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Effectual Use of Costaceae Lacerus Bagasse Fibre and Lime as Expansive Soil Stabilizer

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ABSTRACT

The research work investigated the effectual use of bagasse fibre of costaceae lacerus and lime in combination of 0.2+2.5%, 0.5% + 5.0%, 0.75% + 7.5% and 1.0% + 10% to soils ratio in the modification of weak soils of low properties for subgrade pavement. Soils were classified as A-2-6 SC and A-2-4 SM on the AASHTO classification schemes / Unified Soil Classification System from preliminary investigation and fell below approved standard for its application as road pavement structures. Results of consistency limits (Plastic index) properties decreased with increased in CLBF + lime inclusion to lateritic soils. The swelling potential of treated soil decreased with the inclusion of additives of 0.75% + 7.5% percentage ratio to soils. Unconfined compressive strength results showed tremendous increased with an increase in additive percentages. California bearing ratio of unsoaked and soaked reached optimum values percentage inclusion at 0.75% +7.5 %, beyond this value, crack was formed which resulted to potential failure. Entire results showed the latent use of costaceae lacerus and lime in combined actions as soil stabilizers.

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

1. INTRODUCTION

The properties possessed by the soils determine their degree of reactivity with lime and other additives, and the ultimate strength that the stabilized layers will develop. Lime has a number of effects when added into soil which can be generally categorized as soil drying, soil modification, and soil stabilization (Bhuyan, {1]). Current trend for enhancement of engineering properties of soil is stabilization through deployment of different additives, especially industrial wastes in the projects which create scope for best utilization of abundantly available industrial waste at a substantially low cost.

Charles *et al*. [2] evaluated the geotechnical properties of an expansive clay soil found along Odioku – Odiereke road in Ahoada-West, Rivers State, in the Niger Deltaic region. The application of two cementitious agents of cement and lime, hybridized with costus afer bagasse fiber to strength the failed section of the road. Results obtained of compaction test of Optimum moisture content (OMC) and maximum dry density (MDD) of clay soils cement bush sugarcane bagasse fibre (BSBF) reinforced soils at combined actions to soil ratios of 3.75% 0.25%, 5.5% 0.5%, 7.25% 0.75% and 9% 1.0% of cement and BSBF combined percentages.

Charles *et al*. [3] investigated the susceptible to pavement degradation resulted in very many failures, potholes and cracks along the stretches of Odioku road, Ahoada West, Rivers State. Stabilizers were used in single and combined actions to determine the suitability of the composite material that will solve these problems. Treated soils with Lime decreased in liquid limits and increased in plastic limits. At 8% of lime, CBR values reached optimum, beyond this range, cracks exist and 7.5% lime + 0. 75% BSBF, optimum value are reached.

Charles *et al*. [4] investigated the problematic engineering properties of soils with high plasticity level, high swelling and shrinkage potentials used in pavement design in the Nigerian Niger Delta region. The application of stabilizing agents of cement and costus afer bagasse fibre (Bush Sugarcane Bagaase Fibre) were mixed in single and combines actions to improved their unique properties. Results showed that inclusion stabilizing material improved strength properties of the soils. Results of tests carried out show that the optimum moisture content increased with increasing cement ratios to both soils (clay) and (laterite). Treated soils with Cement decreased in liquid limits and increased in plastic limits. Soils with Cement and fibre products in combinations increased CBR values appreciably both at soaked and unsoaked conditions. At 8% of lime, CBR values reached optimum, beyond this range, cracks exist and 7.5% cement + 0. 75% BSBF, optimum value are reached.

Sabat [5] studied the effect of lime sludge (from paper manufacturing industry) on compaction, CBR, shear strength parameters, coefficient of compression, Ps and durability of an expansive soil stabilized with optimum percentage of RHA after 7days of curing. The optimum proportion soil: RHA: lime sludge was found to be 75:10:15.

Rao *et al*. [6] studied the effects of RHA, lime and gypsum on engineering properties of expansive soil and found that UCS increased by 548 % at 28 days of curing and CBR increased by 1350 % at 14 days curing at RHA- 20%, lime -5 % and gypsum - 3%.

Otoko and Blessing [7] studied the engineering behavior of stabilized marine clay with cement and lime. The authors showed that the strength characteristics of the marine clay was improved as unconfined compressive strength and maximum dry density increased with increase in cement and lime content with of coarse, a corresponding decrease in the optimum moisture content.

2. 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.

2.1.3 Lime

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

2.2 Method

2.2.1 Sampling Locality

The soil sample used in this study were collected along Odioku Town, (latitude 5.07° 14‘S 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‘S and longitude 5.02° 50‘E), Upatabo Town, (latitude 5.35° 34‘S 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.

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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. 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 [8]; Allam and Sridharan [9]; Omotosho and Akinmusuru [10]; Omotosho [11]). 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

Preliminary test results of soils at natural state of maximum dry density (MDD) and optimum moisture content (OMC) results of lateritic soils for Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Town Roads at 100% are 1.954KN/m^3, 1.857KN/m^3, 1.943KN/m^3, 1.758KN/m^3 and 2.105KN/m^3 MDD and 12.39%, 14.35%, 13.85%, 11.79 and 10.95% OMC. With 0.25+2.5%, 0.5% + 5.0%, 0.75% + 7.5% and 1.0% + 10% inclusion of costaceae lacerus bagasse fibre ash (CLBF) + lime, maximum dry density (MDD) increased to 2.325 KN/m^3, 2.150 KN/m^3, 2.205 KN/m^3, 2.118 KN/m^3, 2.465 KN/m^3, and optimum moisture content (OMC) increased to 14.85%, 15.25%, 14.76%, 12.58% and 12.05%. Compaction results showed an increased on both MDD and OMC with an increase in additives inclusion as presented in table 3.4 and represented in figures 3.1 -3.5.

3.2 California Bearing Ratio (CBR) Test

Results obtained at 100% soils are unsoaked CBR values 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 %. With 0.2+2.5%, 0.5% + 5.0%, 0.75% + 7.5% and 1.0% + 10% inclusion of costaceae lacerus bagasse fibre ash (CLBF) + lime, unsoaked values are 58.75%, 49.30%, 53.55%, 52.75%, 57.58% and soaked are 55.58%, 37.25%, 49.57%, 49.35% and 53.30%. Results showed corresponding increased with percentages variation as shown in table 3.4 and figures 3.1- 3.5 with optimum inclusion at 99.25%+ 0.75% ratio (Soil +CLBF + Lime).

3.3 Unconfined Compressive Strength Test

Results obtained of lateritic soils at preliminary engineering soil properties are unconfined compressive strength (UCS) values of 178kPa , 145kPa, 165kPa , 158kPa and 149kPa at 100% soils, increased to 345kPa, 315kPa, 325kPa , 318kPa , 310kPa respectively as shown in table 3.4 and figure 3.5. Results showed tremendous increased in UCS with additives inclusion to lateritic soils

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3.4 Consistency Limits Test

Preliminary results of consistency limits (Plastic Index) are 17.30%, 14.23%, 15.20%, 15.50%, and 16.10% at 100% lateritic soils and 15.75%, 12.85%, 14.02%, 16.23% and 14.85% as shown in table 3.1 and figures 3.1 – 3.5. Decreased in plastic index properties were recorded in stabilized soils with increased in additives inclusion percentages.

Table

Table 3.1: Engineering Properties of Soil Samples

Location Description	**Odiokwu Town Road (CH 0+950)** (Laterite)	**Oyigba Town Road (CH 4+225)** (Laterite)	**Anakpo Town Road (CH6+950)** (Laterite)	**Upatabo Town Road (CH8+650)** (Laterite)	**Ihubuluko Town Road (CH10+150)** (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	A-2-6	A-2-4	A-2-4	A-2-6	A-2-4
Unified Soil Classification System	SC	SM	SM	SC	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

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Table3.2. 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 3.5: Results of Subgrade Soil (Clay) Test Stabilization with Binding Cementitious Products at Different percentages and Combination

SAMPLE LOCATION	SOIL + (CLBF) + LIME	MDD (kN/m^3)	OMC (%)	UNSOAKED CBR (%)	SOAKED CBR (%)	UCS(KPa)	LL(%)	PL(%)	PI(%)	SIEVE #200	AASHTO / USCS (Classification)	Notes
	LATERITE + COSTACEAE LACERUS BAGASSE FIBRE (CLBF)+ LIME											
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
	97.25+0.25+2.5%	1.963	12.42	25.35	21.85	212	39.15	22.10	17.05	28.35	A-2-6/SC	GOOD
	94.5+ 0.5+ 5.0%	1.978	12.58	38.60	33.05	245	38.45	21.70	16.75	28.35	A-2-6/SC	GOOD
	91.75+0.75+7.5%	2.150	12.78	58.75	55.58	297	38.05	21.68	16.25	28.35	A-2-6/SC	GOOD
	89+1.0+10%	2.325	14.85	47.65	42.25	345	36.75	21.65	15.75	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
	97.25+0.25+2.5%	1.875	14.53	21.35	18.65	174	36.45	22.45	14.00	40.55	A-2-4/SM	GOOD
	94.5+ 0.5+ 5.0%	1.896	14.77	33.57	29.05	224	35.67	21.89	13.78	40.55	A-2-4/SM	GOOD
	91.75+0.75+7.5%	1.935	14.95	49.30	37.25	268	35.05	21.75	13.30	40.55	A-2-4/SC	GOOD
	89+1.0+10%	2.150	15.25	44.55	33.89	315	34.25	21.40	12.85	40.55	A-2-4/SM	GOOD
Ayahnakpo	100%	1.943	13.8	7.80	7.20	165	36.7	21.45	15.3	36.8	A-2-	POOR

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Town Road			5				5		0	5	4/SM	
(CH6+950)	97.25+0.25+2.5 %	1.968	13.92	25.48	22.95	195	35.90	20.72	15.18	36.85	A-2-4/SM	POOR
	94.5+ 0.5+ 5.0%	1.995	14.15	39.35	36.85	255	35.75	20.50	14.75	36.85	A-2-4/SM	GOOD
	91.75+0.75+7.5 %	2.115	14.38	53.55	49.57	285	35.50	20.45	14.20	36.85	A-2-4/SM	GOOD
	89+1.0+10%	2.205	14.76	48.75	44.70	325	34.85	20.83	14.02	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
	97.25+0.25+2.5 %	1.856	11.82	25.70	23.45	186	36.28	18.90	17.38	33.45	A-2-6/SM	GOOD
	94.5+ 0.5+ 5.0%	1.975	11.97	39.05	36.65	215	35.85	18.81	17.04	33.45	A-2-6/SM	GOOD
	91.75+0.75+7.5 %	2.005	12.18	52.75	49.35	278	35.25	18.47	16.78	33.45	A-2-6/SC	GOOD
	89+1.0+10%	2.118	12.58	49.05	43.60	318	34.65	18.42	16.23	33.45	A-2-6/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
	97.25+0.25+2.5 %	2.125	11.08	28.95	25.08	181	37.18	21.33	15.85	39.25	A-2-6/SM	POOR
	94.5+ 0.5+ 5.0%	2.186	11.32	39.50	36.85	220	36.75	21.25	15.50	39.25	A-2-6/SM	GOOD
	91.75+0.75+7.5 %	2.225	11.67	57.58	53.30	267	36.25	21.07	15.18	39.25	A-2-6/SC	GOOD
	89+1.0+10%	2.465	12.05	51.75	47.08	310	35.78	20.93	14.85	39.25	A-2-6/SM	GOOD

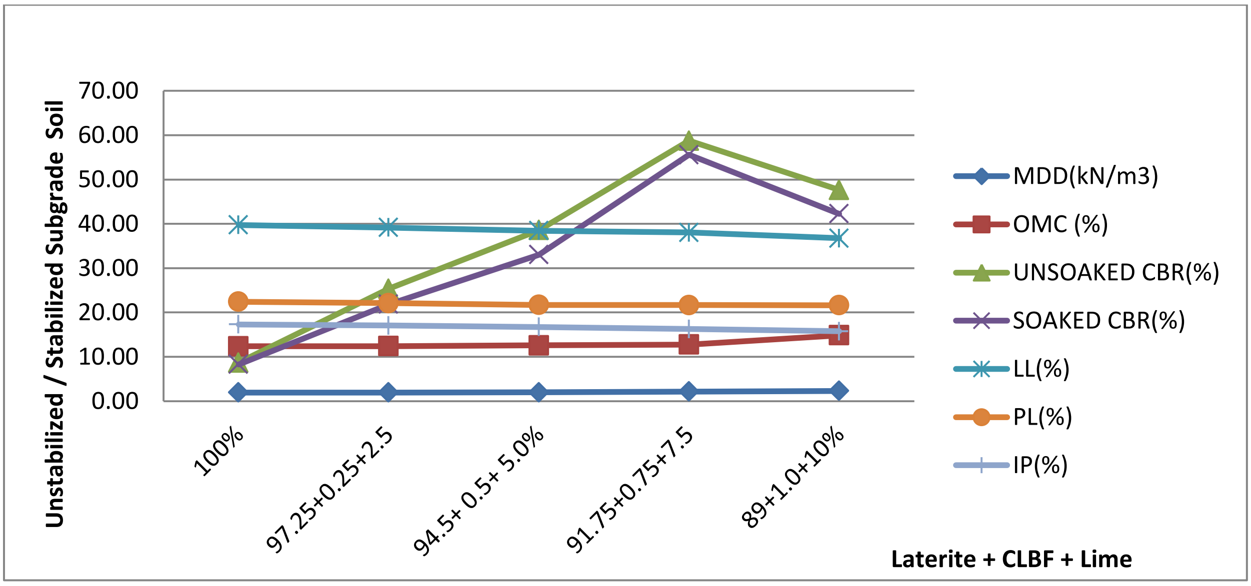

Figure 3.1: Subgrade Stabilization Test of Lateritic Soil from Odioku in Ahoada-West L.G.A of Rivers State with CLBF + Lime at Different Percentages and Combination

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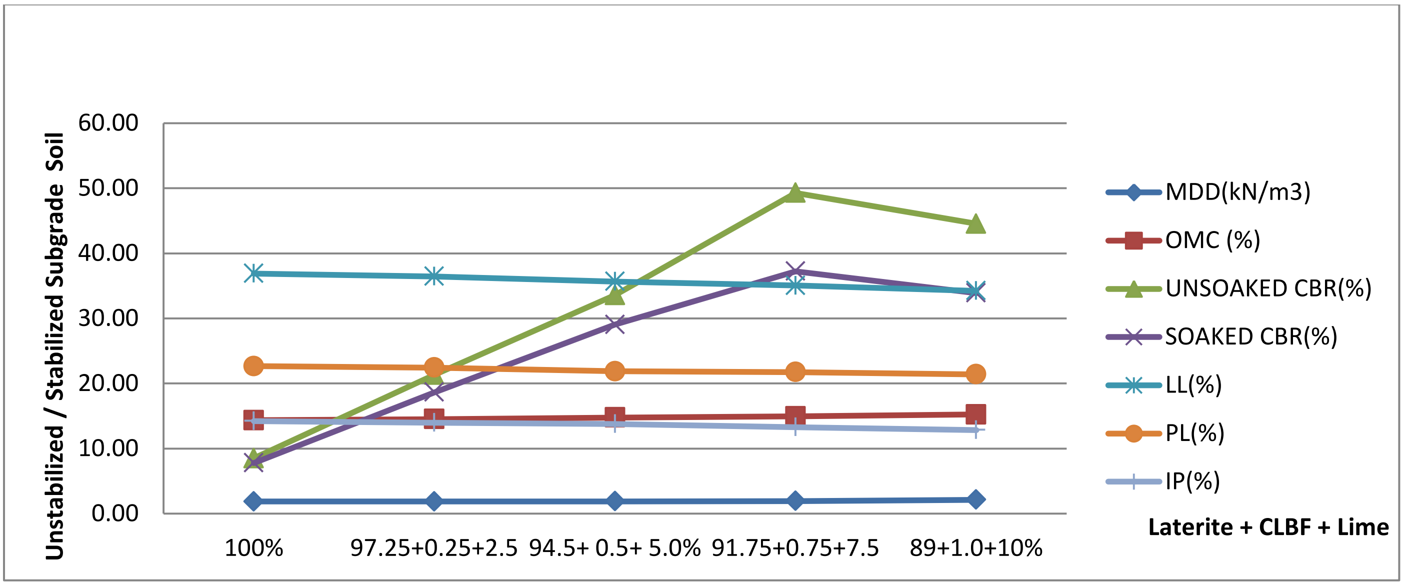

Figure 3.2: Subgrade Stabilization Test of Lateritic Soil from Oyigba in Ahoada-West L.G.A of Rivers State with CLBF + Lime at Different Percentages and Combination

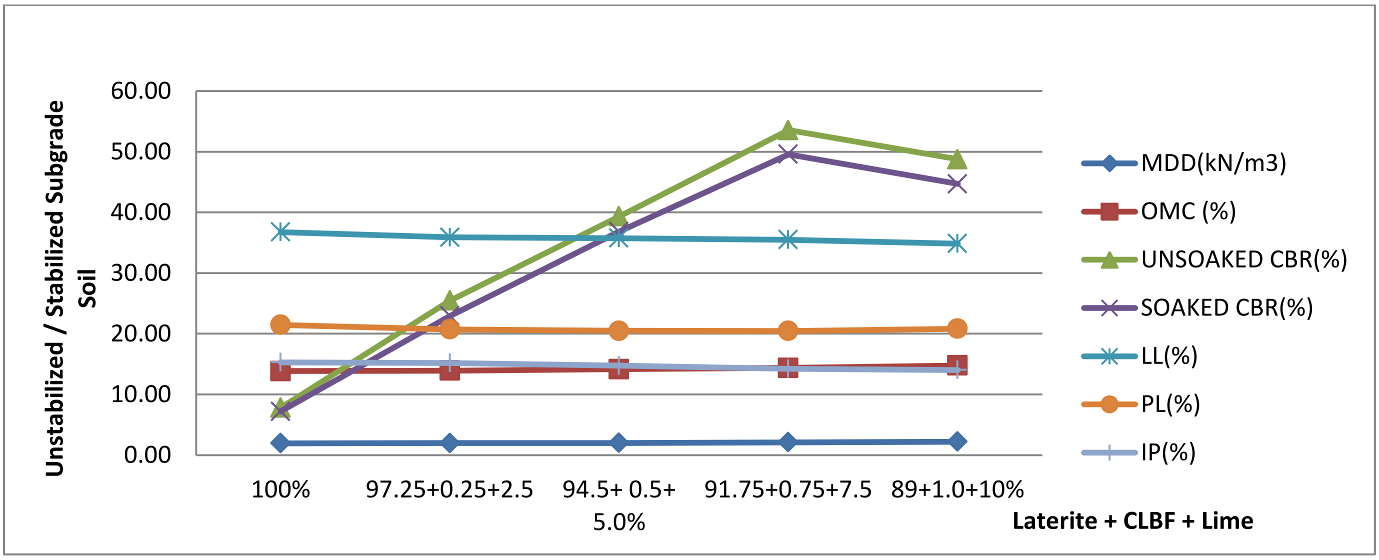

Figure 3.3: Subgrade Stabilization Test of Lateritic Soil from Anakpo in Ahoada-West L.G.A of Rivers State with CLBF + Lime at Different Percentages and Combination

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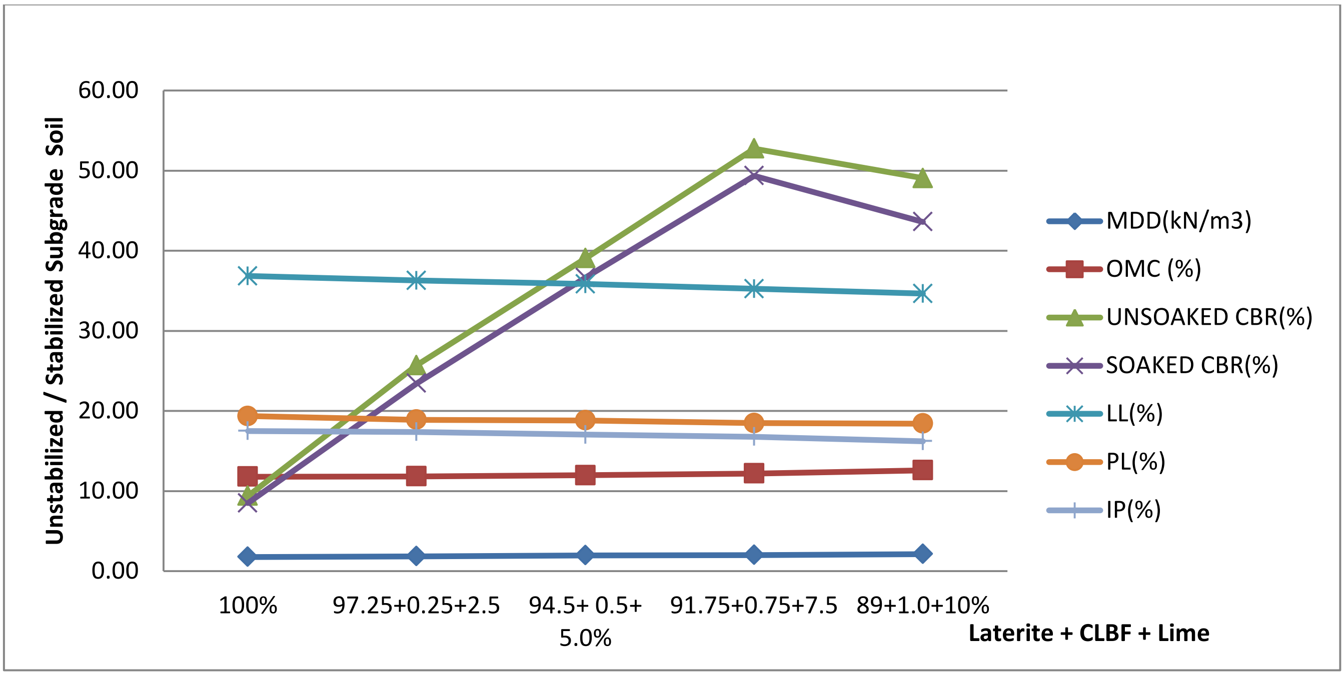

Figure 3.4: Subgrade Stabilization Test of Lateritic Soil from Upatabo in Ahoada-West L.G.A of Rivers State with CLBF + Lime at Different Percentages and Combination

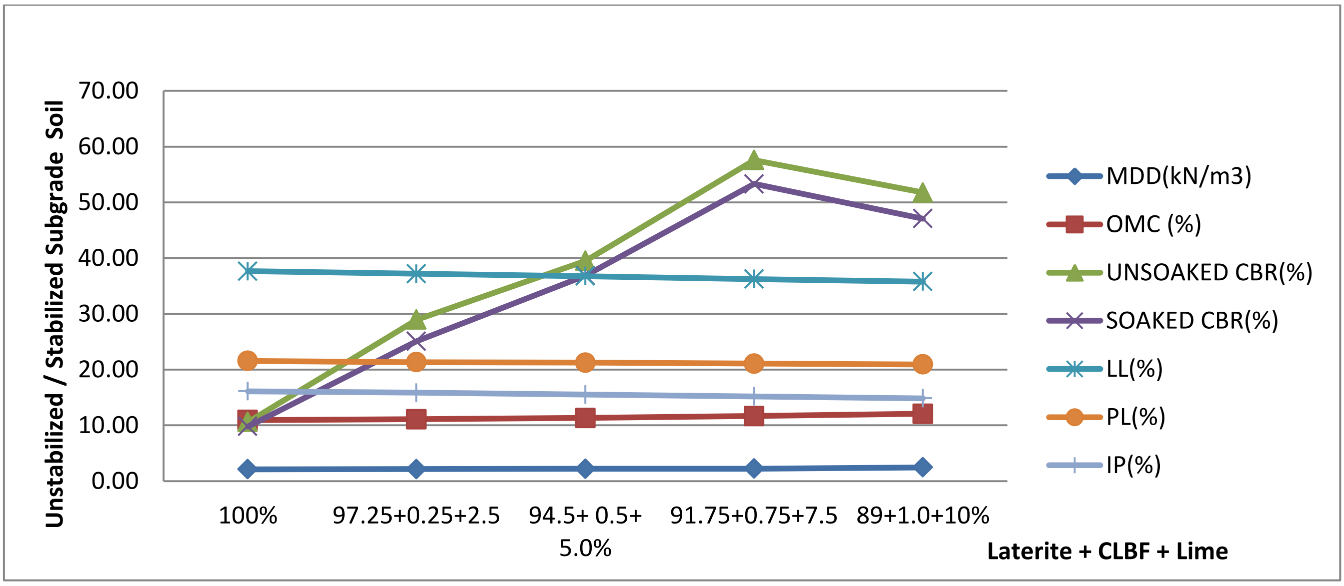

Figure 3.5: Subgrade Stabilization Test of Lateritic Soil from Ihubuluko in Ahoada-West L.G.A of Rivers State with CLBF + Lime at Different Percentages and Combination

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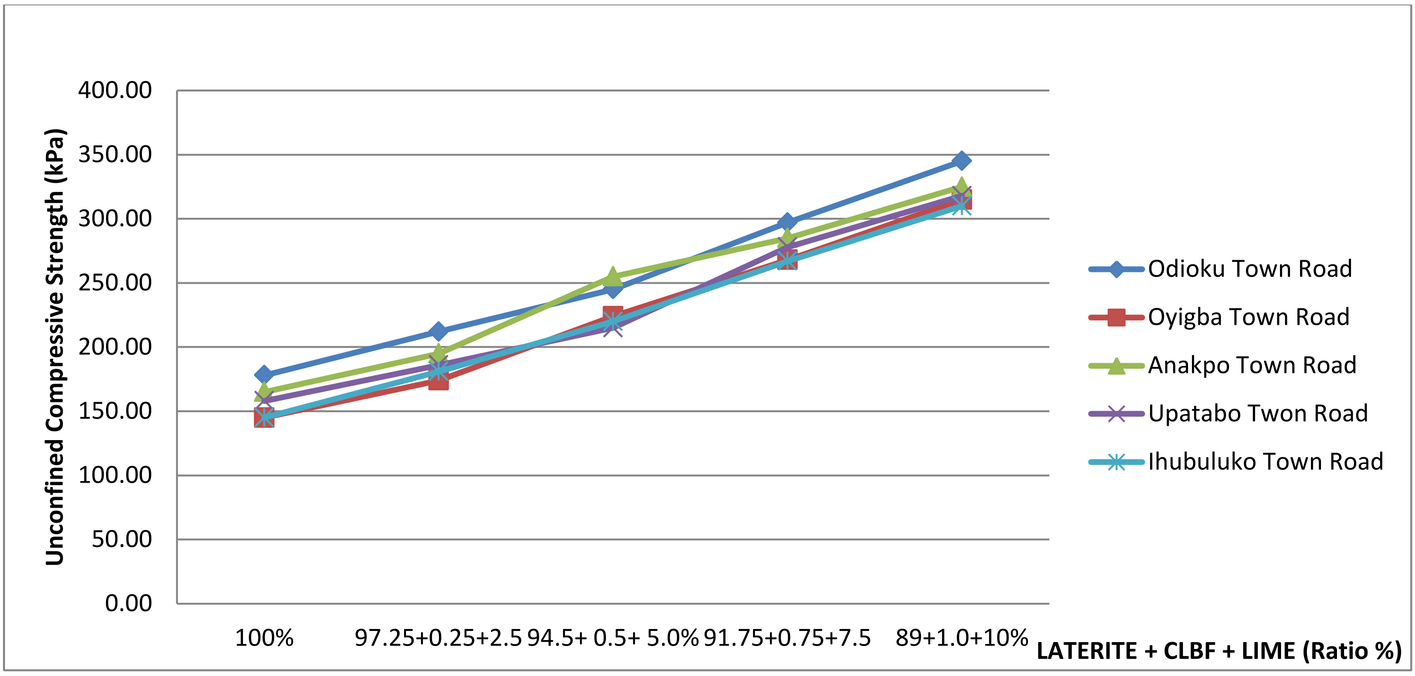

Figure 3.6: Unconfined Compressive Strength (UCS) of Niger Deltaic Lateritic Soils Subgrade with CLBF + Lime of (Odioku, Oyigba, Anakpo, Upatabo and Ihubuluko Towns), Ahoad-West L.G.A, Rivers State

Plate i. Costaceae Lacerus plant

Plate ii. Costaceae Lacerus stem

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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. 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)

ii. Soils are 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.

iii. Consistency limits (Plastic index) properties decreased with increased in CLBF + Lime inclusion to lateritic soils

iv. Swelling potential of treated soil decreased with the inclusion of CLBF + Lime of 0.75% +7.5% percentage ratio to soils

v. Unconfined compressive strength results showed tremendous increased with increase in additive percentages to soil ratio.

vi. California bearing ratio of unsoaked and soaked reached optimum values percentage inclusion at 0.75% +7.5% , beyond this value, crack was formed which resulted to potential failure.

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