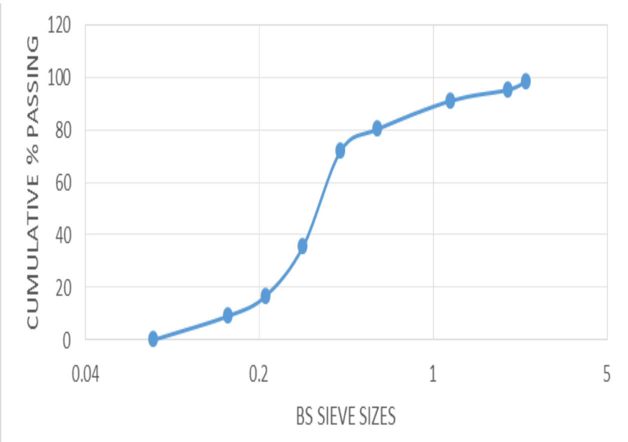

Figure 6 – Particle Size Distribution Curve for Pit 4

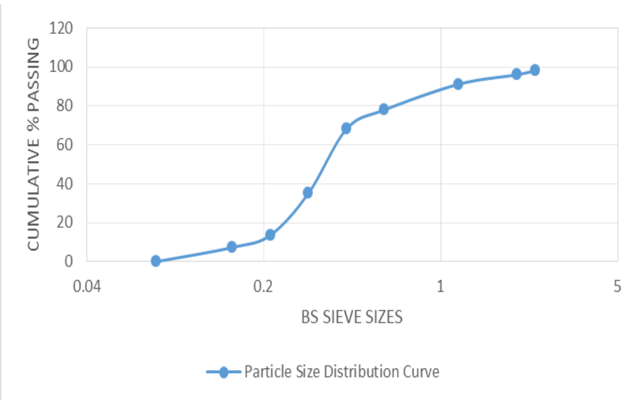

Figure 7 – Particle Size Distribution Curve for Pit 5

Atterberg's limits test results. The analysis of the data obtained from the index proprieties, as shown in Table 6 and graphically represented in Figure 8, shows that the liquid limits values ranged from 19.73% to 28.52% with an average value of 24.14%, the plastic limits varied from 11.89% to 19.03% with an average value of 16.09%. In comparison, the plastic index varied from 6.70% to 9.82%, with an average value of 8.09%. According to the Federal Ministry of Works and Housing (1997), liquid limits of 80% maximum are recommended for road works for subgrade and 35% maximum for base materials. It also recommends a plastic index of 55% maximum for sub grade and 12% maximum for base materials. All the results fall within specification, making the soil samples suitable for use as borrowed pit materials for construction purposes.

Table 6 – Atterberg's Limit Test Results

Index Properties	Pit 1	Pit 2	Pit 3	Pit 4	Pit 5	Average
Liquid Limit (%)	20.90	19.73	26.61	28.52	24.94	24.14
Plastic Limit (%)	11.89	17.95	15.08	19.03	16.50	16.09
Plasticity Index (%)	7.49	9.82	6.70	8.55	7.81	8.07

Specific gravity test results. From Table 7 below, the specific gravity of samples from pit 1, pit 2, pit 3, pit four and pit 5 are 2.3, 2.5, 2.3, 2.8 and 2.4, respectively, with an average of 2.46. According to specification, a good lateritic soil should have a specific gravity that ranges from 2.5 to 2.75. The values obtained for Pits 2 and 5 fall within the specification, while those obtained in Pits 1, 3, and 5 fall below the specification, thus making it unsuitable for use as a borrowed pit material for construction purposes.

Table 7 – Specific Gravity (Gs)

Sample No	Depth of Sampling (m)	Specific Gravity, Gs	Average
P1	1.3	2.3	
P2	1.4	2.5	
P3	1.2	2.3	2.46
P4	1.3	2.8	
P5	1.5	2.4	

Standard Proctor Compaction test. The maximum dry density for the soil samples varies from 0.70 g/cm^3 to 2.04 g/cm^3, while the optimum moisture content ranges between 8.10% and 15.70%. The values 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%. MDD is usually between

1.6 Mg/m^3 and 1.85 Mg/m^3, and OMC ranges between 15-25% for silty clay. For sandy clay, MDD usually ranged between 1.76 Mg/m^3 and 2.17 Mg/m^3 and OMC between 8 and 15% [8]. Thus, looking at the results of the soil samples, as shown in Table 8, it could be noticed that they are sandy clay.

Table 8 – Compaction Test Results

Sample						
P1	OMC (%)	8.50	10.20	11.60	13.50	15.10
	MDD (g/cm^3)	0.71	1.00	2.04	1.96	1.75
P2	OMC (%)	8.30	10.10	11.40	13.20	15.70
	MDD (g/cm^3)	0.72	1.01	2.01	1.92	1.72
P3	OMC (%)	8.50	10.20	11.10	13.40	15.30
	MDD (g/cm^3)	0.71	1.01	2.01	1.91	1.72
P4	OMC (%)	8.60	10.30	11.70	13.60	15.30
	MDD (g/cm^3)	0.72	1.01	2.05	1.97	1.75
P5	OMC (%)	8.10	10.40	11.30	13.40	15.50
	MDD (g/cm^3)	0.72	1.01	2.03	1.92	1.76

California Bearing Ratio (CBR). As shown in Table 9, the California bearing ratio values show that CBR for the unsoaked soil samples ranges between 10.35 % and 22.65%, with an average of 16.6%. The California bearing ratio ranges from 2.24% to 4.37% for the soaked soil samples. From the results, the lateritic material can be used as a borrow pit material for subgrade or earth fill but cannot be used as a base course as it will require stabilisation for founding stable structures. This is because the Federal Ministry of Works and Housing Specification for Roads recommends that the CBR values (unsoaked) for sub-grade and base courses should not be less than 10% and 80%, respectively.

Table 9 – CBR Results

Test on bottom (unsoaked) surcharge											
Penetration (mm)	0	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.0
Load indicator	0	94.20	146.60	203.60	231.40	272.30	307.00	337.50	361.20	422.20	434.20
Ditto Corrected											
Load (KN)	0	1.03	1.60	2.21	2.55	2.97	3.38	3.71	3.97	4.72	5.26
C.B.R (%)											
Test on top (unsoaked) surcharge											
Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.0
Load indicator	0	93.20	114.60	122.80	130.40	135.60	149.00	165.30	188.70	174.5.20	226.50
Ditto Corrected											
Load (KN)	0	1.02	1.26	1.34	1.43	1.48	1.64	1.87	2.07	1.91	2.25
C.B.R (%)											
Test on bottom (soaked) surcharge											
Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.0
Load indicator	0	17.21	26.60	37.30	46.40	51.70	51.70	57.00	61.20	90.00	114.20
Ditto Corrected											
Load (KN)	0	0.19	0.29	0.41	0.51	0.57	0.57	0.62	0.68	0.99	1.26
C.B.R (%)											
Test on top (soaked) surcharge											
Penetration (mm)	0	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.0
Load indicator	0	17.21	26.60	37.30	46.40	51.70	51.70	57.00	61.20	90.00	114.20
Ditto Corrected											
Load (KN)	0	0.19	0.29	0.41	0.51	0.57	0.57	0.62	0.68	0.99	1.26
C.B.R (%)											

	Unsoaked		Soaked	
	2.5 mm	5.0 mm	2.5 mm	5.0 mm
Bottom	22.65	17.81	4.37	3.53
Top	15.17	10.35	2.24	2.34

CONCLUSIONS

The assessment of the suitability of the lateritic soil in Oluku Community, Benin City, as a Borrowed Pit Material has been conducted in compliance with British Standards Methods of Test for Soil for Civil Engineering Purposes (BS 1377:1990) and the Nigeria General Specification for Roads and Bridges construction.

The results from the Geotechnical laboratory test indicated that the soil samples at pits 1, 3 and 5 did not fall within the specifications required for construction due to silty-clay materials, which indicated poor bearing capacity. Soils with high silt and clay content generally have low strength, poor drainage, high plasticity, and are prone to swelling and shrinkage. These characteristics make them unsuitable for construction unless properly treated. Therefore, the soil samples from the Oluku community are unsuitable to borrow pit materials and cannot be used for construction. Methods for improving the Engineering properties of the silty-clay include mechanical Stabilisation, chemical Stabilization, Geosynthetics, coir fibre, and additives to reduce plasticity.

Conflict of interest

There is no conflict of interest between all authors involved.

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