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Effect of Cassava Peel Ash on Lateric Soil Stablized with Bitumen

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ABSTRACT

The effect of cassava peel ash on Lateritic Stabilized with Bitumen was investigated. The lateritic solid was collected from Umuma-Isiaku in Ideato South LGA of Imo State. The Bitumen was collected from New Idea Construction Company Ltd in Owerri. The Cassava peel was collected from Ohaji in Egbema LGA OF Imo State. The Cassava Peel was burnt in a furnace and sieved with 150% sieve to obtain the ahs used in the experiment. The lateritic soil was classified as A-2-7 on AASHITO classification chart. The percentage replacement level of soil by Bitumen and Bitumen/cassava peel ash 0-10% by weight of dry soil. The investigation was carried out with respect to compaction Characteristic and California Bearing Ratio (CBR) tests. The result obtained indicated a decrease in maximum Dry Density (MDD) when the soil was stabilized with bitumen and increases when cassava peel ash was incorporated for 0-10% replacement level of soil with bitumen and bitumen/cassava peel ash respectively. The result of the optimum moisture content (OMC) increases when bitumen was used in stabilizing the soil and decreases when cassava peel ash was incorporated. The result of the MDD when bitumen was used in stabilizing the soil ranges from 2.16-1.76gkmcm^3 for 0-10% replacement of dry soil with bitumen and 2.16-4.20g/cm3 when cassava peel ash was incorporated. The results of OMC ranges from 11.20 -21.90% and 11.20-8.80% for 0-10% replacement of dry soil with bitumen and bitumen/cassava peel ash respectively. The result of CRR text ranges from 22.66-85.75% and 22.66-18.10% for the same replacement level of bitumen and bitumen/cassava peel ash respectively. These results shows that the high shear strength of soil which was achieved by stabilizing the soil with bitumen was reduced by the incorporation of cassava peel ash.

Introduction

Lateritic is well known in Asia Countries as a building material for more than 1000 years [1]. Geologist dealt at first with laterite but later, soil scientists, mineralogist, geographers, geo norphologists, mining and construction engineers participates in the laterite research [2]. Many scientists with their different views did not only result in a great increase in the knowledge of laterite but created also a great confusion in the basic understanding and interpretation of lateritic formation [3]. According to [4]. Chemical decomposition of rocks is a widespread phenomenon in tropical regions which affects each types of rock. Obviously tropical weathering causes an increase in iron deposits which resulted in the reddish brown colour of laterities [5]. Lateritic soils are soil types rich in iron and aluminum, formed in wet and hot tropical areas. They develop by intensive and long lasting weathering of the underlying parent rock [6]. Lateritic soil lover about one third of the earth's continental land area with the majority of it is the land areas between the tropics of cancer and Capricorn [7]. Lateritic soil is formed from the leaching of parent sedimentary rocks (Sandstone, clays, Limestone), volcanic rocks which leaves the insoluble irons predominantly iron and aluminum [8].

Materials and Method

The lateritic soil sample used in this research work was collected from the borrow pit in Umuma-Isiaku in Ideato South LGA of Imo State, Nigeria. The sample was collected at a depth of 0.6m. Bitumen and Bitumen/Cassava Peel Ash were used to stabilize the soil at the certain replacement level of 0-10% of soil by weight. The geotechnical properties of the lateritic soil at 0% replacement with Bitumen and Bitumen/Cassava Peel Ash was obtained in accordance to [9]. This was obtained by the following test: determination of moisture content specific gravity, liquid and plastic limit compaction test and California Bearing Ratio test.

Determination of Moisture Content

This was carried out using the following apparatus: Moisture content cans weighing balance and oven.

Procedure: (i) Two empty cans with their cover were weighed and identified.

ii) 50g of the cans. (iii) The weight of the wet soil and the cans were recorded.

iv) The cans and their content and their lids placed at the bottom were oven dried for 16-20hours at a temperature of 110^{0}c. (v) The cans were weighed again after oven dry (iv) the moisture content of the samples was then computed using the following formular.

$$\text{Moisture content} = \frac{w_2 - w_1}{(w_1 - w_3)} \times \frac{100}{1}$$

Where

W_2 = Weight of wet soil + can

W_1 = Weight of dry soil + can

W_3 = Wight of can

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The average result of the two cans was taken as the moisture content of the soil. The experiment was repeated at 2%, 4%, 6%, 8%, 10% replacement of soil sample with Bitumen and Bitumen/Cassava Peel Ash respectively.

Specific Gravity

The apparatus used includes a standard density bottle, a balance reddish and accurate to 0.01g, a desiccators of at least 20cm in diameter, water.

Procedure: The density bottle with its stopper was weighed empty [w_1]. The bottle with its stopper was filled with 10g of dry sod and weighed (w_2). Water was added to the 10g of dry soil as the bottle with its stopper, fried is a dessicator and weighed (w_3). The sample was removed and the bottle with its stopper was filled with water and weighed after drying the exterior (w_4). The specific gravity of the soil was calculated as follows.

$$\text{Specific gravity} = \frac{w_2 - w_1}{(w_4 - w_1) - (w_3 - w_2)}$$

Where

W_1 = Mass of density bottle and its stopper

W_2 = mass of density bottle + stopper + oven dried soil

W_3 = mass of density bottle + oven dried soil + water

W_4 = Mass of density bottle + stopper + water

Two samples were tested and the average result was taken as the specific gravity of the soil. The experiment was repeated at 2%, 4%, 6%, 8%, 10% replacement of soil sample with Bitumen and Bitumen/Cassava Peel Ash respectively.

Liquid Limit: The apparatus used includes cone penetrometer, cylindrical metal cup, moisture cans, glass plates, porcelain dish, spatula, palette knife, water bottle, balance readable and accurate to 0.019, serve (425/nm), straight edge oven.

Procedure: 200g of the dried sample was sieved size. The sample was added 15-20ml of water in the porcelains dish and thoroughly mixed by using spatula. Further addition of water was in the order of 2-3ml. Each subsequent addition of water was thoroughly mixed as in above. When the soil was thoroughly mix with sufficient water form a uniform mass of consistency, the uniform mass (paste) was gradually pushed into the cylindrical cup with a palette knife. The surface of the paste leveled horizontally using a straight edge. The cone was lowered and allowed to touch the surface of the soil during which the dial gauge reading was taken. The cone was released and allowed to penetrate the surface of the soil for 5seconds, during which the second dial gauge reading was taken. The difference between the two dial gauge readings gives the cone penetration. More soil paste was added to the cup and the test was repeated. 20g of the sample was kept aside or the determination of moisture content. The test was repeated at various moisture contents to give the relationship between cone penetration and moisture content. Four test results were taken with cone penetration within the range of 15mm and 25mm. The experiment was repeated at 2%, 4%, 6%, 8%, 10% replacement of soil sample with Bitumen and Bitumen/Cassava Peel Ash respectively.

Plastic Limit: The 20g of soil set aside was broken into smaller. Samples and rolled on a glass plate using the finger to obtain a thread of uniform diameter, 3mm, the thread was then broken with several other pieces , reformed into a ball and re-rolled, the rolling process was continued until the soil could no longer be rolled. At this mode of failure, the pieces of the soil were put into a weighed moisture can and covered.

The process was repeated for several times and each time the crumbled pieces were added to the same can. The cans were weighed with their hides placed on the bottom. The cans were placed on an oven at the temperature of 110^0c for 24 hours. The cans and the results were used to determine the moisture content. The experiment was repeated at 2%, 4%, 6%, 8%, and 10% replacements of soil sample with Bitumen and Bitumen/Cassava Peel Ash respectively.

Compaction Text: The apparatus used are measuring cylinder (100ml) compaction modules with baze plate and collar, mixing tray rammer (300mm height with 24.5N weight), moisture cans.

Procedure: 300g of lateritic soil which was collected and passed through sieve No 4 (4.75mm) was used for the test. Water equivalent to 4% for the dry weight of the soil was measured and added to the sample in the tray and mixed thoroughly with trowel. The mixed samples was divided into three equal parts for compaction in the mould. The compaction mould was weighed without the collar and baze plat. The soil was then compacted using the mould with collar and baze plate and a rammer (24.5N).the ramming was done in three equal layers with the rammer. The mould of soil was weighed (excluding the collar and baze plate). The soil was extruded from the mould using an extruder. Two samples were taken-one from the top and the other from the bottom. 4% of water by mass of soil sample was added to the sample and mixed thoroughly. The process was repeated using 8%, 12%, 16% and 20% water content. In each of the percentage of water added, town samples were collected – one from the top and one from the bottom. Each of the samples was weighed, and oven dry. After 24hours, the oven dried samples were weighed in order to determine the actual water content of each moisture can. The dry unit weight of the soil was computed and plot of the dry density versus water content was made to determine the optimum moisture content (OMC) and maximum Dry Density (MDD) for each of the test. Computation was done using the following formula.

$$\text{Bulk density} = \frac{\text{Weight of wet soil}}{\text{Volume of wet soil}}$$

$$\text{Moisture content (MC)} = \frac{\text{weight of water}}{\text{Weight of dry sample}} \times \frac{100}{1}$$

$$\text{Dry Density} = \frac{\text{Bulk density}}{1 + MC/100}$$

The experiment was repeated at 2%, 4%, 6%, 8% and 10% replacement of soil sample with Bitumen and Bitumen/Cassava Peel Ash respectively.

California Bearing Ratio (CBR) Test

Apparatus used for this test includes CBR mould, collar, spacer, compaction rammer, surcharge weights, compression machine equipment capable of a penetration rate of 1.27mm/minute.

Procedure

4500kg of soil which passes through sieve No 4 (4.75mm) was used. The sample was mixed with OMC obtained from the compaction test and mixed thorough in a tray. The mixed sample was divided into three parts. Each of the three parts of the sample was put into the CBR mould and was subjected to 56 blows using the rammer. The mould and its content were taken to CBR machine where the sample was loaded with a surcharge load of 4.5kg.

The plunger was then allowed to penetrate the sample. The penetration readings and corresponding load dial gauge readings were recorded. The CBR at 2.5 and 5.0 were calculated by using the following formula.

$$\text{CBR} = \frac{\text{Dial gauge at 2.5 x PRC x 100}}{\text{Standard value (13607.7g)}}$$

Table 1. Properties of Natural Lateritic Soil

Properties	Quantities
Moisture content(%)	46.10
Liquid limit(%)	60.10
Plastic limit(%)	45.75
Plasticity index(%)	14.80
AASHITO classification	A-2-7
Maximum Dry density (g/cm^3)	2.10
Optimum moisture content(%)	11.25
Calfornia bearing ratio(%)	18.90
Specific gravity	2.63

Table 2. Result of Optimum Moisture Content as 0-8% Replacement of Soil with Bitumen

Bitumen(%)	Optimum moisture Content (%)
0	11.20
2	14.30
4	19.32
6	20.40
8	20.68
10	21.90

Table 3. Result of Optimum Moisture Content at 0-10% Replacement of Solid with Bitumen/Cassava Peel Ash

Bitumen (g)	Cassava Peel Ash (%)	Total	Optimum moisture Content (%)
0	0	0	11.20
1	1	2	11.00
2	2	4	10.92
3	3	6	10.40
4	4	8	10.35
5	5	10	8.80

Table 4. Result of Maximum Dry Density at 0-10% replacement of soil with Bitumen

Total	Optimum moisture Content (%)
0	2.16
2	2.14
4	2.05
6	2.10
8	1.98
10	1.76

Table 5. Result of Maximum Dry Density at 0-10% replacement of soil with Bitumen cassava Peel Ash

Bitumen(g)	Cassava Peel Ash (%)	Total	Optimum moisture Content (%)
0	0	0	2.16
1	1	2	2.24
2	2	4	2.60
3	3	6	2.68
4	4	8	3.92
5	5	10	4.20

Table 6. Result of California Bearing Ratio (CBR) at 0-10% replacement of soil with Bitumen

Bitumen(%)	California Bearing Ratio (%)
0	22.66
2	28.30
4	31.10
6	56.70
8	78.45
10	85.78

Table 7. Result of California Bearing Ratio (CBR) at 0-10% replacement of soil with Bitumen/cassava peel ash

Bitumen(g)	Cassava Peel Ash (%)	Total	Optimum moisture Content (%)
0	0	0	22.66
1	1	2	21.40
2	2	4	21.10
3	3	6	18.30
4	4	8	18.15
5	5	10	18.10

For CBR at 5.0 penetration, we have

$$CBR = \frac{\text{Dial gauge at 5.0 x PRC x 100}}{\text{Standard value (20411.5g)}}$$

Where PRC = Proving ring constant

The experiment was repeated using 2%, 4%, 6%, 8% and 10% replacement of soil sample with Bitumen and Bitumen/Cassava Peel Ash respectively.

Result and Discussion

Table 1 shows the result of properties of natural soil. From the table, it can be seen that the natural moisture content of the lateritic soil is 46.10%, liquid unit 60.55^%, plastic unit 45.75% plasticity index 14.80%, maximum dry density 2.10g/cm3, optimum moisture content 11.25% CBR 18.90% specific gravity 2.65. Table 2 shows the result of the optimum moisture content at 0-10% replacement of lateritic soil with bitumen. The result shows an increase in the optimum moisture content as percentage replacement level of soil with bitumen increases. Table 3 shows the result of optimum moisture content at 0-10% replacement of soil with Bitumen and Bitumen/Cassava Peel Ash. The result shows that optimum moisture content decreases when cassava peel ash was incorporated. Table 4 shows the result of maximum dry density at 0-10% replacement of lateritic soil with bitumen. The result shows a decreases in maximum dry density as the percentage replacement level of soil with bitumen increases. Table 5 shows the result of maximum dry density at 0-10% replacement of soil with Bitumen and Bitumen/Cassava Peel Ash. The result shows that was an increase in maximum dry density where cassava peel ash was incorporated. Table 6 shows the result of California bearing ratio (CBR) at 0-10% replacement of soil with bitumen the result shows that CBR increase with the increases in the replacement level with bitumen. Table 7 shows the result of California Bearing Ratio (CBR) at 0-10% replacement of soil with Bitumen /Cassava Peel Ash. The result shows that the CBR decreases with the incorporation of cassava peel ash. These results shows that bituminous materials can be used in the stabilization of sub-base materials during road constructions. However, when the cassava peel ash was used together with the bitumen, the stabilization properties of the bitumen were reduced.

Conclusion

The conclusion of the study can be summarized as follows:

a) The lateritic soil was identified as A-2-7 soil based on [10] classification system which indicates that the soil is good for the construction of pavements.

b)The optimum moisture content increases with the increase in the percentage replacement level of soil with bitumen but decreases when half of bitumen and cassava peel ash were used together.

c) The maximum dry density decreases with the increase in percentage replacement of soil with bitumen but increase when half of bitumen and cassava peel were used together.

d)The California Bearing Ratio increases with increase in the percentage replacement level of soil with bitumen but decreases as cassava peel ash was incorporated.

e) Bitumen can be used for soil stabilization but when cassava peel ash was incorporated, its stabilization properties will be reduced.

f) Bituminous stabilized soil would be able to resist certain level of flexural stresses caused by the application of wheel load on pavements, but not when cassava peel ash was incorporated.

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