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Stabilization of Lateritic Soil with Bamboo Leaf Ash.

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Abstract:
Background of Study*: Engineers are faced with the problem of providing very suitable materials for highway and other foundation construction. Owing to this fact, many researches has been carried out and still on-going by individuals, firms and institutions on ways to improve the engineering properties and characteristics of soils. The most accessible soil may lack some engineering properties to bear the expected loads, so improvements have to be made to make these soils better* **[3].** *Soil type is one of the key features used to determine which method and material should be used for achieving best compaction* **[9].** *In this regard, this study aims to assess the suitability of bamboo leaf ash as stabilization material for lateritic soil.*
Material and Methods*: Different percentages of bamboo leaf ash ranging from 0%, 2%, 4% 6% and 8% were used to ascertain its suitability in stabilizing lateritic soil. Preliminary Test such as grain size distribution (Wet Sieving), Specific gravity, Moisture content and Atterberg limit were all carried out in order to classify the lateritic soil sample, after which strength tests such as California Bearing Ratio(CBR) test and compaction tests were performed using the standard proctor compactive energy because this is easily achieved in the field.*
Results*: The results show that Atterberg limits (liquid limit, plastic limit and plasticity index) generally decreased, maximum dry density (MDD) and optimum moisture content (OMC) increased and decreased respectively, with high bamboo leaf ash content. Generally, the unsoaked California Bearing Ratio (CBR) increased from 6.2% to 35% at 0% to 6% bamboo leaf ash content respectively before slightly decreasingto 27.5% at 8% bamboo leaf ash (BLA) treatment of the soil .It generally shows an increase in compressive strength as the percentage replacement with bamboo leaf ash (BLA) increases with less hydration.*
Conclusion: *Based on a general analysis of the results as well as the logical comparison to the acceptable standard, the improvement observed from the properties of the lateritic soil in relation to each test carried out made bamboo leaf ash at 6% optimal stabilization suitable as a stabilizing agent used for various construction purposes such as sub grade and sub base materials for road construction in accordance with AASHTO requirements.*
Key Words: *Soil Stabilization, Lateritic Soil, Bamboo Leaf ash, Soil.*

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I. Introduction

Soil Stabilization is the process by which the engineering properties of soil layers can be improved or treated by addition of other soil types, mineral materials or by mixing the appropriate chemical additive into the pulverized soil and then carrying out compaction **[8].** It is aimed at improving the soil density, increasing its cohesion, frictional resistance and reducing its plasticity index. However, it is a must to obtain adequate relevant information concerning the ground condition and soil properties relative to the gradingof any layer of the soil. Two general techniques of stabilization are mechanical and additive. In mechanical method of soil stabilization, improvement of engineeringproperties of soil is done by the addition of other soil particles which are missing from its natural grading. The soil as a material is made denser by mechanical means and is used as fill in the construction of embankments, earth dams and sub-grade of roads **[5].** In the additive method of soil stabilization, it refers to a manufactured commercial product that, when added to the soil in the proper quantities will improve the quality of the soil. Theseproducts are Portland cement, lime, lime-cement-fly ash, bitumen, alone or in combination. The selection of these products depends upon the soil classification and degree of improvement in soil quality desired **[6]**. Laterites are reddish brown well-graded and sometimes extend to depth of several tens of meters. They are found almost everywhere in the tropics with wide applications in the construction industries. Earth has been one of thesoils used in construction of houses in Nigeria from time immemorial and found to be efficient **[2].**

II. Material And Methods

Description of Study Site:

The bamboo leaves and the lateritic soil samples were collected within The Federal University of Technology Akure (FUTA) premises in Akure City, which is located in the south western region of Nigeria. Akure is geographically referenced on coordinate lines of 734393E, 808614N on the western part and 737291E, 806714N on the Eastern part of meridians. Down toward the south is Aule Community; up in its north is Ipinsa Community whose lands interpose by Akure-Ilesa Express way; on the west Ilara and Ibule settlements while to the east is southern region of Akure Metropolis. The lateritic soil used for this study was obtained along new west gate road of the institution.

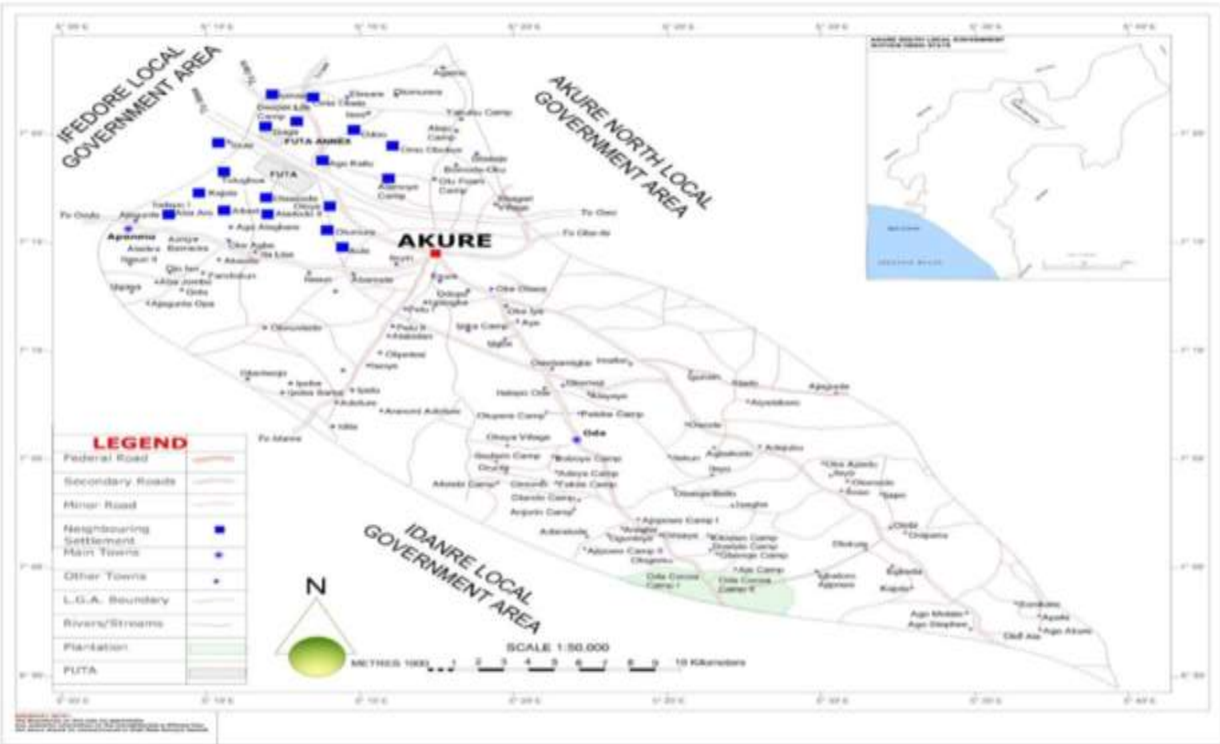

Figure 1.0: Map Showing Location of the Research Area

Soil Investigation/ Field Work:

The materials used for this research are; Lateritic soil sample, bamboo leaf ash sample and water. The lateritic soil sample used in this study was obtained along new West gate road, Federal University of Technology, Akure (FUTA), Ondo State. The soil sample was a disturbed soil sample taken at a depth of between 600mm and 750mm, this was achieved with the help of a digger and spade. The digger was used to remove the top agricultural soils up to a depth of 750mm which is the depth where engineering soils can be taken for test. Immediately the engineering soil was noticed, it was packed into polythene bags to preserve its natural moisture content.

The bamboo leaves samples used as stabilizing agent were collected from Federal University of Technology, Akure (FUTA), close to student union building of the institution and was prepared at the same institution (FUTA). After the bamboo leaf ash has been gotten, it was stored in a cool and dry place away from weather effect. Potable water treated in the laboratory was used for the test carried out during this study.

For the purpose of this study, bamboo leaves were collected from Federal University of Technology, Akure (FUTA), close to student union building of the institution. The bamboo leaf sample was collected in large quantities and was prepared through the following processes;

i. Keeping/storing the collected sample in a cool dry place for few weeks to ensure total dryness of the sample.

ii. Heating and burning the dry bamboo leaves to ashes with the aid of control heat regulating furnace at 550-degree centigrade control temperature.

After the preparation of the bamboo leaf ash, lateritic soil was collected from FUTA environment and oven dried. On this oven dried sample different tests were carried out.

Test Carried Out

Generally, the procedures used in carrying out the underlisted tests were in accordance to American Society for Testing and Materials **[4]** specifications and the results was checked using the American Association of State Highway and Transportation officials **[1]** classification. Test experiment carried out could be grouped into two significant categories.

- Preliminary Test

These tests were performed for the purpose of identifying and classifying the soil. These tests were carried out on oven-dried samples. They include grain size distribution (Wet Sieving), Specific gravity, Moisture content and Atterberg limits.

- Engineering Property Test

The purpose of these tests was to analyze the strength performance of the soil alone without admixture (i.e., control), soil-bamboo leaf ash mixture for 0% ,2%, 4%, 6%, and 8% of the bamboo leaf ash content. To effectively carry out these tests, the soil was oven dried, pulverized, and divided into batches before each batch was mixed thoroughly with the various admixture to form a uniform colour, water was then added as required, mixed and then compacted. Tests such as CBR and compaction were performed using the standard proctor compaction energy because this is easily achieved in the field; 0%, 2%, 4%, 6%, and 8% bamboo leaf ash were utilized. The CBR test were performed with 4.5kg surcharge weights, after which they were tested.

III. Results

For the aim of identification, classification and determination of the engineering properties or characteristics of the lateriticsoil sample used for this research work, laboratory tests were carried out on the natural soil sample collected in FUTA. The soil sample was then stabilized with bamboo leaf ash. Below are the results of the respective test carried out on the soil sample.

Moisture Content Test Result

The weight of empty can, weight of empty can + wet soil sample and weight of empty can + dry soil sample are shown in the table below.

Table 1.0: Natural Moisture Content Result

	Sample A	**Sample B**
Mass of Empty Container, M1 (g)	115.8	91.0
Mass of Empty Container + Moist soil,M_2(g)	4594.0	3450.1
Mass of Empty Container + dry soil,M_3(g)	4448.1	3324.4
Mass of water, Mw + (M_2-M_3) (g)	150.9	125.7
Mass of Dry Soil, Ms =(M_3-M_1) (g)	4332.3	3233.4
Moisture Content (%)	3.48	3.88
Average Moisture Content (%)	3.68	

$\omega = \frac{Mw}{Ms} \times 100\%$

WHERE: Mw= mass of water

Ms = mass of dry soil

From the result, it can be seen that the soil has a natural moisture content of 3.68%.

Specific Gravity Test Result

The weight of the oven dried sample = 50g.

Table 2.0: Specific Gravity Test Result

Bottle label	**Sample A**	**Sample B**
Mass of Empty bottle, M1 (g)	313.6	313.6
Mass of bottle + dry soil, M2 (g)	363.6	363.6
Mass of bottle + soil +water M3(g)	640.9	640.9
Mass of bottle +soil + water filled up to brim, M4 (g)	610.0	609.84
Specific gravity, Gs	2.62	2.64

average specific gravity	2.63

Where;

$$Gs = \frac{M2 - M1}{(M4 - M1) - (M3 - M2)}$$

The value of the specific gravity for the lateritic soil used for the test was found to be 2.63, which is in the range of specific gravity for lateritic soils.

Grain Size Distribution Test Result

Result of the particle size analysis is given in table 4.3 below:

Weight of oven dried sample = 400g

Weight of lateritic soil soaked in water for 24 hours = 400g

Weight of sample retained = (weight of sieve +sample) – (weight of sieve)

Percentage retained = $\frac{WEIGHTOFSAMPLERETAINED}{TOTALWEIGHT} \times 100\%$

Percentage passing =100% $- PERCENTAGERETAINED$

Percentage finer = 100% - percentage passing

Table 3.0: Grain Size Distribution Result

Sieve Sizes	Mass Retained	Percent Retained %	Cumulative Percent Retained(%)	Cumulative Percent Finer (%)
4.75	29.5	7.365792759	7.365792759	92.63420724
2.36	43.3	10.81148564	18.1772784	81.8227216
1.7	9.4	2.347066167	20.52434457	79.47565543
1.18	18.2	4.5443196	25.06866417	74.93133583
0.6	24.4	6.092384519	31.16104869	68.83895131
0.5	17.1	4.269662921	35.43071161	64.56928839
0.425	1.1	0.274656679	35.70536829	64.29463171
0.212	39.6	9.887640449	45.59300874	54.40699126
0.15	16.6	4.144818976	49.73782772	50.26217228
0.075	14.4	3.595505618	53.33333333	46.66666667
Pan	186.9	46.66666667	100	0
Total	400	100		

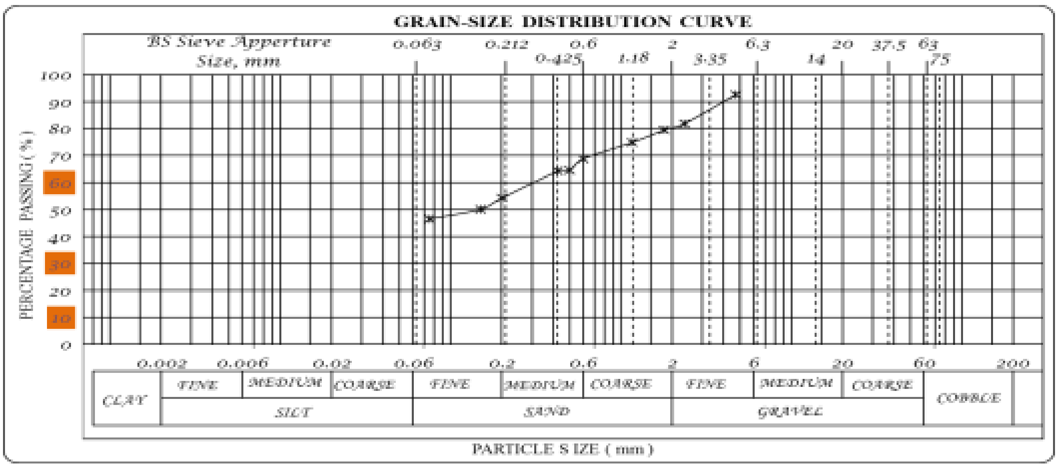

Figure 2.0:Particle size distribution curve for the soil sample

Atterberg Limit Test Result

Table 3.0: Effect of the Various Percentage of Bamboo Leaf Ash on Atterberg's Limit

PERCENTAGE MIX	LIQUID LIMIT (%), LL	PLASTIC LIMIT (%), PL	PLASTICITY INDEX (%), PI
0	40	23.57	16.43
2	38	22.08	15.92
4	33.2	21.49	11.71
6	32	20.098	11.90
8	31	19.375	11.623

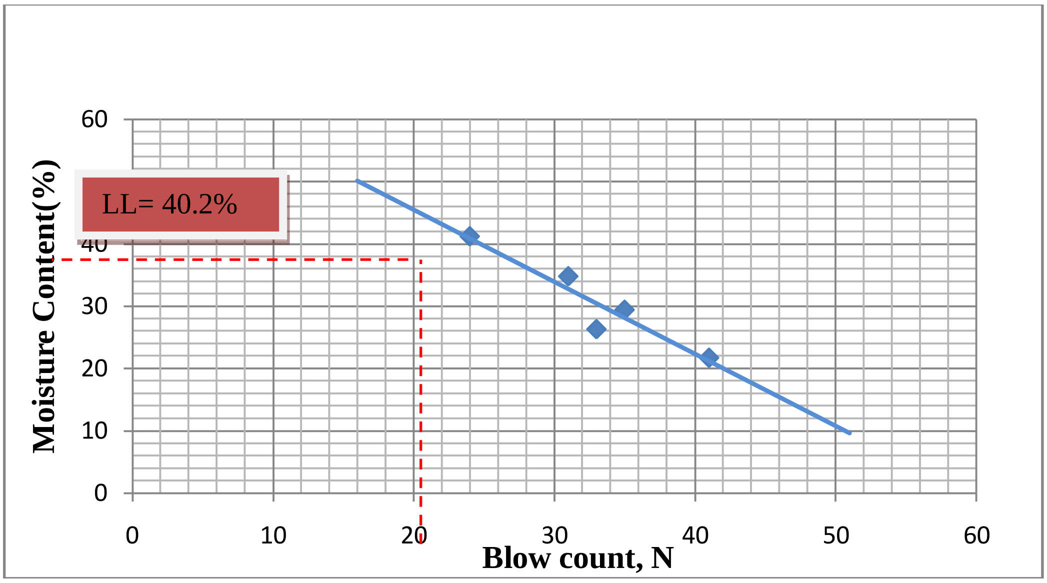

Figure 3.0: Graph of Liquid Limit for 0% bamboo leaf ash.

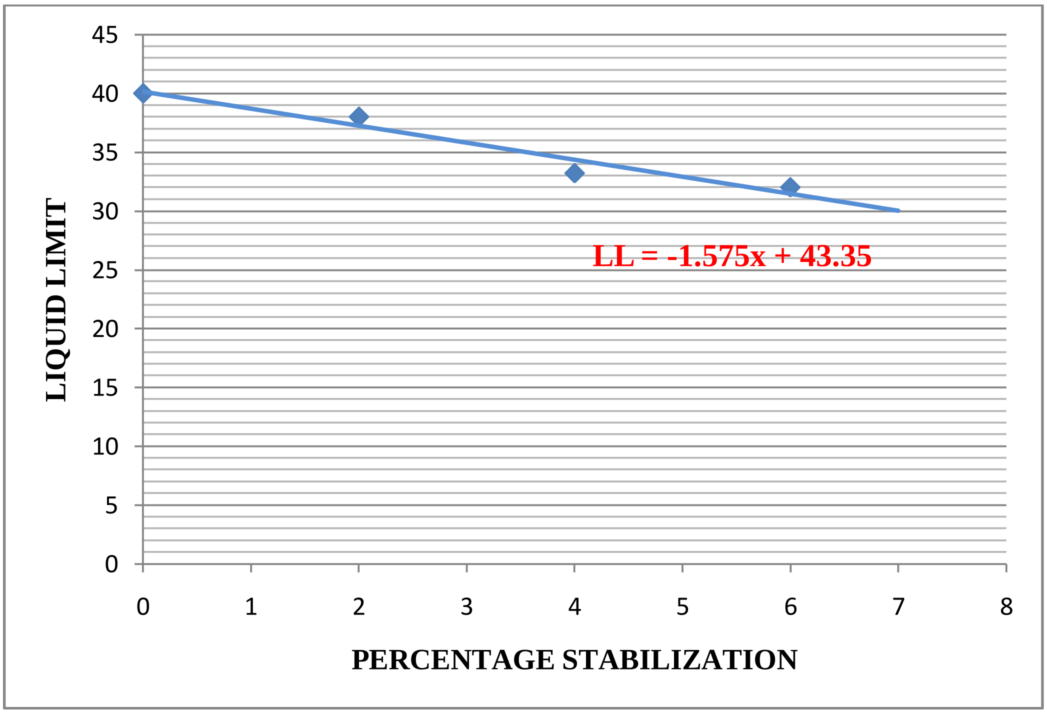

Figure4.0: Graph showing variation of liquid limit for the various bamboo leaf ash samples.

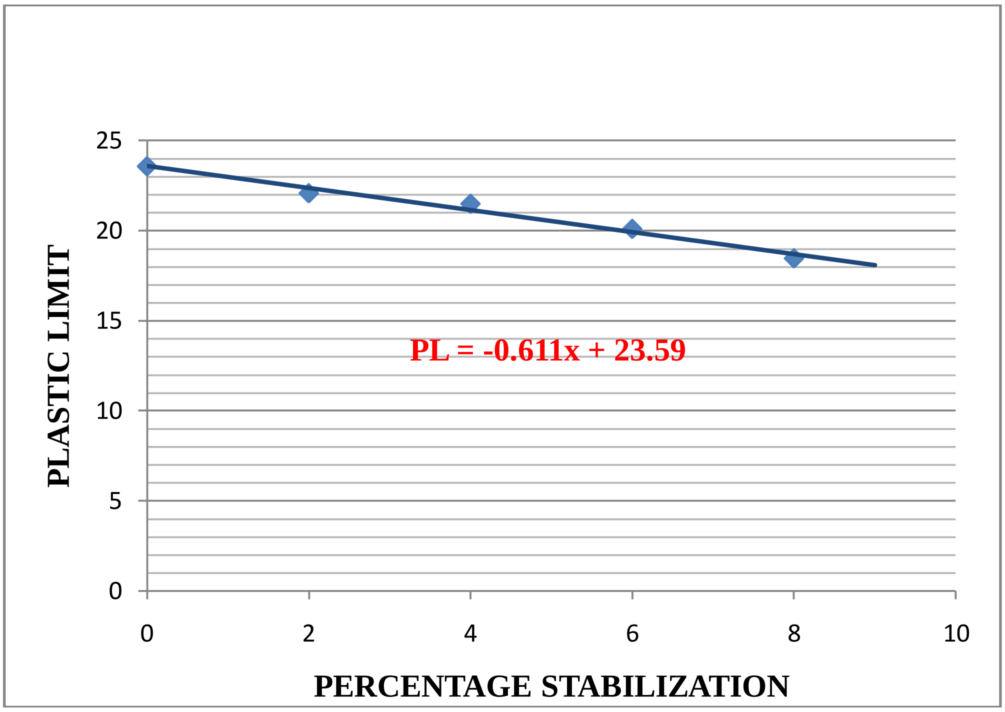

Figure 5.0: Graph showing variation of plastic limit for the various bamboo leaf ash samples.

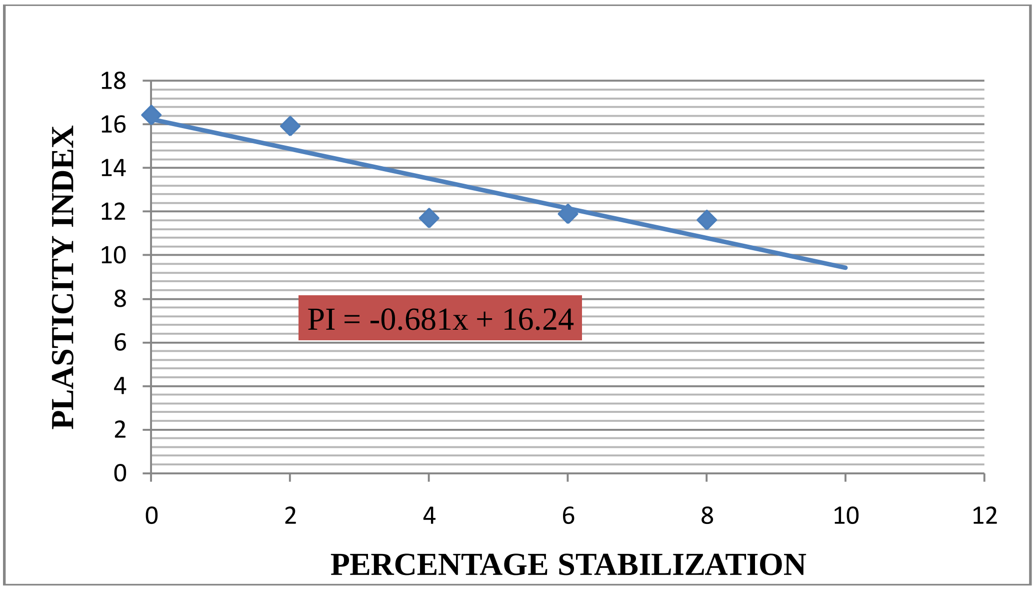

Figure 6.0: Graph showing variation of plasticity index for the various bamboo leaf ash samples.

Compaction Test Result

Table 4.0: Effect of Bamboo leaf ash on the MDD and OMC of the Soil

S/N	PERCENTAGE STABILIZATION (%)	MAXIMUM DRY DENSITY (g/cm^3), MDD	OPTIMUM MOISTURE CONTENT (%), OMC
1	0	1.845	13.6
2	2	1.82	11.15
3	4	1.75	15.52
4	6	1.9	15.76
5	8	1.86	17.49

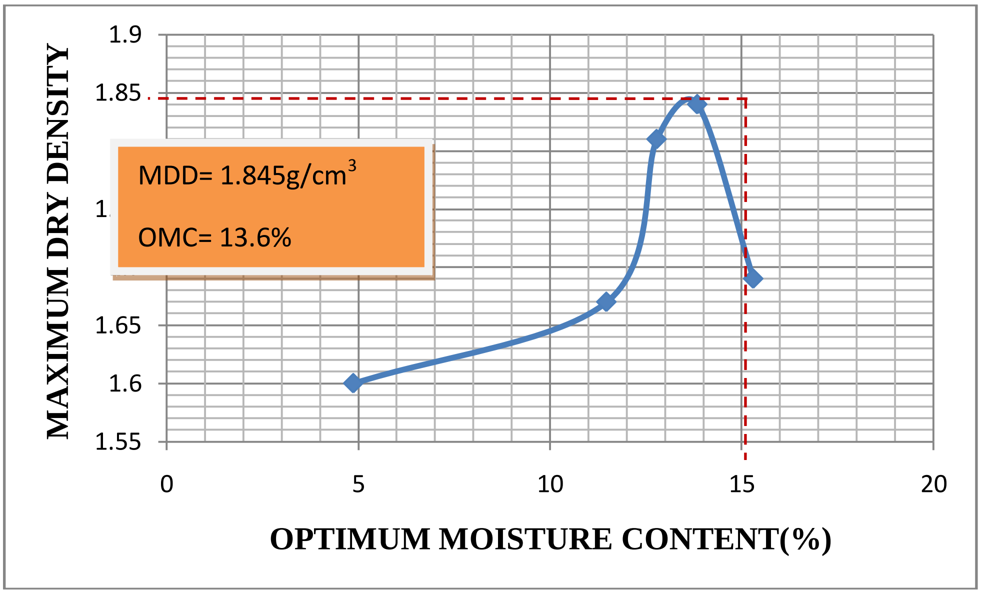

Figure 7.0: Graph of Dry Density against Moisture Content for 0% bamboo leaf ash.

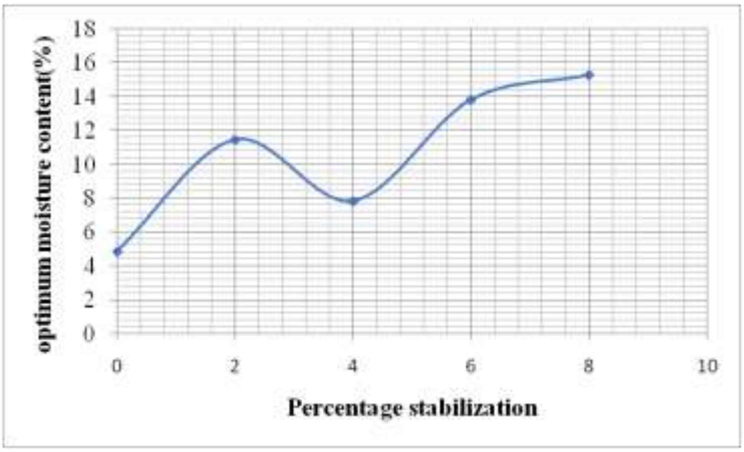

Figure 8.0: Graph Showing Variation of Optimum Moisture Content with percentage stabilization of bamboo leaf ash.

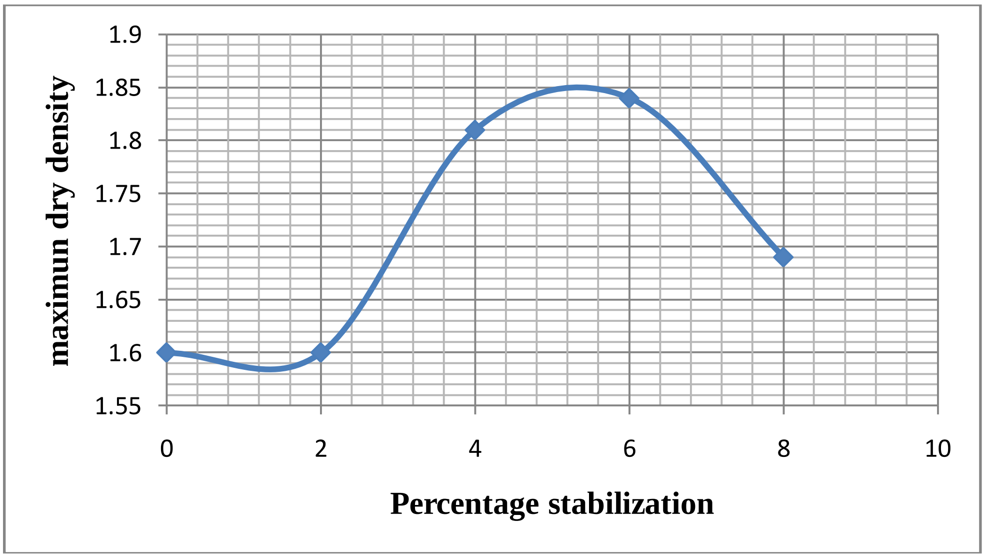

Figure 9.0: Graph Showing the Variation of Maximum Dry Density with percntage stabilization of bamboo leaf ash.

California Bearing Ratio Test Result (C.B.R)

Table 5.0: Table Showing the Effect of the Bamboo Leaf Ash on the California Bearing Ratio for the A-6 Lateritic Soil

S/N	PERCENTAGE STABILIZATION(%)	CBR VALUES (%)
+	0	6.2
2	2	13.0
3	4	14.3
4	6	35.0
5	8	27.5

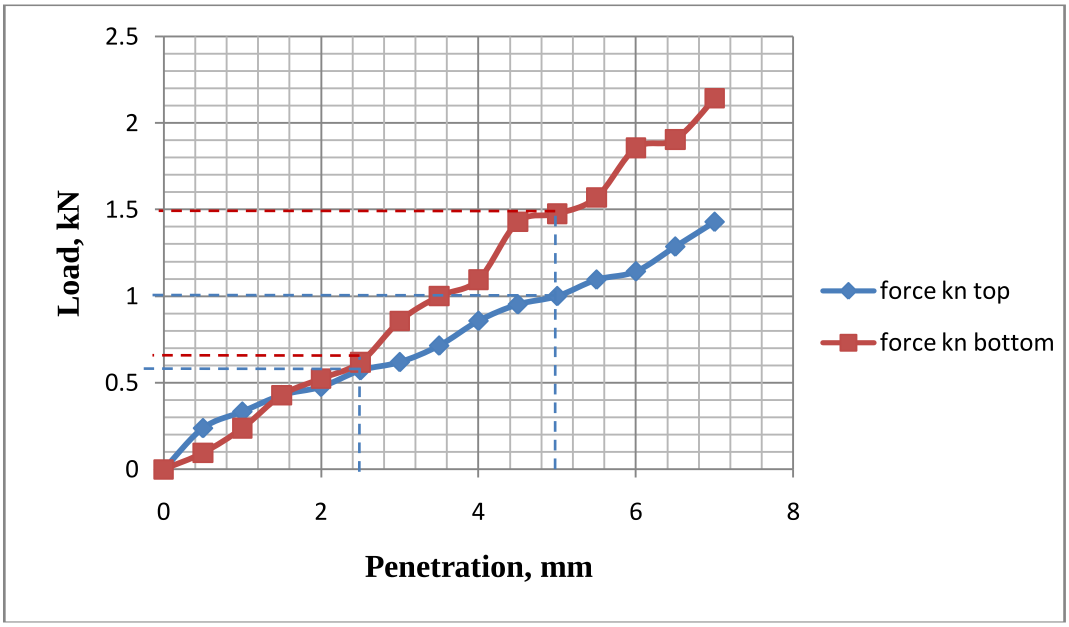

Figure 10: Graph of California Ratio Values for 0% Bamboo Leaf Ash.

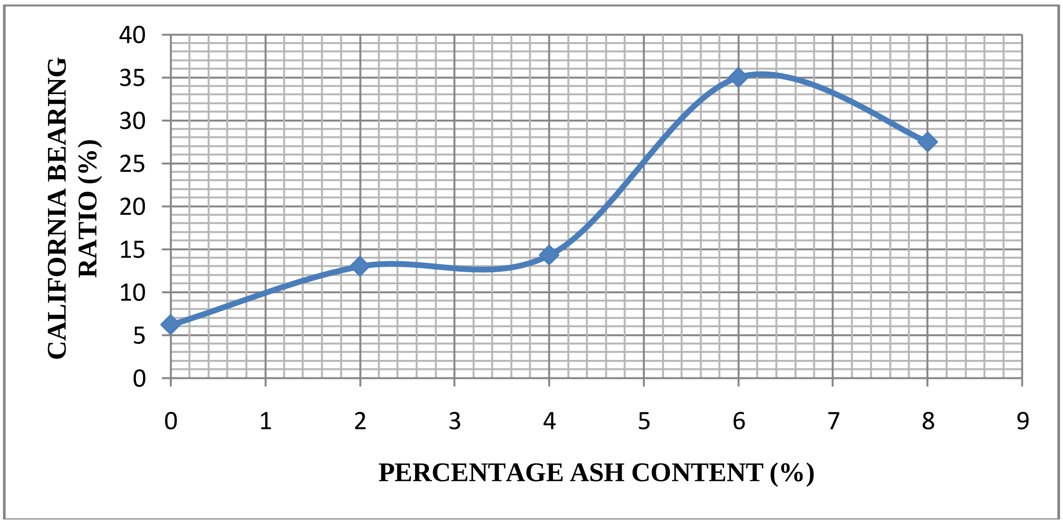

Figure 11: Graph Showing the Variation of CBR values with the Various Percentage Ash Content.

IV. Discussion of Results

For the purpose of identification, classification and determination of the engineering properties or characteristics of the lateritic soil used for this research work, laboratory tests were carried out on the natural soil sample collected in FUTA. The soil sample was then stabilized with bamboo leaf ash. Below are the results discussion of the respective test carried out on the soil sample;

From the result shown in Table 1.0 and Table 2.0, the soil has a natural moisture content of 3.68% and the value of the specific gravity for the lateritic soil used for testing was found to be 2.63, which is in the range of specific gravity for lateritic soils. The result shows that the lateritic soil is poorly graded because it does not vary uniformly among the particles sizes present. The silt content is low and the percentage by weight of sand is quite high and fairly well distributed.

It was confirmed in this study from the result gotten from Table 3.0 that the addition of the bamboo leaf ash to the soil generally reduces the liquid limit from natural value of 40% consistently to 31% and on getting to 8%, it reduces the plastic limit from natural value of 23.57% to 19.375% at 8% and finally caused a reduction in the plasticity index of the soil from 16.43% natural value to 11.623% at 8%. Also, the different graphs showing the effect of bamboo leaf ash on the liquid limit, plastic limit and plasticity index are shown in the results gotten from the tests.

When the values gotten from the result were slotted into the AASHTO soil classification system (Highway Research Board Classification System), a soil corresponding to group classification A-6 (4) was obtained. Thus, the soil has 'Fair to Poor' drainage characteristics and a 'Fair to Poor' general rating as a sub-grade material.

The variation in maximum dry density and moisture content with increase in bamboo leaf ash content are shown below in Table 4.0 with its curve shown in Fig. 7.0. It was observed that the addition of bamboo leaf ash had considerable effect on the optimum moisture content, increasing its value from 11.15% to 15.52%, 15.76% and 17.4% due to finest of the bamboo leaf ash particles.

It was also observed that bamboo leaf ash reduced the maximum dry densities considerably though inconsistent at 6% i.e., from 1.845g/cm3 to 1.82g/cm3, 1.75g/cm3, 1.90g/cm3 and 1.86g/cm3. **[7]** attributed this behavior to the grain size distribution, the specific gravity of the soil and the stabilizer used, which in this case is bamboo leaf ash. He said; fine grained soils have a tendency to decrease in maximum dry density. The introduction of bamboo leaf ash initially causes the soil to form large aggregates which occupy larger spaces and tends to increase the dry density, but the low specific gravity of bamboo leaf ash makes this impossible, since the specific gravity of bamboo leaf ash (which is 2.2) is less than that of the soil (which is 2.59) hence, the maximum dry density tends to reduce.

The CBR result of the soil under study is given in Table 5.0 for the various percentage bamboo leaf ash specimen. It can be seen from the table that there is a significant increase in the unsoaked CBR value from natural value of 6.2% to 12.996%, 14.31%, 34.996% before it drops to 27.48% at 0%, 2%, 4%, 6% and 8% respectively for the bamboo leaf ash content. It can be seen that the natural soil is grossly unstable but with the bamboo leaf ash stabilization, a little improvement was achieved thus improving the soil to the sub base level with a CBR value of 35%. The variation of the CBR values and with the bamboo leaf ash content is shown clearly in the results gotten.

V. Conclusion

The results obtained from this research which was discussed in (iv) above to ascertain the suitability of bamboo leaf ash as a stabilizing agent or pozzolan led to the following conclusions:

(a) Compaction test show that increase in percentage of bamboo leaf ash led to increase in both OMC and MDD of the soil as the bamboo leaf ash content increased to optimum bamboo leaf ash percentages suitable for stabilization.

(b) The California Bearing Ratio (CBR) values increase from 6.2% at 0% ash content to 35% at 6% ash content. This improvement in its properties made it suitable for various construction purposes such as: sub grade and sub base of roads and fillings in accordance with AASHTO requirements.

(c) There is reduction in the plasticity of the soil. Also, the linear shrinkage decreases while the shrinkage limit increases as the bamboo leaf ash content increases.

(d) Optimal strength was achieved at 6% bamboo leaf ash content.

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