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PROBLEMATIC SOILS MODIFICATION USING COSTACEAE LACERUS BAGASSE FIBRE AS SOIL STABILIZER

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ABSTRACT

Niger Deltaic soils are known with unique attributes of swelling and shrinkage potentials that have resulted to poor life span of road pavement. This study investigated the effective use of costaceae lacerus bagasse fibre (CLBF) as soil stabilizer/ reinforcement. Results of preliminary investigations of soils at natural state are percentage (%) passing BS sieves #200 are 28.35%, 40.55%, 36.85%, 33.45% and 39.25% (laterite), and soils classified as A-2-6 SC and A-2-4 SM on the AASHTO classification schemes / Unified Soil Classification System and CBR values of 8.7%,8.5%, 7.8%, 9.4% and 10.6% (unsoaked) and 8.3%, 7.8%, 7.2%, 8.5% and 9.8 %, (unsoaked) and fell below minimum requirement for such application and needs stabilization to improve its properties. Results showed the potential of using fibre bagasse (CLBF) as admixtures in lateritic soil stabilization with 0.2%, 0.4%, 0.6%, 0.8% and 1.0% inclusion. Swelling potential of treated soils decreased with the inclusion of fibre bagasse up to 0.75% for soils The plastic index of the stabilized soil showed continuous decreased with increased in fibre percentages. Compaction test results recorded decreased values of MDD with increased values while OMC increases with increased in fibre percentages. An optimum values percentage inclusion at 0.75% was recorded of CBR at both unsoaked and soaked, beyond this value, a decreased recorded which indicated maximum inclusion, crack was formed which resulted to potential failure state. The entire results showed good potential of using Bush sugarcane bagasse fibre as soil stabilizer.

Key Words: Lateritic soils, Costaceae Lacerus, CBR, UCS, Consistency, Compaction

1.0 Introduction

Soils in the Niger delta region of Nigeria are mainly lateritic and clayey and are known to posses deceptive characteristics of swelling and shrinkage potentials during rainy and dry seasons, which are in terms of construction, do not conform to FMW Specifications ([1]). 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).

Charles *et al*. [2] investigated the effectiveness of natural fibre, costus afer bagasse (Bush sugarcane bagasse fibre (BSBF) as soil stabilizer / reinforcement in clay and lateritic soils with fibre inclusion of 0.25%, 0.50%, 0.75% and 1.0%. They concluded that both soils decreased in MDD and OMC with inclusion of fibre percentage, CRB values increased tremendously with optimum values percentage inclusion at 0.75%, beyond this value, crack was formed which resulted to potential failure state.

Prabakar and Sridhar [3] studied on soil specimens reinforced with sisal fibres showed that both fibre content and aspect ratio have important influences in shear strength parameters (c, ∅). They observed that an optimum value for the fibre content exists such that the shear strength decreases with increasing fibre content above this optimum value

Sharma *et al*. [4] studied the geotechnical behavior of remoulded expansive clay mixed with lime, calcium chloride, and rice-husk ash (RHA). The effect of additives on California bearing ratio (CBR) was reported. They observed the optimum CBR value at 12% RHA content in the presence of either lime (4 %) or calcium chloride (1%).

Bouhicha *et al*. [5] used the shear box test method to evaluate the strength of compacted earth reinforced with barley straw. Their work was part of a wider study of the physical and mechanical properties of fibre-reinforced compressed earth blocks. Their test results are showed that a 1.5 and 3.5 % (by weight of soil) addition of straw increased the apparent cohesion by up to 50 % (from 330 to 493 kPa), but decreased the angle of internal friction.

Sabat [6] studied the effects of polypropylene fiber on engineering properties of RHA-lime stabilized expansive soil. Polypropylene fiber added were 0.5 % to 2 % at an increment of 0.5 %.The properties determined were compaction, UCS, soaked CBR, hydraulic conductivity and P effect of 0 day, 7 days and 28 days of curing ware also studied on UCS, soaked CBR, hydraulic conductivity and swelling pressure. The optimum proportion of Soil: RHA: lime: fiber was found to be 84.5:10:4:1.5.

Mesbah *et al*. [7] carried out tensile tests on soil specimens reinforced with sisal fibres and concluded that the fibres, length and their tensile strength are the most important factors affecting the tensile strength of the soil composite.

Ramakrishna and Pradeep [8] studied combined effects of RHA and cement on engineering properties of black cotton soil. From strength characteristics point of view they had recommended 8 % cement and 10 % RHA as optimum dose for stabilization.

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2.0 Materials and Methods

2.1 Materials

2.1.1 Soil

The soils used for the study were collected from Ubie, Upata and Igbuduya Districts of Ekpeye, Ahoada- East and Ahoada-West Local Government of Rivers State, beside the at failed sections of the Unity linked roads at 1.5 m depth, at Odiokwu Town Road(CH 0+950), Oyigba Town Road(CH 4+225), Anakpo Town Road(CH6+950) , Upatabo Town Road (CH8+650), Ihubuluko Town Road, all of Rivers State, Niger Delta, Nigeria. It lies on the recent coastal plain of the North-Western of Rivers state of Niger Delta.

2.1.2 Costaceae Lacerus Bagasse Fibre

The Costaceae Lacerus bagasse fibre are wide plants, medicinally used in the local areas, abundant in Rivers State farmlands / bushes, they covers larger areas, collected from at Oyigba Town Farmland / Bush, Ubie Clan, Ahoada-West, Rivers State, Nigeria.

2.2 Method

2.2.1 Sampling Locality

The soil sample used in this study were collected along Odioku Town, (latitude 5.07° 14‘N and longitude 6.65° 80‘E), Oyigba Town, (latitude 7.33° 24‘S and longitude 3.95° 48‘E), Oshika Town, latitude 4.05° 03‘N and longitude 5.02° 50‘E), Upatabo Town, (latitude 5.35° 34‘N and longitude 6.59° 80‘E) and Ihubujuko Town, latitude 5.37° 18‘S and longitude 7.91° 20‘E) all in Rivers State, Nigeria.

2.2.2 Test Conducted

Test conducted were (1) Moisture Content Determination (2) Consistency limits test (3) Particle size distribution (sieve analysis) and (4) Standard Proctor Compaction test, California Bearing Ratio test (CBR) and Unconfined compressive strength (UCS) tests;

2.2.3 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.

2.2.4 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.

2.2.5 Consistency Limits

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.

2.2.6 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.

2.2.7 Unconfined Compression (UC) Test

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. 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

2.2.8 California Bearing Ratio (CBR) Test

The California Bearing Ratio (CBR) test was developed by the California Division of Highways as a method of relegating and evaluating soil- subgrade and base course materials for flexible pavements.

3.0 Results and Discussions

Preliminary results on lateritic soils as seen in detailed test results given in Tables: 5 showed that the physical and engineering properties fall below the minimum requirement for such application and needs stabilization to improve its properties. The soils classified as A-2-6 SC and A-2-4 SM on the AASHTO classification schemes / Unified Soil Classification System as shown in table 3.1 and are less matured in the soils vertical profile and probably much more sensitive to all forms of manipulation that other deltaic lateritic soils are known for (Ola [9]; Allam and Sridharan [10]; Omotosho and Akinmusuru [11]; Omotosho [12]). The soils are reddish brown and dark grey in colour (from wet to dry states) plasticity index of 17.30%, 14.23%, 15.20%, 15.50%, and 16.10% respectively for Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Town Roads. The soil has unsoaked CBR values of 8.7%,8.5%, 7.8%, 9.4%, and 10.6% and soaked CBR values of 8.3%, 7.8%, 7.2%, 8.5% and 9.8 %, unconfined compressive strength (UCS) values of 178kPa, 145kPa, 165kPa , 158kPa and 149kPa when compacted with British Standard light (BSL), respectively.

3.1 Compaction Test Results

The results of lateritic soils of Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Town Roads at 100% of maximum dry density (MDD) at preliminary test were 1.954KN/m^3, 1.857KN/m^3, 1.943KN/m^3, 1.758KN/m^3

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and 2.105KN/m^3 with costaceae lacerus bagasse fibre (CLBF) at 0.25%, 0.50%, 0.75%, and 1.0% inclusion decreased to 1.725KN/m^3, 1.685KN/m^3, 1.811KN/m^3, 1.525KN/m^3 and 1.845KN/m^3 respectively. Optimum moisture content of lateritic soils were 12.39%, 14.35%, 13.85%, 11.79 and 10.95% at 100% soils (ie no additives), increased to 14.85%, 16.55%, 18.45%, 15.98% and 14.85% correspondingly.

3.2 California Bearing Ratio (CBR) Test

Table 3.5 and figures 3.1 – 3.4 enumerated the results of lateritic soils at 100% and of fibre bagasse inclusion as 8.7%,8.5%, 7.8%, 9.4% and 10.6% unsoaked and 8.3%, 7.8%, 7.2%, 8.5% and 9.8 %, unsoaked and with fibre inclusion of 0.25%, 0.50%, 0.75% and 1.0% increased to 16.25%. 15.75%, 15.25%, 15.40% and 17.11% (unsoaked) and 13.58%, 13.82%, 13.57%, 13.85% and 15.85% (soaked) respectively, with an optimum values percentage inclusion at 0.75%, beyond this value, crack was formed which resulted potential failure state.

3.3 Unconfined Compressive Strength Test

Table 3.1, 3.4 and figures 3.6 showed the Preliminary and final unconfined compressive strength results of engineering properties of soils from Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Town Roads at 100% and fibre bagasse as 178kPa, 145kPa, 165kPa , 158kPa and 149kPa are and with fibre inclusion increased to 248kPa, 215kPa, 235kPa, 221kPa and 198kPa respectively. Results showed increased in unconfined compressive strength with increased in fibre percentages.

3.4 Consistency Limits Test

Results of consistency limits at 100% lateritic soil were of 17.30%, 14.23%, 15.20%, 15.50%, and 16.10%. For fibre inclusion as shown in table 3.5, decreased to 12.20%, 6.67%, 8.9%, 8.07% and 7.48% respectively. The results showed continuous decreased with increased in fibre percentages

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Table 3.1: Engineering Properties of Soil Samples

Location Description	Odiokwu Town Road (CH 0+950)	Oyigba Town Road (CH 4+225)	Anakpo Town Road (CH6+950)	Upatabo Town Road (CH8+650)	Ihubuluko Town Road (CH10+150)
Samples	Laterite	Laterite	Laterite	Laterite	Laterite
Depth of sampling (m)	1.5	1.5	1.5	1.5	
Percentage(%) passing BS sieve #200	28.35	40.55	36.85	33.45	39.25
Colour	Reddish	Reddish	Reddish	Reddish	Reddish
Specific gravity	2.65	2.50	2.59	2.40	2.45
Natural moisture content (%)	9.85	11.25	10.35	11.85	8.95
Consistency Limits					
Liquid limit (%)	39.75	36.90	36.75	36.85	37.65
Plastic limit (%)	22.45	22.67	21.45	19.35	21.55
Plasticity Index	17.30	14.23	15.20	15.50	16.10
AASHTO soil classification Unified Soil Classification System	A-2-6 SC	A-2-4 SM	A-2-4 SM	A-2-6 SC	A-2-4 SM
Compaction Characteristics					
Optimum moisture content (%)	12.39	14.35	13.85	11.79	10.95
Maximum dry density (kN/m$^{3)}$	1.953	1.857	1.943	1.953	2.105
Grain Size Distribution					
Gravel (%)	6.75	5.35	5.05	8.25	7.58
Sand (%)	35.56	37.35	28.45	29.56	34.25
Silt (%)	33.45	35.65	39.45	38.85	33.56
Clay (%)	24.24	21.65	27.05	23.34	24.61
Unconfined compressive strength (kPa)	178	145	165	158	149
California Bearing capacity (CBR)					
Unsoaked (%) CBR	8.7	8.5	7.8	9.4	10.6
Soaked (%) CBR	8.3	7.8	7.2	8.5	9.8

Table 3.2: Properties of Coataceae Lacerus bagasse fibre. (University of Uyo, Chemical Engineering Department, Material Lab.1)

PROPERTY	**VALUE**
Fibre form	Single
Average length (mm)	400
Average diameter (mm)	0.86
Tensile strength (MPa)	68 – 33
Modulus of elasticity (GPa)	1.5 – 0.54
Specific weight (g/cm^3)	0.69
Natural moisture content (%)	6.3
Water absorption (%)	178 – 256

Source, 2018

Table 3.3: Composition of Bagasse. (University of Uyo, 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

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Table 3.4: Results of Subgrade Soil (laterite) Test Stabilization with Fibre Bagasse Products at Different Percentages

SAMPLE LOCATION	RATIO SOIL + FIBRE	MDD (kN/m^3)	OMC (%)			UCS(KPa)	LL(%)	PL(%)	PI(%)	SIEVE #200	AASHTO / USCS (Classification)	NOTES
	LATERITE + COSTACEAE LACERUS BAGASSE FIBRE (CLBF)											
Odiokwu Town Road (CH (0+950)	100%	1.954	12.39	8.70	8.30	178	39.75	22.45	17.30	28.35	A-2-6/SC	POOR
	99.75% + 0.25%	1.938	12.87	10.48	10.25	183	37.45	23.05	14.40	28.35	A-2-6/SC	GOOD
	99.50%+ 0.5%	1.925	13.05	13.45	11.82	198	37.15	23.55	13.60	28.35	A-2-6/SC	GOOD
	99.25%+ 0.75%	1.886	13.50	16.25	13.58	215	36.85	23.95	12.90	28.35	A-2-6/SC	GOOD
	99%+ 1.0%	1.725	14.85	14.35	12.55	248	36.75	24.55	12.20	28.35	A-2-6/SC	GOOD
Oyigba Town Road (CH 4+225)	100%	1.857	14.35	8.50	7.80	145	36.90	22.67	14.23	40.55	A-2-4/SM	POOR
	99.75% + 0.25%	1.834	14.85	11.65	10.25	158	35.57	23.65	12.22	40.55	A-2-4/SM	GOOD
	99.50%+ 0.5%	1.815	15.03	12.55	11.45	165	33.88	24.12	9.7	40.55	A-2-4/SM	GOOD
	99.25%+ 0.75%	1.768	15.45	15.75	13.82	185	32.23	24.65	7.80	40.55	A-2-6/SC	GOOD
	99%+ 1.0%	1.685	16.55	13.83	12.35	215	31.95	25.28	6.67	40.55	A-2-4/SM	GOOD
Anakpo Town Road (CH6+950)	100%	1.943	13.85	7.80	7.20	165	36.75	21.45	15.30	36.85	A-2-4/SM	POOR
	99.75% + 0.25%	1.905	14.65	9.50	8.70	173	36.23	22.23	14.00	36.85	A-2-4/SM	POOR
	99.50%+ 0.5%	1.882	15.22	12.44	11.95	196	35.65	22.75	12.90	36.85	A-2-4/SM	GOOD
	99.25%+ 0.75%	1.855	17.25	15.25	13.57	215	33.95	23.71	10.24	36.85	A-2-4/SM	GOOD
	99%+ 1.0%	1.811	18.45	13.35	12.35	235	33.15	24.25	8.9	36.85	A-2-4/SM	GOOD
Upatabo Town Road (CH8+650)	100%	1.758	11.79	9.40	8.50	158	36.85	19.35	17.50	33.45	A-2-6/SC	POOR
	99.75% + 0.25%	1.689	13.55	11.65	10.15	168	35.55	21.08	14.47	33.45	A-2-4/SM	GOOD
	99.50%+ 0.5%	1.621	14.25	13.55	11.75	189	33.78	21.68	12.1	33.45	A-2-4/SM	GOOD
	99.25%+ 0.75%	1.562	15.40	15.85	13.85	205	33.05	22.95	10.10	33.45	A-2-6/SC	GOOD
	99%+ 1.0%	1.525	15.98	13.05	11.35	221	32.35	24.28	8.07	33.45	A-2-4/SM	GOOD
Ihubuluko Town Road (CH10+150)	100%	2.105	10.95	10.60	9.80	145	37.65	21.55	16.10	39.25	A-2-6/SC	GOOD
	99.75% + 0.25%	1.933	12.02	13.32	11.28	151	35.92	22.25	13.67	39.25	A-2-4/SM	POOR
	99.50%+ 0.5%	1.905	12.85	15.45	13.35	159	35.23	23.58	11.65	39.25	A-2-4/SM	GOOD
	99.25%+ 0.75%	1.896	14.20	17.11	15.85	175	33.75	23.98	9.77	39.25	A-2-6/SC	GOOD
	99%+ 1.0%	1.845	14.86	15.03	12.05	198	31.56	24.08	7.48	39.25	A-2-4/SM	GOOD

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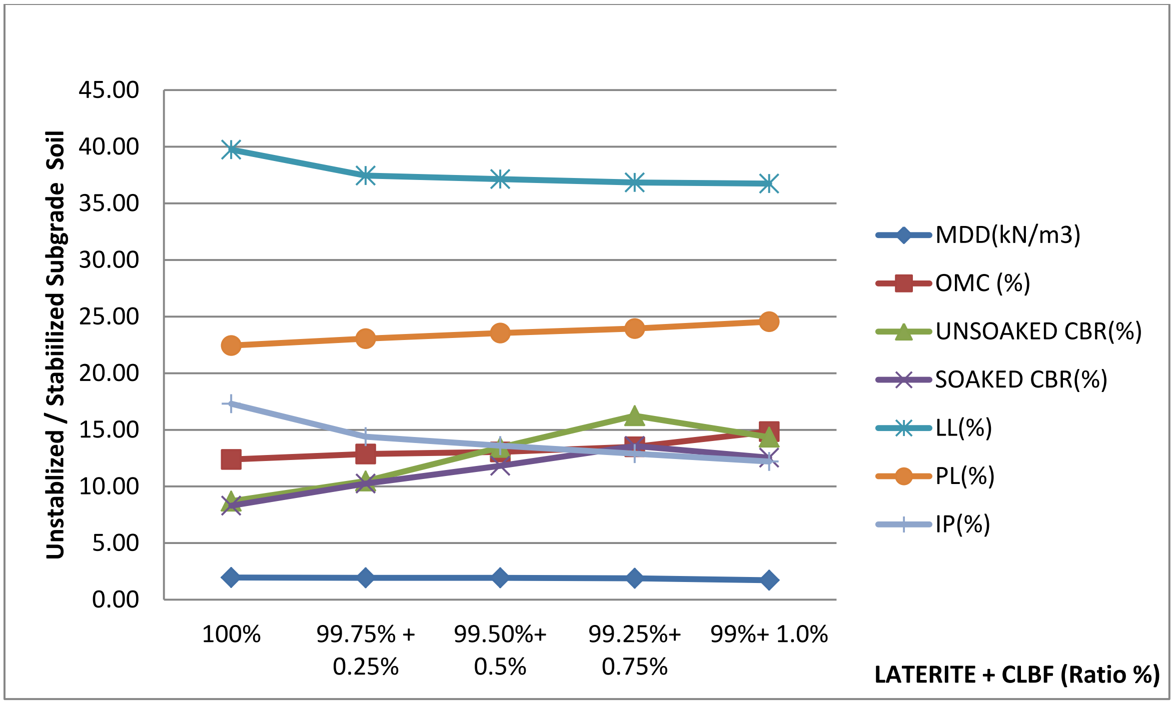

Figure 3.1: **Subgrade Stabilization Test of Lateritic Soil from Odioku in Ahoada-West L.G.A of Rivers State with CLBF at Different Percentages and Combination**

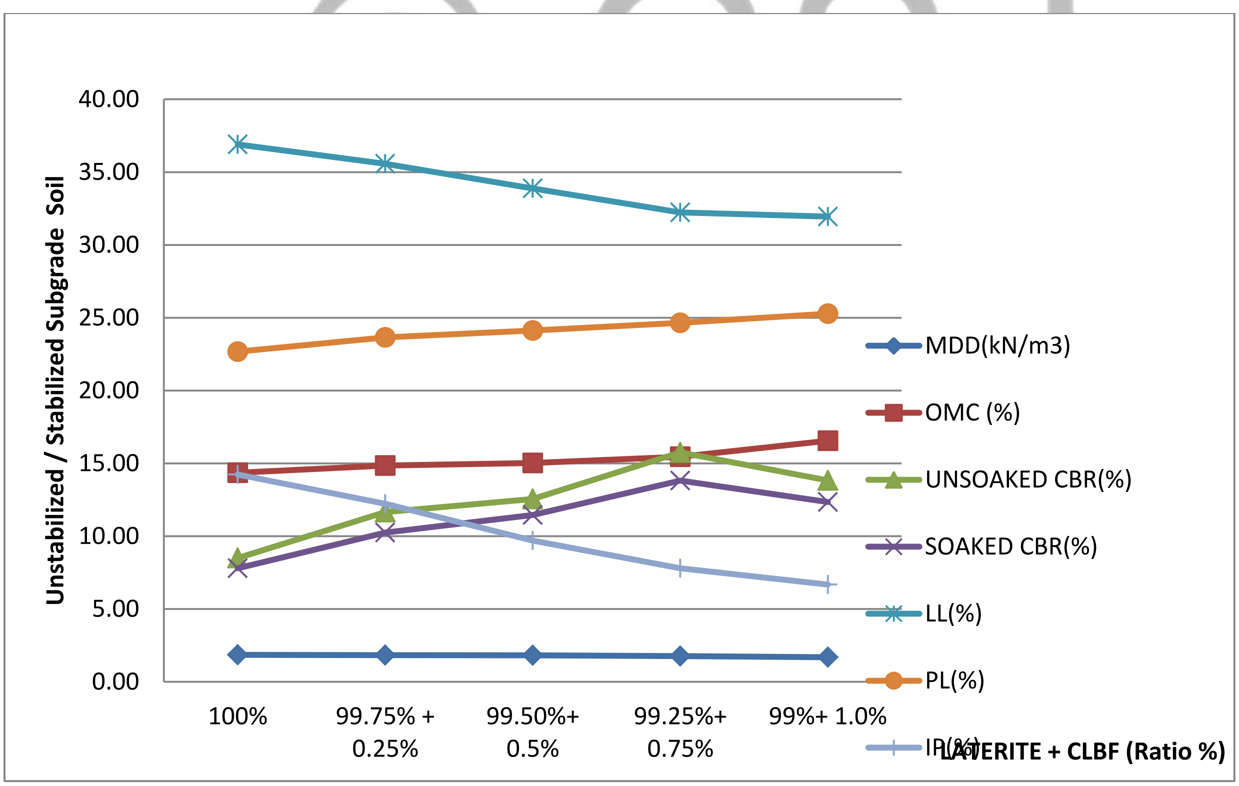

Figure 3.2: **Subgrade Stabilization Test of Lateritic Soil from Oyigba in Ahoada-West L.G.A of Rivers State with CLBF at Different Percentages and Combination**

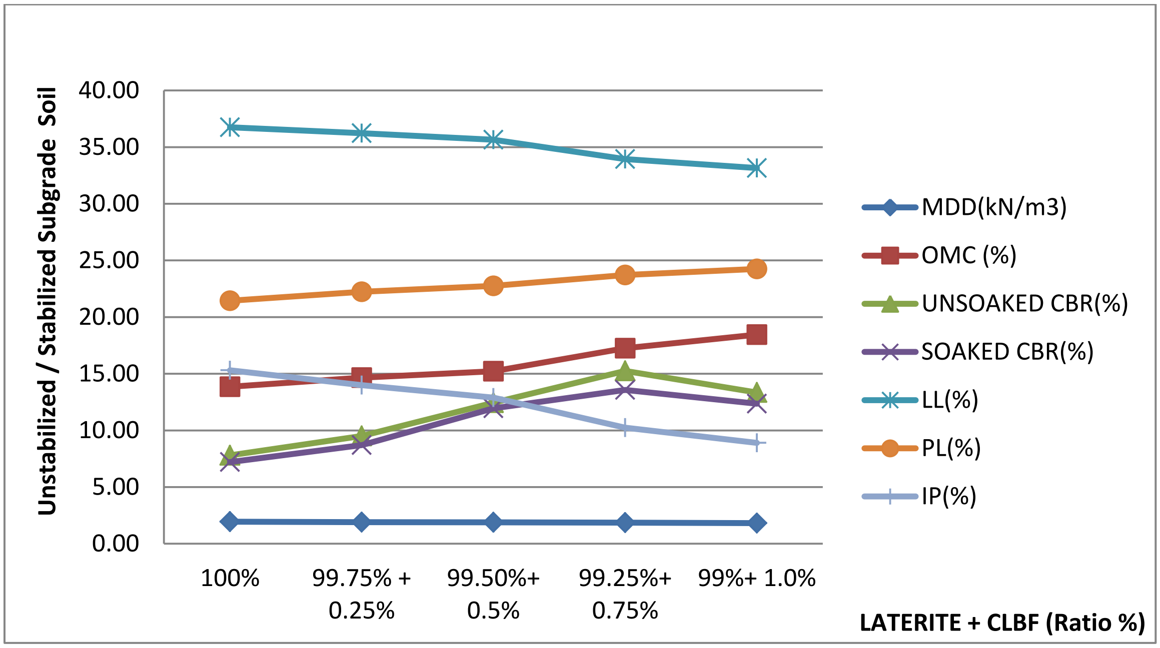

Figure 3.3: **Subgrade Stabilization Test of Lateritic Soil from Anakpo in Ahoada-West L.G.A of Rivers State with CLBF at Different Percentages and Combination**

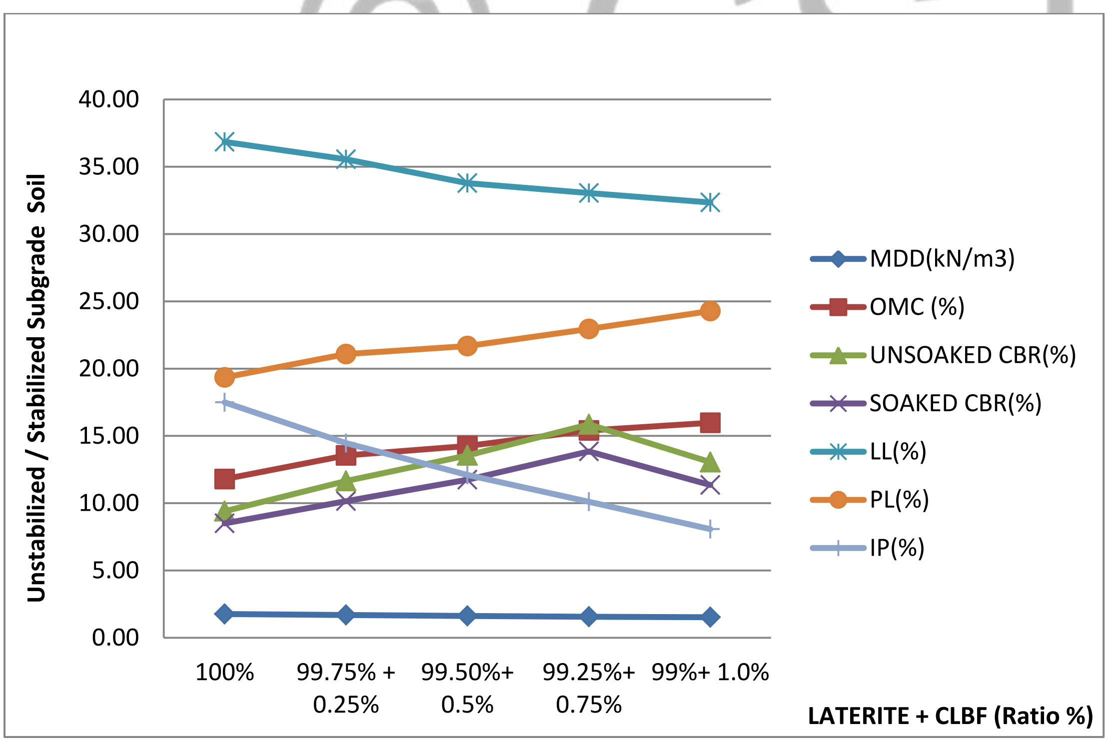

Figure 3.4: **Subgrade Stabilization Test of Lateritic Soil from Upatabo in Ahoada-West L.G.A of Rivers State with CLBF at Different Percentages and Combination**

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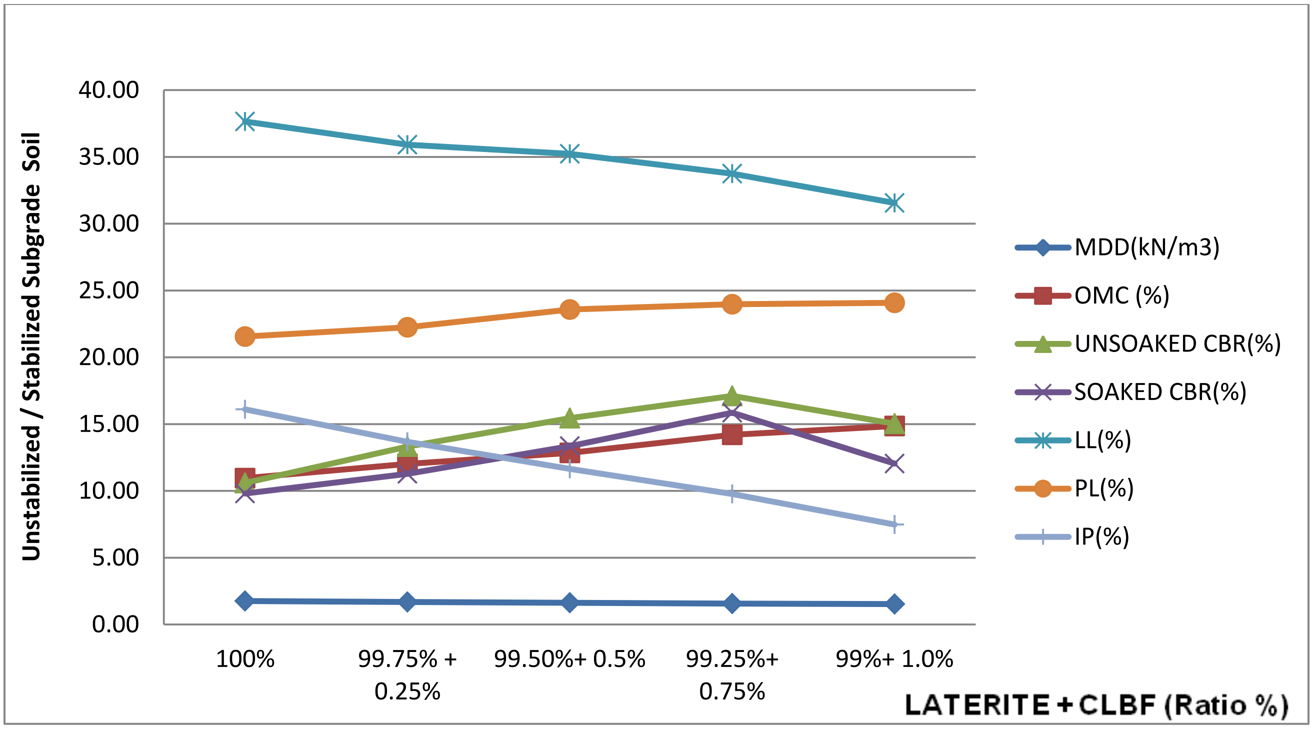

Figure 3.5: Subgrade Stabilization Test of Lateritic Soil from Ihubuluko in Ahoada-West L.G.A of Rivers State with CLBF at Different Percentages and Combination

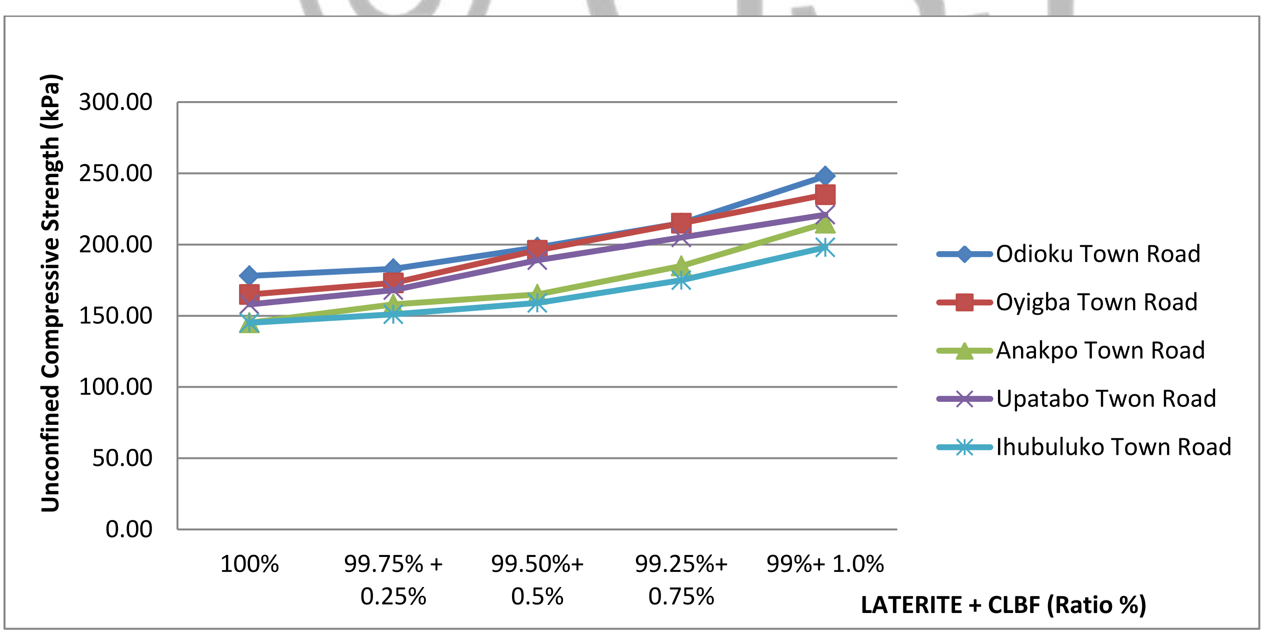

Figure 3.6: Unconfined Compressive Strength (UCS) of Niger Deltaic Laterite Soils Subgrade with CLBF of (Odioku, Oyigba, Anakpo, Upatabo and Ihubuluko Towns), Ahoad-West L.G.A, Rivers State

Plate i. **Costaceae Lacerus** plant

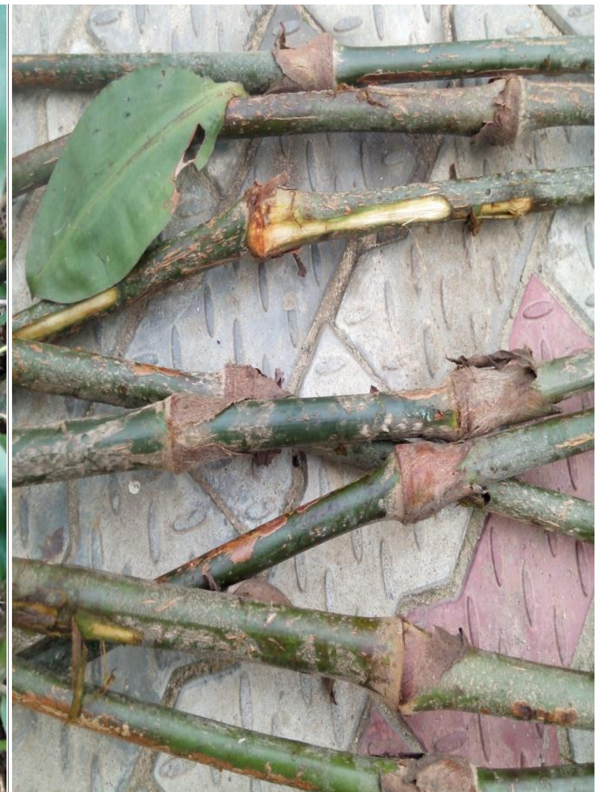

Plate ii. **Costaceae Lacerus** stem

Plate iii. **Costaceae Lacerus piled stem**

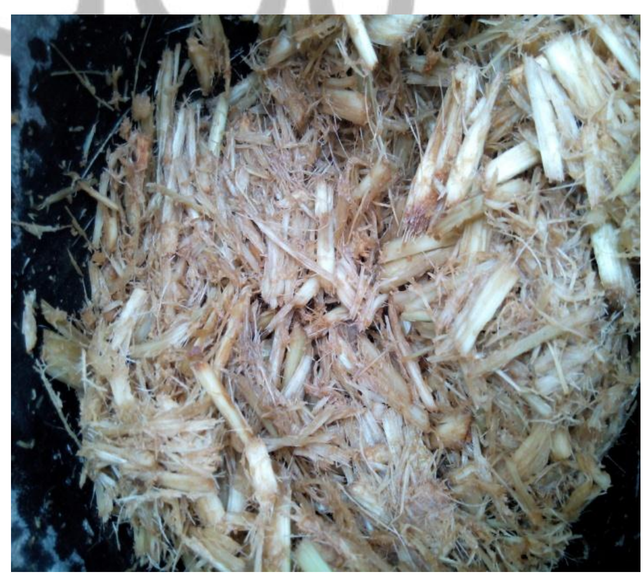

Plate iv. **Costaceae Lacerus pulverized stage**

Plate vi. Bush sugarcanedry fibre bagasses

Plate vii. Bush sugarcane wet bagasses/fibre at day 3

4.0 Conclusions

The following conclusions were made from the experimental research results.

i. Preliminary investigations of the engineering Properties of soils at natural state are percentage (%) passing BS sieves #200 are 28.35%, 40.55%, 36.85%, 33.45% and 39.25% (laterite), and soils classified as A-2-6 SC and A-2-4 SM on the AASHTO classification schemes / Unified Soil Classification System as shown in table 3.1.

ii. Results showed the potential of using fibre bagasse (CLBF) as admixtures in lateritic soil stabilization

iii. Swelling potential of treated soil decreased with the inclusion of fibre bagasse up to 0.75% for soils

iv. The plastic index of the stabilized soil showed continuous decreased with increased in fibre percentages

v. Compaction test results recorded a decreased values of MDD with increased while OMC increases with increased with fibre percentages

vi. An optimum values percentage inclusion at 0.75% was recorded of CBR at both unsoaked and soaked, beyond this value a decreased recorded which indicated maximum inclusion, crack was formed which resulted to potential failure state

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