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COMPARATIVE ON STRENGTH VARIANCE OF CEMENT / LIME WITH COSTUS AFER BAGASSE FIBRE ASH STABILIZED LATERITIC SOIL

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ABSTRACT

This study investigated and evaluated the engineering properties of an expansive lateritic soil with the inclusion of cement / lime and costus afer bagasse fibre ash (locally known as bush sugarcane fibre ash(BSBFA) with ratios of laterite to cement, lime and BSBFA of 2.5% +2.5%, 5.0% + 5.0%, 7.5% + 7.5% and 10% + 10% to improve the values of CBR of less than 10% and termed poor on remarks required subgrade and strength fo constructional works. Compaction test results of maximum dry density (MDD) and optimum moisture content (OMC) of soil at natural state of 100%, soil + cement + BSBFA and lime + BSBFA treated lateritic soil with inclusion of soil percentage ratios to cement ,lime and BSBFA of ratios of cement / lime and (BSBFA). MDD of 0% at 1.803KN/m^3 increased to 1.860KN/m^3 (laterite + cement + BSBFA) and 1.803KN/m^3 and 1.838KN/m^3. (laterite + Lime + BSBFA) with 1.196% higher of cement combination difference. OMC values of clay / laterite + cement + BSBFA increased from 11.79% to 14.02% (cement) and 11.79% to 12.405% (lime) with 18.91% higher of cement and BSBFA treated laterite. CBR results of laterite + cement / lime + bagasse fibre ash (BSBFA) treated laterite soil increased from 9.8% to 35.3% and to 32.2% respectively, with 9.6% higher strength of cement treated, both showed tremendous strength increased at optimum ratio of 85% + 7.5% + 7.5% of soils + cement / lime + BSBFA. Results of UCS of laterite + cement / lime + BSBFA treated soil, increased from 155kPa to 984kPa and 299.1kPa respectively with 228.9% higher of cement to lime combinations at optimum inclusion percentage of 85% (laterite) + 7.5% (cement / lime) + 7.5 (BSBFA). Beyond this specified percentage combination, crack was noticed and strength. Results of soil + cement / lime + BSBFA treated soil IP decreased from 22.8% to 19.5%.and 15.8% , with higher value by 23.42% in cement treated to lime. The entire results showed both cement and lime with BSBFA showed tremendous strength increased with cement treated at the peak in comparison.

Key Words: Clay and lateritic soils, Costus Afer Fibre , CBR, UCS, Consistency, Compaction

1.0 INTRODUCTION

Deltaic soils are deposits found in the plain land of the Niger Delta region of South-South part of Nigeria. They have been found to differ noticeably from the other more matured lateritic soils on which most previous reported studies have concentrated. They are derived from much more recent (younger) non-crystalline parent materials commonly referred to as the coastal plain sand obviously deficient in chemically degradable rock-forming minerals such as feldspars, which are the major contributors to laterization process. They are formed in a flat terrain (characteristic of the Niger Delta region) hence deficient in two of the three necessary and sufficient conditions for full laterization (Little [1]; Tuncer and Lohnes [2]; Blight [3]; Mitchell and Sitar [4]; Townsend [5]).

They are less matured in the lateritic soil vertical profile and probably much more sensitive to all forms of manipulation that other lateritic soils are known for (Ola [6]; Allamand and Sridharam [7]; Omotosho and Akinmusuru [8]; Omotosho [9])

They do not conform to the widely reported parent-rock-related gradation trend common to other lateritic soils (Ola [6]; Lohnes, Fish, and Daniel [10]; Tuncer and Lohnes [2]; Akpokodje 1986; Omotosho [8]; Leton and Omotosho [11]).They are, however, the most suitable and most widely used soil materials for road earthworks in the entire Niger Delta (Arumala and Akpokodje, [12]). Except in very rare and exceptional cases, soils (including deltaic lateritic soils) in their natural states hardly possess characteristics suitable for desired engineering applications, particularly for road works. The minimum requirements for soils or soil-based materials usable in road pavement structures have been indicated by the FMW Specifications [13]. To achieve the required standards, soils have to be improved before use. Stabilization is an obvious option and could be mechanical (if simply compacted with or without the addition of sand addition), chemical (if compacted with controlled proportions of stabilizing agents, including bitumen, lime and cement), thermal (which could produce dehydrated hard-pans) and even electrical (through, for example, electro-osmosis). Studies have shown the effect of reinforcement on swelling behavior of clays (Puppala and Musenda, [14] reduction of soil swell potential with fibre reinforcement (Loher *et al*. [15]), and effect of fibres on swelling characteristics of bentonite (Banu *et al*., [16]).

Natural fibres have been used to reduce shrinkage cracks in clayey soils without the least environmental nuisances and at almost low performance costs (Sivakumar *et al.* [17]). They are obtained from the waste of palm fruits and have acceptable mechanical properties and durability in natural conditions (Marandi *et al.*, [18]; Zare, [19]). Manikandan and Moganraj [20] , found that the joined impact of bagasse fiery remains and lime were more successful than the impact of bagasse powder alone in controlling the union attributes of broad soil alongside the change in different properties

2.0 MATERIALS AND METHODS

2.1 Materials

2.1.1 Soil

The deltaic soils (laterite) are abundant in Rivers State within the dry flat country. The soils used for the study was collected from a borrow pit at 1.5 m depth, at Odioku – Odiereke Town Road, Ubie Clan, Ahoada-West, Rivers State, Nigeria, lies on the recent coastal plain of the North-Western of Rivers state of Niger Delta.

2.2.2 Cement

The cement used was Eagle Portland Cement, purchased in the open market at Mile 3 market road, Port Harcourt, Rivers State.

2.2.3 Lime

The lime used for the study was purchased in the open market at Mile 3 market road, Port Harcourt.

2.2.4 Costus Afer (Bush Sugarcane) Bagasse Fibre

The bush sugarcane bagasse fibre are abundant in Rivers State farmlands / bushes, they are wide plants and covers larger areas, collected from at Odioku Town Farmland / Bush, Ubie Clan, Ahoada-West, Rivers State, Nigeria.

2.3 METHOD

2.3.1 Sampling Locality

The soil sample used in this study were collected along Odioku Community road in Ahoada West Local Government, in Rivers state, of Nigeria, (latitude 5.07° 14‘S and longitude 6.65° 80‘E), from trial borrow-pits the various earthworks within the entire roads. The top soil was removed to a depth of 0.5 m before the soil samples were taken, sealed in plastic bags and put in sacks to avoid loss of moisture during transportation. All samples were air dried for about two weeks to take advantage of the aggregating potentials of lateritic soils upon exposure (Allam and Sridharan [7]; Omotosho and Akinmusuru [8]) .

These tests were conducted to prove that fibre product at varying proportions to give positive effect on the stabilization of soil and with binding cementitious inclusions. A number of tests were conducted as these tests include (1) Moisture Content Determination (2) Atterberg limits test (3) Particle size distribution (sieve analysis) and (4) Standard Proctor Compaction test, Califonia Bearing Ratio test (CBR) and Unconfined compressive strength (UCS) tests;

2.3.1 Moisture Content Determination

The natural moisture content of the soil as obtained from the site was determined in accordance with BS 1377 (1990) Part 2. The sample as freshly collected was crumbled and placed loosely in the containers and the containers with the samples were weighed together to the nearest 0.01g.

2.3.2 Grain Size Analysis (Sieve Analysis)

This test is performed to determine the percentage of different grain sizes contained within a soil. The mechanical or sieve analysis is performed to determine the distribution of the coarser, larger-sized particles.

2.3.3 Atterberg Limits

This test is performed to determine the plastic and liquid limits of a fine grained soil. The liquid limit (LL) is arbitrarily defined as the water content, in percent, at which a part of soil in a standard cup and cut by a groove of standard dimensions will flow together at the base of the groove for a distance of 13 mm (1/2in.) when subjected to 25 shocks from the cup being dropped 10 mm in a standard liquid limit apparatus operated at a rate of two shocks per second. The plastic limit (PL) is the water content, in percent, at which a soil can no longer be deformed by rolling into 3.2 mm (1/8 in.) diameter threads without crumbling.

2.3.4 Moisture – Density (Compaction) Test

This laboratory test is performed to determine the relationship between the moisture content and the dry density of a soil for a specified compactive effort. The compactive effort is the amount of mechanical energy that is applied to the soil mass. Several different methods are used to compact soil in the field, and some examples include tamping, kneading, vibration, and static load compaction. This laboratory will employ the tamping or impact compaction method using the type of equipment and methodology developed by R. R. Proctor in 1933, therefore, the test is also known as the Proctor test.

2.3.5 Unconfined Compression (UC) Test

The primary purpose of this test is to determine the unconfined compressive strength, which is then used to calculate the unconsolidated undrained shear strength of the clay under unconfined conditions. According to the ASTM standard, the unconfined compressive strength (qu) is defined as the compressive stress at which an unconfined cylindrical specimen of soil will fail in a simple compression test. In addition, in this test method, the unconfined compressive strength is taken as the maximum load attained per unit area, or the load per unit area at 15% axial strain, whichever occurs first during the performance of a test.

2.3.6 California Bearing Ratio (CBR) Test

The California Bearing Ratio (CBR) test was developed by the California Division of Highways as a method of classifying and evaluating soil- subgrade and base course materials for flexible pavements. CBR is a measure of resistance of a material to penetration. The CBR tests were performed in order to determine effect of fibre inclusion on CBR values of reinforced soils.

3.0 RESULTS AND DISCUSSIONS

3.1 Compaction Test Results

Results from table 3.1 enumerated the preliminary results obtained of engineering properties of soil at its natural state before inclusion of cementitious agents of cement, lime and Bush Sugarcane Fibre Ash (BSBFA) for comparison evaluations.

Tables 3.2 and 3.3 showed the experimental results of the properties and composition of Bush Sugarcane Fibre Ash (BSBFA) and table 3.4, showed the oxides composition with the attributes of cement and lime.

Table 3.5 and figure 3.1 showed the compaction test of maximum dry density (MDD) and optimum moisture content (OMC) of soil at natural state of 100%, soil + cement + BSBFA and lime + BSBFA treated lateritic soil with inclusion of soil percentage ratios to cement ,lime and BSBFA of ratios 2.5% +2.5%, 5.0% + 5.0%, 7.5% + 7.5% and 10% + 10% of cement / lime and (BSBFA).

MDD of 0% was 1.803KN/m^3 and increased to 1.860KN/m^3 (laterite + cement + BSBFA) and and 1.803KN/m^3 and 1.838KN/m^3. (laterite + Lime + BSBFA) with 1.196% higher in cement combination difference. OMC values of clay / laterite + cement + BSBFA increased from 11.79% to 14.02% (cement) and 11.79% to 12.405% (lime) with 18.91% higher in cement and BSBFA treated laterite.

3.2 California Bearing Ratio (CBR) Test

CBR results of laterite + cement / lime + bagasse fibre ash (BSBFA) treated laterite soil increased from 9.8% to 35.3% and to 32.2% respectively, with 9.6% higher strength in cement treated, both showed tremendous strength increased at optimum ratio of 85% + 7.5% + 7.5% of soils + cement / lime + BSBFA.

3.3 Unconfined Compressive Strength Test

Results of UCS of laterite + cement / lime + BSBFA treated soil, increased from 155kPa to 984kPa and 299.1kPa respectively with 228.9% higher of cement to lime combinations at optimum inclusion percentage of 85% (laterite) + 7.5% (cement / lime) + 7.5 (BSBFA). Beyond this specified percentage combination, crack was noticed and strength.

3.4 Consistency Limits Test

Results of soil + cement / lime + BSBFA treated soil IP decreased from 22.8% to 19.5%.and 15.8% , with higher value by 23.42% in cement treated to lime.

Table 3.1: Engineering Properties Of Soil Samples

		(Laterite)
Percentage(%) passing BS sieve #200		36.8
Colour		Reddish
Specific gravity		2.40
Natural moisture content (%)		31.2
Atterberg limits		
Liquid limit (%)		44.5
Plastic limit (%)		18.3
Plasticity Index		26.1
AASHTO soil classification		A-2-6
Compaction characteristics		
Optimum moisture content (%)		11.79
Maximum dry density (kN/m$^{3)}$		1.803
Grain size distribution		
Gravel (%)		5
Sand (%)		20
Silt (%)		38
Clay (%)		37
Unconfined compressive strength (kPa)		155
California Bearing capacity (CBR)		
Unsoaked (%) CBR		9.8
Soaked (%) CBR		9.2

Table 3.2: Properties of Bush sugarcane bagasse fibre. (Rivers State University of Science and Technology, Chemical Engineering Department, Material Lab.1)

Property	Value
Fibre form	Single
Average length (mm)	150
Average diameter (mm)	0.5
Tensile strength (MPa)	60 - 23
Modulus of elasticity (GPa)	1.1 – 0.35
Specific weight (g/cm^3)	0.52
Natural moisture content (%)	8.8
Water absorption (%)	150 - 223

Source, 2018

Table 3.3: Composition of Bagasse. (Rivers State University of Science and Technology, Chemical Engineering Department, Material Lab.1)

Item	%
Moisture	49.0
Soluble Solids	2.3
Fiber	48.7
Cellulose	41.8
Hemicelluloses	28
Lignin	21.8

Source, 2018

Table 3.4: Oxides Composition of Bagasse Ash (Rivers State University of Science and Technology, Chemical Engineering Department, Material Lab.1)

Oxide	Composition (%)
SiO2	57.95
Al2O3	8.23
FeO3	3.96
CaO	4.52
MgO	4.47
K2O	2.41
LOI*	5.0

Source, 2018

Table 3.5: Results of Subgrade Soil (Lateritic) Test Stabilization with Binding Cementitious Products at Different percentages and Combination

\`S/no	Description of materials Bush sugarcane bagasses fibre products	MDD (kN/m^3)	OMC (%)	CBR (%)	LL(%)	PL(%)	PI(%)	SIEVE #200	AASHTO Class	Remarks
					LATERITE					
1	LATERITE 100%	1.803	11.78	9.8	39	22	17	36.8	A-2-6	POOR
	LATERITE + LIME + BSBFA									
7	LATERITE 95%+ LIME 2.5% +BSBFA 2.5%	1.831	11.20	20.15	43.9	22	21.9	36.8	A-2-6	GOOD
8	LATERITE 90%+ LIME 5% +BSBFA 5%	1.833	12.40	27.40	44.3	23.8	20..5	36.8	A-2-6	GOOD
9	LATERITE 85%+ LIME 7.5% +BSBFA 7.5%	1.837	13.71	32.20	45.8	25	20.8	36.8	A-2-6	GOOD
10	LATERITE 80%+ LIME 10% +BSBFA 10%	1.831	14.53	19.80	46.7	27	19.7	36.8	A-2-6	GOOD
	LATERITE + CEMENT + BSBFA									
7	LATERITE 95%+ CEMENT 2.5% +BSBFA 2.5%	1.858	12.61	21.30	44.8	22	22.8	36.8	A-2-6	GOOD
8	LATERITE 90 %+ CEMENT 5% +BSBFA 5%	1.860	14.03	28.14	45.9	24.2	21.7	36.8	A-2-6	GOOD
9	LATERITE 85%+ CEMENT 7.5% +BSBFA 7.5%	1.850	16.45	35.30	46.9	25.6	21.3	36.8	A-2-6	GOOD
10	LATERITIE 80%+ CEMENT 10% +BSBFA 10%	1.846	17.89	27.30	45.6	26.1	19.5	36.8	A-2-6	GOOD

Table 3.6: Unconfined Compressive Strength (UCS) Test Summary Results

S/NO	DESCRIPTION OF MATERIALS BUSH SUGARCANE BAGASSES FIBRE PRODUCTS	2 DAYS CURING PERIODS	7 DAYS CURING PERIODS	14 DAYS CURING PERIODS	21 DAYS CURING PERIODS	28 DAYS CURING PERIODS
CLAY						
1	LITERITE 100% + LIME 0%	155	155	155	155	155
LITERITE + LIME + BSBFA						
2	LITERITE 95%+ LIME 2.5% +BSBFA 2.5%	214.1	221.3	236.1	253.1	268.1
3	LITERITE 90 %+ LIME 5% +BSBFA 5%	234.1	248.1	256.1	256.1	273.1
4	LITERITE 85%+ LIME 7.5% +BSBFA 7.5%	256.6	259.1	267.4	283.1	299.1
5	LITERITE 80%+ LIME 10% +BSBFA 10%	236.3	253.1	271.2	286.5	289.5
	LITERITE					
1	LITERITE 100% + CEMENT 0%	155	155	155	155	155
	CLAY + CEMENT + BSBFA					
2	LITERITE 95%+ CEMENT 2.5% +BSBFA 2.5%	478	493	515	533	553
3	LITERITE 90 %+ CEMENT 5% +BSBFA 5%	735	752	770	794	805
4	LITERITE 85%+ CEMENT 7.5% +BSBFA 7.5%	914	930	948	963	984
5	LITERITE 80%+ CEMENT 10% +BSBFA 10%	785	816	835	856	874

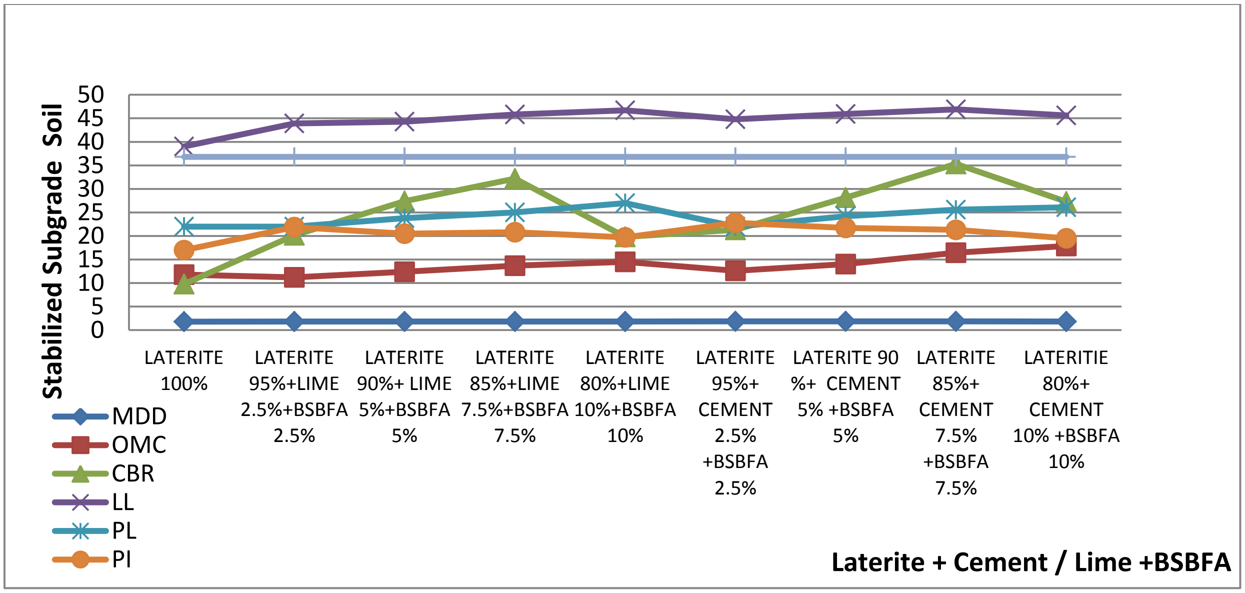

Figure 3.1: Subgrade Stabilization Test of Lateritic Soil from Odioku in Ahoada-West L.G.A of Rivers State with Cement / Lime + BSBFA at Different Percentages and Combinatio

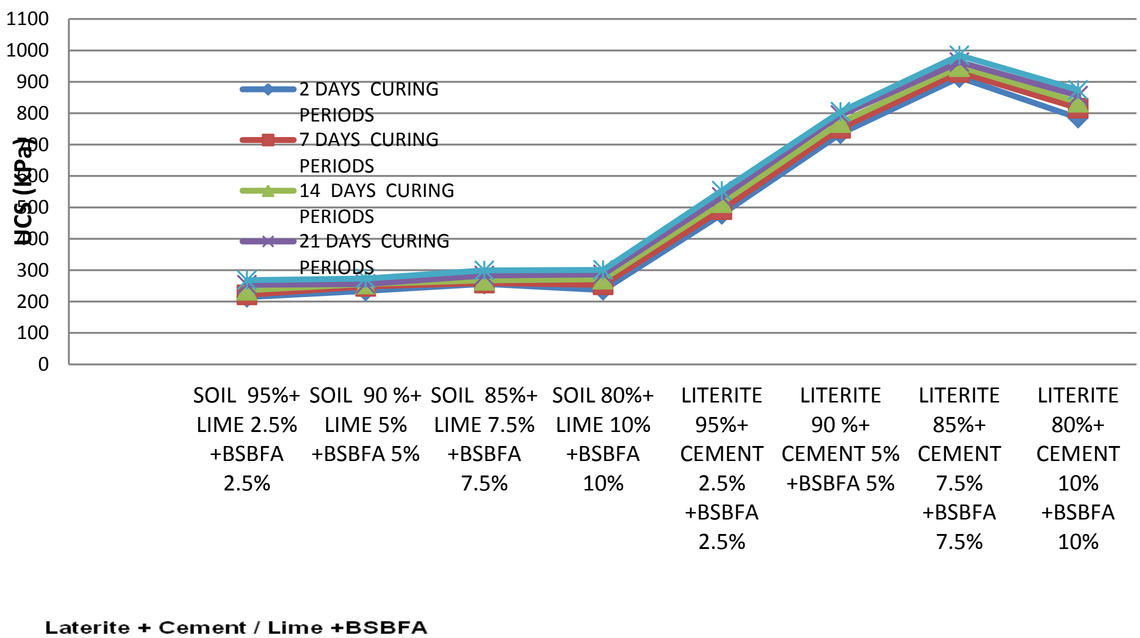

Figure 3.2: Unconfined Compressive Strength (UCS) of Lateritic Soil from Odioku in Ahoada-West L.G.A of Rivers State with Cement / Lime and BSBFA at Different Percentages and Combinations

4.0 Conclusions

The following conclusions can be made from the final investigations:

i. Bagasse ash proved to be a good pozzolana in soil stabilization and modification.

ii. The entire results showed the potential of using bagasse BSBF and BSBFA as admixture in cement and lime treated soils of clay and laterite with 8 % cement and lime and 7.5% +7.5 % of cement / lime + BSBFA

iii. At 8% of both cement and lime, CBR values reached optimum, beyond this range, cracks exist and 7.5% cement and lime+ 7.5% BSBFA, and 7.25% cement and lime+ 0. 7.5% BSBF, optimum value are reached.

iv. The entire results showed the potential of using bagasse, BSBFA as admixtures in cement and lime treated soils of laterite.

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