OPEN ACCESS
Saudi Journal of Civil Engineering
Abbreviated Key Title: Saudi J Civ Eng
ISSN 2523-2657 (Print) |ISSN 2523-2231 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: http://saudijournals.com/sjce/

Original Research Article

Black Cotton Soil Properties Modification using Costaceae Lacerus Bagasse Fibre as Road Pavement Stabilizer

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DOI: 10.36348/sjce.2020.v04i02.001 | **Received:** 19.02.2020 | **Accepted:** 26.02.2020 | **Published:** 29.02.2020

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Abstract

The research work examined the modification of expansive soils with bagasse fibre to improve its engineering properties for road pavement structures. Preliminary investigations classified the clay soils as A – 7 – 6 on the AASHTO Classification System and soils are dark grey at all conditions and percentage (%) passing BS sieves #200 are 73.85%, 67.38%, 6.35%, 82.35%, and 71.55%. Comparative results confirmed a decrease in plastic index properties of clay soils. Compaction test results showed a decreased in MDD values while OMC recorded increased values due to bagasse fibre inclusion. Results obtained showed an increase in UCS with an increase in fibre percentages to soil corresponding ratio. Relative results showed an increased in CBR values with an increase in bagasse fibre percentages to a peak ratio of 0.75% to soil ratio. The entire results showed the potential of using costaceae lacerus bagasse fibre (CLBF) as admixtures in the treatment of clay soils. The swelling potential of treated soil decreased with the inclusion of bagasse fibre up to 0.75%.

Keywords: Clay Soils, *Costaceae Lacerus Bagasse Fibre*, CBR, UCS, Consistency, Compaction.

INTRODUCTION

Large soils are formed by the breakdown of the original igneous rocks where seasonal variations of weather occur at the peak. Nigerian black cotton soil is formed by weathering of the Shelley and mud sediments and basaltic rocks. They contain more montmorillonite, with a later appearance of self-propelling properties and a tendency to expand [1].Expansive soils are problematic and are commonly encountered in foundation engineering designs for highways, embankments, retaining walls, etc. These soils are found in arid and semi-arid regions of tropical/temperate regions marked with dry and wet climates; and is found in the Niger Delta region of the River State of Nigeria with low rainfall, poor drainage, and extreme heat. Climate conditions are such that annual evaporation exceeds precipitation ([2-4]). The vast soil found in the extensive deposits in the northeastern part of Nigeria is referred to as black cotton soil, which is dark brown to black soil with high clay content, typically from 50% more in which montmorillonite is the main clay mineral [5]. These expansion soils do not conform to the standard subgrade pavement specified by the Federal Ministry of Works FMW, 1997. Soil stabilization is an approved alternative to measure this trend.

Investigated the effectiveness of natural fiber, Cotus afer bagasse (stabilizer/reinforcement in bush sugarcane bagasse fiber (BSBF) soils with inclusion of 0.25%, 0.50%, 0.75% and 1.0% fiber). MDD and OMC decreased in both soils with the inclusion of fiber percentage, CBR values increased significantly with the optimum value percent inclusion of 0.75%, beyond this value, cracks were formed, resulting in potential failure states[6].

Studied the combined effects of RHA and cement on the engineering properties of black cotton soil. From the strength characteristics point of view, they recommended 8% cement and 10% RHA as the optimal dosage for stabilization[7].

Studied the effects of polypropylene fibers on the engineering properties of RHA-Lime. Polypropylene fibers were added 0.5% to 2% at a 0.5% increase. The determined properties were condensation, the effect of UCS, soaked CBR, hydraulic conductivity and P soaking of 0-day, 7-day and 28-day curing

vessels were also studied by UCS. CBR, hydraulic conductivity and swelling pressure. The optimum soil ratio: RHA: lime: fiber was found to be 84.5: 10: 4: 1.5[8].

Reinforced on soil samples showed that both fiber content and aspect ratio have significant effects in shear strength parameters (C, Ø)[9].

Investigated the effectiveness and application of waste agricultural products from plantain rachis fibers as stabilizers for lateritic soil amendments with unrelated and volatile characteristics. The comparative results for un-stabilized and stabilized soils showed a decrease in the values of maximum dry density and an increase in the optimum moisture content values for stabilized lateritic soil. Results on the comparison with un-stabilized soil showed a percentage of decreasing ratio with a decrease in the values of the plastic index parameters of the stabilized soils. Comparative results show increased values of unconfined compression strength tests with similar percentage ratio inclusions compared to non-stationary soils. Results on the comparison with un-stabilized soil showed a percentage of decreasing ratio with a decrease in the values of the plastic index parameters of the stabilized soils. The overall results showed the potential use of plantain rachis fibers in soil stabilization [10].

MATERIALS AND METHODS

Materials

Soil

Sampled soils are gotten from Ogoda Town Road, Ubie, Districts of Ekpeye, Ahoada-East and Ahoada-West Local Government Area, Bodo Town Road, Gokana Local Government Area, Ogbogu Town Road, Egbema/Ndoni/Egbema Local Government Area, Ula-Ikata Town Road, Ahoada-East Local Government area, and Kaani Town Road, Khana Local Government Area, all of Rivers State, Niger Delta, Nigeria.

Costaceae Lacerus Bagasse Fibre (CLBF)

Costaceae Lacerus bagasse fibre is abundantly and widely medicinal plants gotten from bushes of Oyigba Town, Ubie Clan, Ahoada-West, and Rivers State, Nigeria.

Method

Sampling Locality

Sampled soils are gotten from Rivers State in Ogoda Town Road, (latitude 5.04 ° 59'S and longitude 6.38 ° 42'E), Bodo Town Road, (latitude 4.65 ° 05'S and longitude 7.27 ° 15'E, Ogbogu Town Road, Latitude 5.13 ° 08'S and longitude 6.33 ° 25'E), Ula Ikata Town Road, (latitude 5.95 ° 45'S and longitude 6.66 ° 13'E) and Kanni Town Roads, latitude 4.67 ° 13'S and longitude 6.81 ° 55'E).

Test Conducted

Tests performed included(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;

Moisture Content Determination

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

Grain Size Analysis (Sieve Analysis)

Mechanical or sieve analysis is performed to determine the distribution of course, large-sized particles. This test is performed to determine the percentage of different grain sizes contained within the soil.

Consistency Limits

The liquid limit (LL) is defined as the arbitrary water content, in percentage, at which a portion of the soil in the standard cup and a groove of standard dimensions is cut, for a distance of 13 mm will flow simultaneously at the base of the drain (1 / 2in.) When subjected to 25 shocks being dropped 25 mm from the cup in a standard fluid limit mechanism operated at a rate of two shocks per second.

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 compaction effort.

Unconfined Compression (UC) Test

Unconfined compressed power is taken as the maximum load achieved per unit area, or loaded at 15% axial stress per unit area, whichever occurs during the performance of a test. The primary objective of this test is to determine the undefined compressive strength, which is then used to calculate the unconsolidated shear strength of the soil under unconfined conditions.

California Bearing Ratio (CBR) Test

The California Bearing Ratio (CBR) test by the California Division of Ratio was developed and evaluated and evaluated the soil-sub-base and base course material for flexible pavements

RESULTS AND DISCUSSIONS

The soils classified as A – 7 – 6 on the AASHTO 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 [11-14]. Preliminary results on clay 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 are

reddish brown and dark grey in color (from wet to dry states) plasticity index of 20.33%, 20.35%, 21.85%, 26.30%, and 21.35% respectively for Ogoda, Bodo, Ogbogu, Ula-Ikata, Kaani Town Roads. The soil has unsoaked CBR values of 8.58%,8.83%, 8.05%, 7.38%, and 9.05% and soaked CBR values of 6.33%, 7.15%, 7.35%, 5.9% and 8.23 %, unconfined compressive strength (UCS) values of 58.85kPa, 63.35kPa, 57.75 kPa , 53.75kPa and 63.85kPa when compacted with British Standard light (BSL), respectively.

Compaction Test Results

Table 3.1 showed the compaction test of maximum dry density (MDD) at natural state 100% clay as 1.875KN/m3, 1.923KN/m3, 1.823KN/m3, 1.795KN/m3, 1.985KN/m3 and Optimum moisture content (OMC) as 15.68%, 14.93%, 16.30%, 17.45% and 15.35%. Stabilized soil with costaceae lacerus bagasse fibre (CLBF) at 0.25%, 0.50%, 0.75%, and 1.0% decreased to 1.758 KN/m3, 1.825 KN/m3, 1.794 KN/m3, 1.683 KN/m3, 1.883 KN/m3 with percentile representations from 99.58%, 98.26%, 98.75%, 98.84%,99.35%, 109.46% to 103.15%, 111.80%, 104.06%, 105.07%, 121.31%, 128.72%. Optimum moisture content (OMC) increased to 16.48%,15.98%, 17.45%, 18.38% and 16.42% with percentile values from 97.51%, 98.16%, 98.25%, 97.92%,97.77% to 109.69%, 108.17%, 106.63%, 107.91%, 107.30%. Results showed decreased in MDD values while OMC recorded increased values due to bagasse fibre inclusion.

California Bearing Ratio (CBR) Test

CRB results obtained at 100% natural state are 8.58%, 8.83%, 8.05%, 7.38%, and 9.05% unsoaked with percentile values representation of 32.04%, 29.83%, 30.17%, 31.54%, 36.89%, and 6.33%, 7.15%, 7.35%, 5.9% and 8.23 % soaked with percentile values of 31.00%, 26.63%, 30.12%, 30.97%, 29.93%. Stabilized clay soils with 0.25%, 0.50%, 0.75% and 1.0% increased 14.30%, 14.88%, 14.15%, 13.55%, 15.38%. Unsoaked stabilized values with percentile increased of 633.15%, 637.60%, 603.03%, 620.60%, and 599.42%. Soaked stabilized values are 13.45%, 13.22%, 13.88%, 12.85%, 15.38% with represented percentile increased of 763.82%, 736.36%, 642.86%, 688.14%, 684.69%. Comparative results showed an increased in CBR values with increase in bagasse fibre percentages to a peak ratio of 0.75% to soil ratio.

Unconfined Compressive Strength Test

Results obtained of clay soils at preliminary engineering soil properties of Ogoda, Bodo, Ogbogu, Ula-Ikata, Kaani Town Roads at 100% soils unconfined compressive strength (UCS) values of 58.85kPa, 63.35kPa, 57.75kPa, 53.75kPa and 63.85kPa, with percentile values of 87.38%, 92.75%, 70.90%, 78.64%, 80.52%. Stabilized clay soils with inclusion as represented in figures 3.5 increased to 138.18kPa, 158.75kPa, 150.45kPa, 127.38kPa, and 163.10kPa with percentile representation of 234.80%, 250.59%, 260.52%, 236.99%, and 255.44%. Results obtained showed increased in UCS with increase in fibre percentages to soil corresponding ratio.

Consistency Limits Test

Results of consistency limits (Plastic Index) at 100% clay soils are 20.33%, 20.35%, 21.85%, 26.30% and 21.35%, with percentile representation of 101.04%, 102.62%, 105.30%, 101.39%, 101.50%. At Stabilized conditions, the obtained vales are 15.08%, 17.65%, 18.85%, 19.23% and 17.16% with percentile values representation of 94.69%, 92.78%, 90.71%, 93.17%, and 93.22%. Comparative results showed decreased in plastic index properties of clay soils.

Table-3.1: Engineering Properties of Soil Samples

LOCATION DESCRIPTION	OGODA TOWN ROAD, AHOADA-WEST L.G.A RIVERS STATE	BODO TOWN ROAD, GOKANA L.G.A RIVERS STATE	OGBOGU TOWN-ROAD, OGBA/EGBEMA NDONI L.G.A RIVERS STATE	ULA-IKATA TOWN ROAD, AHOADA-BEMA EAST L.G.A RIVERS STATE	KAANI TOWN ROAD, KHANNA L.G.A RIVERS STATE
Depth of sampling (m)	1.5	1.5	1.5	1.5	1.5
Percentage(%) passing BS sieve #200	73.85	67.38	76.35	82.35	71.55
Colour	Grey	Grey	Grey	Grey	Grey
Specific gravity	2.71	2.68	**2.1 2.63**	2.63	2.71
Natural moisture content (%)	46.25	45.38	45.86	49.30	46.85
Consistency Limits					
Liquid limit (%)	58.85	59.45	58.35	56.67	48.25
Plastic limit (%)	38.52	39.10	37.50	30.37	24.90
Plasticity Index	20.33	20.35	21.85	26.30	21.35
AASHTO soil classification	A – 7 – 6	A – 7 – 6	A – 7 – 6	A – 7 – 6	A – 7 – 6
Optimum moisture content (%)	15.68	14.93	16.30	17.45	15.35
Maximum dry density (kN/m$^{3)}$	1.875	1.923	1.823	1.795	1.9.85
Gravel (%)	1.85	0.85	2.45	0.53	1.95
Sand (%)	12.35	11.08	9.75	7.34	13.25
Silt (%)	52.35	47.35	47.85	53.68	48.25
Clay (%)	33.45	40.72	39.95	38.45	36.55
Unconfined compressive strength (kPa)	58.85	63.35	57.75	53.75	63.85
California Bearing Capacity (CBR)					
Unsoaked (%) CBR	8.58	8.83	8.05	7.38	9.05
Soaked (%) CBR	6.33	7.15	7.35	5.9	8.23

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	

Table-3.4: Results of Subgrade Soil (Clay) Test Stabilization with Binding Cementitious Products at Different Percentages and Combination

SAMPLE LOCATION	SOIL + FIBRE RATIO	MDD (kN/m^3)	OMC (%)	UNSOAKED CBR (%)	SOAKED CBR (%)	UCS(KPa)	LL(%)	PL(%)	PI(%)	SIEVE #200	AASHTO / USCS (Classification)	NOTES
	SOFT CLAY + COSTACEAE LACERUS BAGASSES FIBRE (CLBF)											
OGODA TOWN ROAD, AHOADA-WEST L.G.A	100%	1.875	15.68	8.56	6.33	58.85	58.85	38.52	20.33	73.85	A – 7 – 6	POOR
	99.75+0.25 %	1.858	15.77	10.25	10.05	67.35	58.58	40.33	18.25	73.85	A – 7 – 6	GOOD
	99.50+0.50 %	1.838	15.93	12.85	11.35	82.30	58.21	41.96	17.25	73.85	A – 7 – 6	GOOD
	99.25+0.75 %	1.785	16.28	14.30	13.45	118.15	57.93	42.25	16.38	73.85	A – 7 – 6	GOOD
	99.0+1.0%	1.758	16.48	13.18	12.35	138.18	57.72	42.64	15.08	73.85	A – 7 – 6	GOOD
BODO TOWN ROAD GOKANA L.G.A	100%	1.923	14.93	8.88	7.15	63.35	59.45	39.10	20.35	67.38	A – 7 – 6	POOR
	99.75+0.25%	1.904	15.21	10.38	10.15	68.30	59.18	39.23	19.95	67.38	A – 7 – 6	GOOD
	99.50+0.50%	1.886	15.38	12.58	11.86	89.50	58.83	40.08	18.75	67.38	A – 7 – 6	GOOD
	99.25+0.75%	1.866	15.78	14.88	13.22	127.30	58.55	40.37	18.18	67.38	A – 7 – 6	GOOD
	99.0+1.0%	1.825	15.98	12.35	12.05	158.75	58.17	40.54	17.65	67.38	A – 7 – 6	GOOD
OGBOGU TOWN ROAD OGBA EGE/ ELEANA NDONI L.G.A	100%	1.823	16.30	8.25	7.35	57.75	58.35	37.50	21.85	76.35	A – 7 – 6	POOR
	99.75+0.25%	1.785	16.81	11.25	10.86	81.45	58.13	36.18	19.95	76.35	A – 7 – 6	GOOD
	99.50+0.50%	1.733	16.93	13.45	12.98	117.40	57.85	38.07	19.78	76.35	A – 7 – 6	GOOD
	99.25+0.75%	1.718	17.15	14.15	13.88	138.53	57.53	38.28	19.25	76.35	A – 7 – 6	GOOD
	99.0+1.0%	1.794	17.45	12.38	12.08	150.45	57.15	38.30	18.85	76.35	A – 7 – 6	GOOD
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A	100%	1.794	17.45	7.38	5.90	53.75	56.67	38.37	18.30	82.35	A – 7 – 6	POOR
	99.75+0.25%	1.769	17.17	9.25	8.75	68.35	56.45	38.60	17.85	82.35	A – 7 – 6	POOR
	99.50+0.50%	1.740	17.78	11.15	10.38	79.30	56.18	38.58	17.66	82.35	A – 7 – 6	GOOD
	99.25+0.75%	1.762	18.15	13.55	12.85	107.85	55.89	38.56	17.33	82.35	A – 7 – 6	GOOD
	99.0+1.0%	1.683	18.38	12.85	12.05	127.38	55.52	38.36	17.16	82.35	A – 7 – 6	GOOD
KAANI TOWN ROAD, KHANA L.G.A	100%	1.985	15.35	9.05	8.23	63.85	48.25	27.90	20.35	71.55	A – 7 – 6	POOR
	99.75+0.25%	1.962	15.61	11.65	10.95	79.30	48.03	27.94	20.09	71.55	A – 7 – 6	GOOD
	99.50+0.50%	1.938	15.38	12.93	12.38	93.28	47.88	28.05	19.83	71.55	A – 7 – 6	GOOD
	99.25+0.75%	1.908	16.15	15.38	14.95	125.78	47.65	28.02	19.63	71.55	A – 7 – 6	GOOD
	99.0+1.0%	1.883	16.42	13.93	13.25	163.10	47.28	28.05	19.23	71.55	A – 7 – 6	GOOD

Table-3.5: Percentile Combination of Soft Clay + Costaceae Lacerus Bagasses Fibre (CLBF)

RATIO %	100%	97.25+0.25 +2.5	94.5+ 0.5+ 5.0%	91.75+0.75 +7.5	89+1.0 +10
MAXIMUM DRY DENSITY (MDD(kN/m^3)					
OGODA TOWN ROAD, AHOADA-WEST L.G.A MDD(kN/m3)	1.88	1.88	1.94	1.93	1.99
BODO TOWN ROAD GOKANA L.G.A MDD(kN/m3)	1.92	1.96	1.99	2.15	2.11
OGBOGU TOWN ROAD OGBA/EGBEMA/NDONI L.G.A MDD(kN/m3)	1.82	1.85	1.88	1.90	1.94
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A MDD(kN/m3)	1.79	1.82	1.87	1.89	1.91
KAANI TOWN ROAD, KHANA L.G.A MDD(kN/m3)	1.99	2.00	2.12	2.41	2.56
OPTIMUM MOISTURE CONTENT (%)					
OGODA TOWN ROAD, AHOADA-WEST L.G.A OMC (%)	15.68	16.08	16.35	16.85	17.20
BODO TOWN ROAD GOKANA L.G.A OMC (%)	14.93	15.21	15.31	15.78	16.15
OGBOGU TOWN ROAD OGBA/EGBEMA/NDONI L.G.AOMC (%)	16.30	16.59	16.83	17.05	17.38
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A OMC (%)	17.45	17.82	18.15	18.52	18.83
KAANI TOWN ROAD, KHANA L.G.A OMC (%)	15.35	15.70	15.96	16.12	16.47
CONSISTENCY LIMITS (%)					
OGODA TOWN ROAD, AHOADA-WEST L.G.A LL(%)	58.85	58.93	59.83	59.83	60.15
OGODA TOWN ROAD, AHOADA-WEST L.G.A PL(%)	38.52	38.91	40.21	40.21	40.90
OGODA TOWN ROAD, AHOADA-WEST L.G.A IP(%)	20.33	20.12	19.62	19.62	19.25
BODO TOWN ROAD GOKANA L.G.A LL(%)	59.45	59.78	60.15	61.48	62.65
BODO TOWN ROAD GOKANA L.G.A PL(%)	39.10	39.95	40.53	43.87	43.77
BODO TOWN ROAD GOKANA L.G.A IP(%)	20.35	19.83	19.62	19.30	18.88
OGBOGU TOWN ROAD OGBA/EGBEMA/NDONI L.G.A LL(%)	58.35	59.85	60.18	60.66	60.97
OGBOGU TOWN ROAD OGBA/EGBEMA/NDONI L.G.A PL(%)	37.50	39.10	39.82	40.63	41.15
OGBOGU TOWN ROAD OGBA/EGBEMA/NDONI L.G.A IP(%)	21.85	20.75	20.36	20.03	19.82
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A LL(%)	56.67	57.15	57.65	58.15	58.65
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A PL(%)	38.37	34.10	39.83	40.72	41.60
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A IP(%)	18.30	18.05	17.82	17.43	17.05
KAANI TOWN ROAD, KHANA L.G.A LL(%)	48.25	48.53	48.96	49.23	49.75
KAANI TOWN ROAD, KHANA L.G.A PL(%)	27.90	28.48	29.14	29.88	30.98
KAANI TOWN ROAD, KHANA L.G.A IP(%)	20.35	20.05	19.82	19.35	18.97
CALIFORNIA BEARING RATIO (%)					
OGODA TOWN ROAD, AHOADA-WEST L.G.A UNSOAKED CBR(%)	8.65	23.45	37.55	51.85	46.33
OGODA TOWN ROAD, AHOADA-WEST L.G.A SOAKED CBR (%)	6.33	21.15	32.80	48.35	41.60
BODO TOWN ROAD GOKANA L.G.A UNSOAKED CBR(%)	8.83	29.60	41.30	56.30	48.36
BODO TOWN ROAD GOKANA L.G.A SOAKED CBR (%)	7.15	26.85	38.15	52.65	39.30
OGBOGU TOWN ROAD OGBA/EGBEMA/NDONI L.G.A UNSOAKED CBR(%)	8.25	27.35	34.30	49.75	37.37
OGBOGU TOWN ROAD OGBA/EGBEMA/NDONI L.G.A.SOAKED CBR(%)	7.35	24.40	29.88	47.25	32.35
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A UNSOAKED CBR(%)	7.38	23.40	31.45	45.80	36.35
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A SOAKED CBR(%)	5.90	19.05	27.35	40.60	31.78
KAANI TOWN ROAD, KHANA L.G.A UNSOAKED CBR(%)	9.05	28.25	48.35	57.30	53.45
KAANI TOWN ROAD, KHANA L.G.A SOAKED CBR(%)	8.23	26.55	46.85	56.35	49.75
UNCONFINED COMPRESSIVE STRENGTH (KPa)					
OGODA TOWN ROAD, AHOADA-WEST L.G.A UCS (Kpa)	58.85	67.35	82.30	118.15	138.18
BODO TOWN ROAD GOKANA L.G.A UCS (Kpa)	63.35	68.30	89.50	127.30	158.75
OGBOGU TOWN ROAD OGBA/EGBEMA/NDONI L.G.A UCS (Kpa)	57.75	81.45	117.40	138.53	150.45
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A UCS (Kpa)	53.75	68.35	79.30	107.85	127.38
KAANI TOWN ROAD, KHANA L.G.A UCS (Kpa)	63.85	79.30	93.28	125.78	163.10

Table-3.6: Percentile Decrease / Increase of Soft Clay + Costaceae Lacerus Bagasses Fibre (CLBF)

RATIO %	**1.000**	**97.25+0.25 +2.5**	**94.5+ 0.5+ 5.0**	**91.75+0.75 +7.5**	**89+1.0 +10**
MAXIMUM DRY DENSITY (MDD(kN/m^3)					
OGODA TOWN ROAD, AHOADA-WEST L.G.A MDD(kN/m3)	99.575	100.427	103.253	103.147	105.867
BODO TOWN ROAD GOKANA L.G.A MDD(kN/m3)	98.263	101.768	103.328	111.804	109.464
OGBOGU TOWN ROAD OGBA/EGBEMA/NDONI L.G.A MDD(kN/m3)	98.754	101.262	102.852	104.059	106.144
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A MDD(kN/m3)	98.843	101.171	103.958	105.072	106.466
KAANI TOWN ROAD, KHANA L.G.A MDD(kN/m3)	99.349	100.655	106.801	121.310	128.715
OPTIMUM MOISTURE CONTENT (%)					
OGODA TOWN ROAD, AHOADA-WEST L.G.A OMC (%)	97.512	102.551	104.273	107.462	109.694
BODO TOWN ROAD GOKANA L.G.A OMC (%)	98.159	101.875	102.545	105.693	108.171
OGBOGU TOWN ROAD OGBA/EGBEMA/NDONI L.G.AOMC (%)	98.252	101.779	103.252	104.601	106.626
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A OMC (%)	97.924	102.120	104.011	106.132	107.908
KAANI TOWN ROAD, KHANA L.G.A OMC (%)	97.771	102.280	103.974	105.016	107.296
CONSISTENCY LIMITS (%)					
OGODA TOWN ROAD, AHOADA-WEST L.G.A LL(%)	99.864	100.136	101.665	101.665	102.209
OGODA TOWN ROAD, AHOADA-WEST L.G.A PL(%)	98.998	101.012	104.387	104.387	106.179
OGODA TOWN ROAD, AHOADA-WEST L.G.A IP(%)	101.044	98.967	96.508	96.508	94.688
BODO TOWN ROAD GOKANA L.G.A LL(%)	99.448	100.555	101.177	103.415	105.383
BODO TOWN ROAD GOKANA L.G.A PL(%)	97.872	102.174	103.657	112.199	111.944
BODO TOWN ROAD GOKANA L.G.A IP(%)	102.622	97.445	96.413	94.840	92.776
OGBOGU TOWN ROAD OGBA/EGBEMA/NDONI L.G.ALL(%)	97.494	102.571	103.136	103.959	104.490
OGBOGU TOWN ROAD OGBA/EGBEMA/NDONI L.G.APL(%)	95.908	104.267	106.187	108.347	109.733
OGBOGU TOWN ROAD OGBA/EGBEMA/NDONI L.G.AIP(%)	105.301	94.966	93.181	91.670	90.709
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A LL(%)	99.160	100.847	101.729	102.612	103.494
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A PL(%)	112.522	88.872	103.805	106.125	108.418
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A IP(%)	101.385	98.634	97.377	95.246	93.169
KAANI TOWN ROAD, KHANA L.G.A LL(%)	99.423	100.580	101.472	102.031	103.109
KAANI TOWN ROAD, KHANA L.G.A PL(%)	97.963	102.079	104.444	107.097	111.039
KAANI TOWN ROAD, KHANA L.G.A IP(%)	101.496	98.526	97.396	95.086	93.219
CALIFORNIA BEARING RATIO (%)					
OGODA TOWN ROAD, AHOADA-WEST L.G.A UNSOAKED CBR (%)	36.887	271.098	434.104	599.422	535.607
OGODA TOWN ROAD, AHOADA-WEST L.G.A SOAKED CBR (%)	29.929	334.123	518.167	763.823	657.188
BODO TOWN ROAD GOKANA L.G.A UNSOAKED CBR (%)	29.831	335.221	467.724	637.599	547.678
BODO TOWN ROAD GOKANA L.G.A SOAKED CBR (%)	26.629	375.524	533.566	736.364	549.650
OGBOGU TOWN ROAD OGBA/EGBEMA/NDONI L.G.A UNSOAKED CBR(%)	30.165	331.515	415.758	603.030	452.970
OGBOGU TOWN ROAD OGBA/EGBEMA/NDONI L.G.A SOAKED CBR(%)	30.123	331.973	406.531	642.857	440.136
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A UNSOAKED CBR(%)	31.538	317.073	426.152	620.596	492.547
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A SOAKED CBR(%)	30.971	322.881	463.559	688.136	538.644
KAANI TOWN ROAD, KHANA L.G.A UNSOAKED CBR (%)	32.035	312.155	534.254	633.149	590.608
KAANI TOWN ROAD, KHANA L.G.A SOAKED CBR(%)	30.998	322.600	569.259	684.690	604.496
UNCONFINED COMPRESSIVE STRENGTH (KPa)					
OGODA TOWN ROAD, AHOADA-WEST L.G.A UCS (Kpa)	87.379	114.444	139.847	200.765	234.800
BODO TOWN ROAD GOKANA L.G.A UCS (Kpa)	92.753	107.814	141.279	200.947	250.592
OGBOGU TOWN ROAD OGBA/EGBEMA/NDONI L.G.A UCS (Kpa)	70.902	141.039	203.290	239.879	260.519
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A UCS (Kpa)	78.639	127.163	147.535	200.651	236.986
KAANI TOWN ROAD, KHANA L.G.A UCS (Kpa)	80.517	124.197	146.092	196.993	255.442

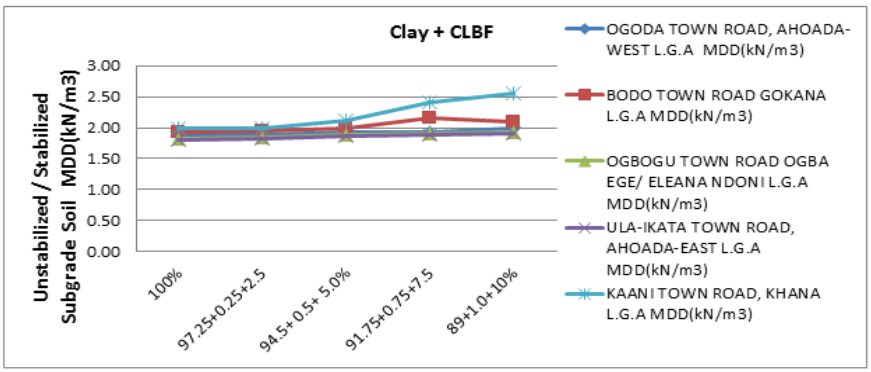

Fig-3.1: Maximum Dry Density of Subgrade Stabilization Test of Clay Soil from Ogoda, Bodo, Ogbogu, Ula-Ikata, Kaani Towns), Rivers State with CLBF at Different Percentages and Combinations

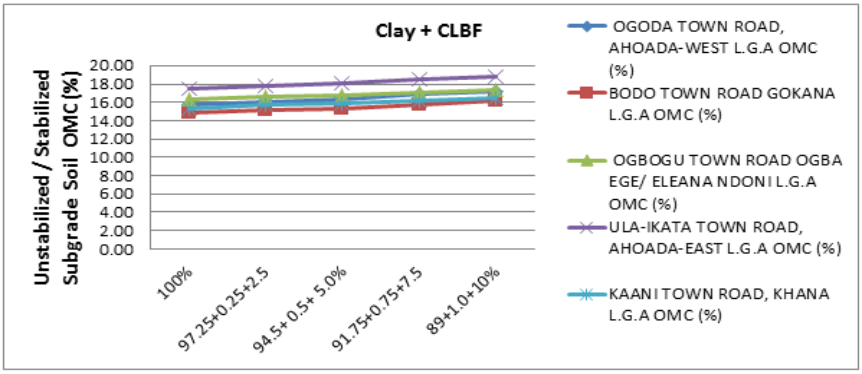

Fig-3.2: Optimum Moisture Content of Subgrade Stabilization Test of Clay Soil Ogoda, Bodo, Ogbogu, Ula-Ikata, Kaani Towns), Rivers State with CLBF at Different Percentages and Combinations

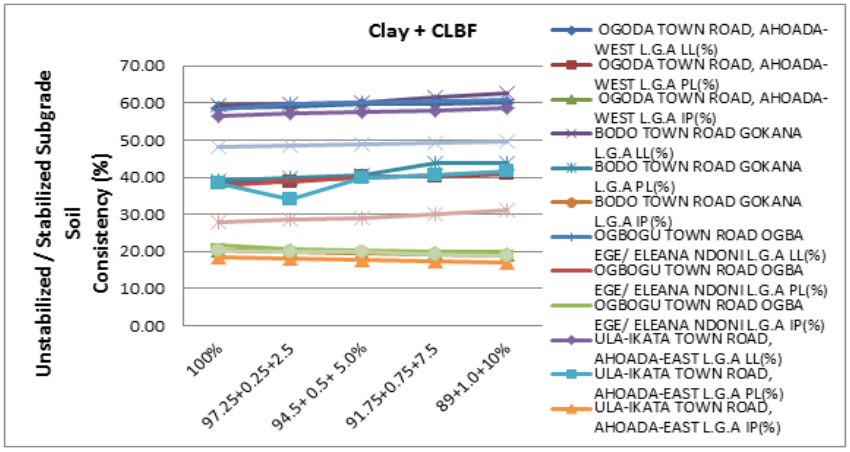

Fig-3.3: Consistency Limits of Subgrade Stabilization Test of Clay Soil from Ogoda, Bodo, Ogbogu, Ula-Ikata, Kaani Towns), Rivers State with CLBF at Different Percentages and Combination

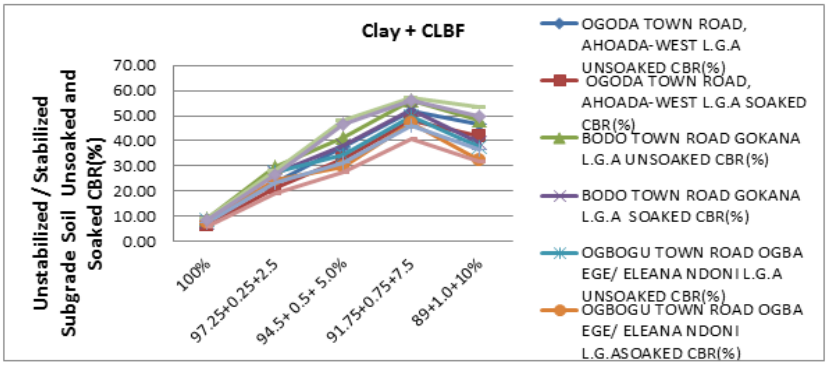

Fig-3.4: California Bearing Ratio of Subgrade Stabilization Test of Clay Soil from Ogoda, Bodo, Ogbogu, Ula-Ikata, Kaani Towns), Rivers State with CLBF at Different Percentages and Combination

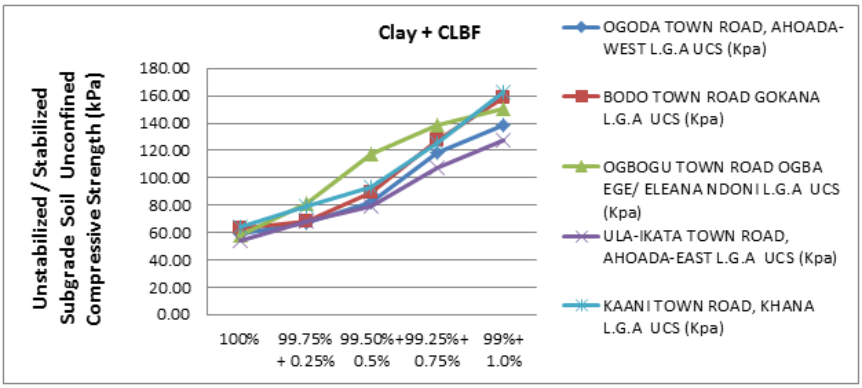

Fig-3.5: Unconfined Compressive Strength (UCS) of Subgrade Soil from Ogoda, Bodo, Ogbogu, Ula-Ikata, Kaani Towns), Rivers State with CLBF at Different Percentages and Combinations

Plate i. **Costaceae Lacerus** plant

Plate ii. **Costaceae Lacerus** stem

Plate iii. **Costaceae Lacerus piled stem**

Plate iv. **Costaceae Lacerus pulverized stage**

Plate vi. Costaceae Lacerus fibre bagasses

Plate vii. Costaceae Lacerus wet bagasses/fibre at day 3

CONCLUSIONS

The following conclusions were made from the experimental research results.

i. The soils classified as A – 7 – 6 on the AASHTO Classification System and soils are dark grey in color (from wet to dry states) plasticity index of 20.33%, 20.35%, 21.85%, 26.30%, and 21.35% respectively for Ogoda, Bodo, Ogbogu, Ula-Ikata, and Kaani.

ii. The entire results showed the potential of using CLBF as admixtures in the treatment of clay soils

iii. The swelling potential of treated soil decreased with the inclusion of bagasse fibre up to 0.75%.

iv. Preliminary investigations of the engineering properties of soils at natural state are percentage (%) passing BS sieves #200 are 73.85%, 67.38%, 6.35%, 82.35%, and 71.55%.

v. Comparative results showed decreased in plastic index properties of clay soils

vi. Results obtained showed increased in UCS with an increase in fibre percentages to soil the corresponding ratio

vii. Comparative results showed an increased in CBR values with increase in bagasse fibre percentages to a peak ration of 0.75% to soil ratio

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