International Journal of
Advances in Scientific Research and Engineering (ijasre)

E-ISSN : 2454-8006

DOI: http://doi.org/10.31695/IJASRE.2018.32940

Volume 4, Issue 11
November - 2018

Influence of Waste Agricultural Fibre Products Material and Lime on Geotechnical Characteristics of Expansive Soils

Letam Leelee Prince[1], Charles Kennedy[2] and Terence Temilade Tam Wokoma[3]

[1,2,3]School of Engineering, Department of Civil Engineering,

Kenule Beeson Saro-Wiwa Polytechnic, Bori,

Rivers State, Nigeria.

ABSTRACT

The study evaluated the failures associated with the sampled roads of Ebiriba, Ochigba, Eneka and Isiokpo in the Niger Delta of Nigeria with the application of composite materials of plantain rachis fibre ash + lime as soil stabilizer to strengthened the poor state of the failed sections. First stage of investigations classified the clay soils as A-7-6/CH on the AASHTO classification schemes / Unified Soil Classification System with percentage passing sieve #200 as 75.55%, 75.05%, 82.85% and 69.55%, unsoaked CBR values of 6.38%, 7.75%, 8.24% and 7.85%, and soaked CBR values of 5.25%, 6.03%, 6.35% and 6.30%, unconfined compressive strength (UCS) values of 68.85kPa, 77.35kPa, 79.85kPa and 65.57kPa.Soils fell below the minimum requirement for such application as road embankment and needs stabilization to improve their properties. Comparatively results shown in table 3.1 and 3.2 on compaction test parameters indicated increased values of maximum dry density (MDD) and optimum moisture content (OMC) relative to percentage inclusion increase. In contrast to results of tables 3.1 and 3.2, stabilized clay soils California bearing ratio of unsoaked and soaked values increased with respect to composite materials of plantain rachis fibre + lime percentile ratio with the optimum percentage of 0.75% + 7.5%. Cracks and values reduction were confirmed outside optimum percentile. Comparative results are shown in table 3.2 and figure 3.5 illustrated unconfined compressive strength tests increased relative to inclusion percentile increase. Comparative results shown in table 3.1, 3.2 and figures 3.1 – 3-4 showed decreased values of the plastic index with respect to additives inclusion percentages. The entire results showed the good potential of using plantain rachis fibre ash + limet as the soil stabilizer

Key Words: *Clay, Plantain Rachis Fibre Ash, Lime, CBR, UCS, Consistency, Compaction*

1.0 INTRODUCTION

Expansive soils with unique potentials of swelling, shrinkage and with excessive in situ water contents are susceptible to massive settlements and possess low shear strength until they attained cemented. An alternative to that is cementation of the smooth clay with supplementary cementing substances together with lime and cement (Horpibulsuk *et al.* [1]).

Charles *et al.* [2] 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%. 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. The entire results showed the potential of using bagasse, BSBFA as admixtures in cement and lime treated soils of laterite.

Sharma *et al*., [3] investigated the behavior of expansive clay stabilized with lime, calcium chloride and RHA. The optimum percentage of lime and calcium chloride was found to be 4 % and 1% respectively in stabilization of expansive soil without addition of RHA. From UCS and CBR point of view when the soil was mixed with lime or calcium chloride, RHA content of 12

DOI: 10.31695/IJASRE.2018.32940

% was found to be the optimum. In expansive soil – RHA mixes, 4% lime and 1% calcium chloride were also found to be optimum.

Ramakrishna and Pradeep [4] 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.

Sabat [5] 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.

2.0 MATERIALS AND METHODS

2.1 Materials

2.1.1 Soil

The soils used for the study were collected from Ebiriba Town Road, in Ahoada-West Local Government, Ochigba Town Road, in Ahoada-East Local Government Area, Eneka Town Road, in Obio/Akpor Local Government Area and IsiokpoTown Road, in Ikwerre Local Government area, all in Rivers State, Niger Delta region, Nigeria. It lies on the recent coastal plain of the North-Western of Rivers state of Niger Delta.

2.1.2 Plantain Rachis Fibre

The Plantain Rachis fibres are obtained from Iwofe markets, in Obio/Akpor Local Area of Rivers State, they are abundantly disposed as waste products both on land and in the river.

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 Ebiriba Town, (latitude 5.10° 31‘N and longitude 6.38° 8‘E), Ochigba a Town, (latitude 5.1° 30‘N and longitude 6.35° 55‘E), Eneka Town, latitude 4.90° 28‘N and longitude 7.03° 15‘E), and Isiokpo Town, latitude 5.05° 41‘N and longitude 6.92° 33‘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, Califonia 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

DOI: 10.31695/IJASRE.2018.32940

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 [6] Allam and Sridharan [7]; Omotosho and Akinmusuru [8]; Omotosho [9]). The soils are reddish brown and dark grey in colour (from wet to dry states) plasticity index of 28.55%, 25.97%, 33.50%, and 28.40% respectively for Ebiriba, Ochigba, Eneka and Isiokpo Town Roads. The soil has unsoaked CBR values of 6.38%, 7.75%, 8.24% and 7.85%, and soaked CBR values of 5.25%, 6.03%, 6.35% and 6.30%, unconfined compressive strength (UCS) values of 68.85kPa, 77.35kPa, 79.85kPa and 65.57kPa when compacted with British Standard light (BSL), respectively.

3.1 Compaction Test Results

Compaction test results of sampled roads preliminary geotechnical investigation are maximum dry density (MDD) values 1.685 KN/m^3, 1.705 KN/m^3, 1.663 KN/m^3, 1.605 KN/m^3 and optimum moisture content (OMC) 16.38%, 17.45%, 16.75% and 15.87%. Stabilized clay soils with plantain rachis fibre ash + lime at 2.5% + 2,5%, 5.0% + 5.0%, 7.5% + 7.5% and 10% + 10% to soils ratio peak values are maximum dry density (MDD) values are 1.762KN/m^3, 1.785KN/m^3, 1.735KN/m^3, 1.684KN/m^3 and optimum moisture content (OMC) 18.43%, 18.98%, 18.43% and 17.34%.

Results from table 3.2 and figures 3.1- 3.4 illustrated results of un-stabilized and stabilized cly soils compaction test results which showed increased in both maximum dry density (MDD) and optimum moisture content (OMC) relative to ratio percentage increase.

3.2 California Bearing Ratio (CBR) Test

Results from table 3.1, illustrated the California bearing ratio (CBR) of clay soils at 100% natural state are unsoaked 6.38%, 7.75%, 8.24% and 7.85%, and soaked 5.25%, 6.03%, 6.35% and 6.30%. Stabilized clay soils with plantain rachis fibre ash + lime to soils peak values of California bearing ratio (CBR) unsoaked are 48.35%, 52.48%, 54.38%, 49.85%, and soaked 46.80%, 51.05%, 52.80% and 47.35%.

Results computed in table 3.2 and figure 3.1 – 3.4, illustrated California bearing ratio (CBR) values increased of unsoaked and soaked of stabilized clay soils as against un-stabilized with optimum inclusion of 7.5% + 7.5%. Mixed ration beyond optimum experienced value reduction and cracks.

3.3 Unconfined Compressive Strength Test

From table 3.1, results obtained of un-stabilized clay soils at 100% of unconfined compressive strength test are 68.85kPa, 77.35kPa, 79.85kPa and 65.57kPa. Stabilized plantain rachis fibre ash + lime to clay soils unconfined compressive strength test maximum yielded values are 436kPa, 456kPa, 483kPa and 415kPa. Comparative results shown in table 3.2 and figure 3.5 illustrated unconfined compressive strength tests increased relative to inclusion percentile increase.

3.4 Consistency Limits Test

Results of consistency limits (Plastic index) ocf clay soils at zero percentage inclusion are 28.55%, 25.97%, 33.50%, and 28.40%. Results of modified plastic index of clay soils are 27.36%, 28.56%, 36.65% and 27.43%. Comparative results shown in table 3.1, 3.2 and figures 3.1 – 3-4 showed decreased values of plastic index with respect to additives inclusion percentages.

DOI: 10.31695/IJASRE.2018.32940

Table 3.1: Engineering Properties of Soil Samples

Location Description	**Ebiriba Road Ahoada West L.G.A**	**Ochigba Road Ahoada East L.G.A**	**Eneka Road Obio/Akpor L.G.A**	**Isiokpo Road Ikwerre L.G.A**
Depth of sampling (m)	1.0	1.0	1.0	1.0
Percentage(%) passing BS sieve #200	75.55	75.05	82.85	69.55
Colour	Greyish/black	Grey	Greyish	Greyish
Specific gravity	2.45	2.68	2.62	2.48
Natural moisture content (%)	47.36	43.85	47.80	48.15
Consistency limits				
Liquid limit (%)	57.30	56.35	63.30	57.75
Plastic limit (%)	28.75	30.38	29.80	29.35
Plasticity Index	28.55	25.97	33.50	28.40
AASHTO soil classification Unified Soil Classification System	A-7-6/CH	A-7-6/CH	A-7-6/CH	A-7-6/CH
Compaction characteristics				
Optimum moisture content (%)	16.38	17.45	16.75	15.87
Maximum dry density ($kN/m^{3)}$	1.685	1.705	1.663	1.665
Grain size distribution				
Gravel (%)	0	0	0	0
Sand (%)	16.25	12.35	12.80	14.35
Silt (%)	43.83	39.85	41.85	42.35
Clay (%)	39.92	46.80	45.35	56.70
Unconfined compressive strength (kPa)	68.85	77.35	79.85	65.57
California Bearing Capacity (CBR)				
Unsoaked (%) CBR	6.38	7.75	8.24	7.85
Soaked (%) CBR	5.25	6.03	6.35	6.30

DOI: 10.31695/IJASRE.2018.32940

Table 3.2: Results of Subgrade Soil (Clay) Test Stabilization with Binding Cementitious Products at Different Percentages And Combination

SAMPLE LOCATION	SOIL + FIBRE PLANTAIN RACHIS ASH + LIME	MDD (kN/m^3)	OMC (%)	UNSOAKED CBR (%)	SOAKED CBR (%)	UCS(KPa)	LL(%)	PL(%)	PI(%)	SIEVE #200	AASHTO / USCS (Classification)	NOTES
CLAY SOIL + PLATAIN RACHIS FIBRE ASH (PRFA)+ LIME												
EBIRIBA ROAD AHOADA WEST L.G.A	100%	1.685	16.38	6.38	5.25	68.85	57.30	28.75	28.55	79.55	A – 7 – 6/CH	POOR
	95+2.5+2.5%	1.692	16.83	25.50	22.45	88.85	57.83	29.41	28.41	79.55	A – 7 – 6/CH	GOOD
	90+5.0+5.0%	1.708	17.53	32.68	29.65	197	58.30	30.12	28.18	79.55	A – 7 – 6/CH	GOOD
	85+7.5+7.5%	1.741	17.98	48.35	46.80	380	58.62	30.19	27.83	79.55	A – 7 – 6/CH	GOOD
	80+10+10%	1.762	18.43	41.85	38.23	436	58.93	31.07	27.36	79.55	A – 7 – 6/CH	GOOD
OCHIGBA ROAD AHOADA EAST L.G.A	100%	1.705	17.45	7.75	6.03	77.35	56.35	30.38	25.97	75.05	A – 7 – 6/CH	POOR
	95+2.5+2.5%	1.718	17.85	28.35	26.89	96	59.71	27.26	29.45	75.05	A – 7 – 6/CH	GOOD
	90+5.0+5.0%	1.733	18.23	36.81	33.45	216	57.18	28.18	29.00	75.05	A – 7 – 6/CH	GOOD
	85+7.5+7.5%	1.755	18.67	52.48	51.05	338	57.45	28.57	28.88	75.05	A – 7 – 6/CH	GOOD
	80+10+10%	1.785	18.98	48.25	46.30	456	57.93	29.37	28.56	75.05	A – 7 – 6/CH	GOOD
ENEKA ROAD OBIO/AKPOR L.G.A	100%	1.663	16.75	8.24	6.35	79.85	63.30	29.80	38.50	82.85	A – 7 – 6/CH	POOR
	95+2.5+2.5%	1.672	17.23	33.30	29.65	108	63.57	25.27	38.30	82.85	A – 7 – 6/CH	GOOD
	90+5.0+5.0%	1.683	17.74	41.40	38.83	263	63.93	25.87	38.06	82.85	A – 7 – 6/CH	GOOD
	85+7.5+7.5%	1.718	18.05	54.38	52.80	347	64.13	26.18	37.95	82.85	A – 7 – 6/CH	GOOD
	80+10+10%	1.735	18.43	46.05	44.15	483	58.53	25.93	31.65	82.85	A – 7 – 6/CH	GOOD
ISIOKPO ROAD IKWERRE L.G.A	100%	1.605	15.87	7.85	6.30	65.75	57.75	29.35	28.40	69.55	A – 7 – 6/CH	POOR
	95+2.5+2.5%	1.618	16.18	31.35	29.10	85	57.53	29.32	28.21	69.55	A – 7 – 6/CH	GOOD
	90+5.0+5.0%	1.643	16.48	38.23	37.05	163	57.81	29.78	29.03	69.55	A – 7 – 6/CH	GOOD
	85+7.5+7.5%	1.663	16.87	49.85	47.35	296	58.08	30.22	29.86	69.55	A – 7 – 6/CH	GOOD
	80+10+10%	1.684	17.34	43.40	39.38	415	58.53	30.10	27.43	69.55	A – 7 – 6/CH	GOOD

DOI: 10.31695/IJASRE.2018.32940

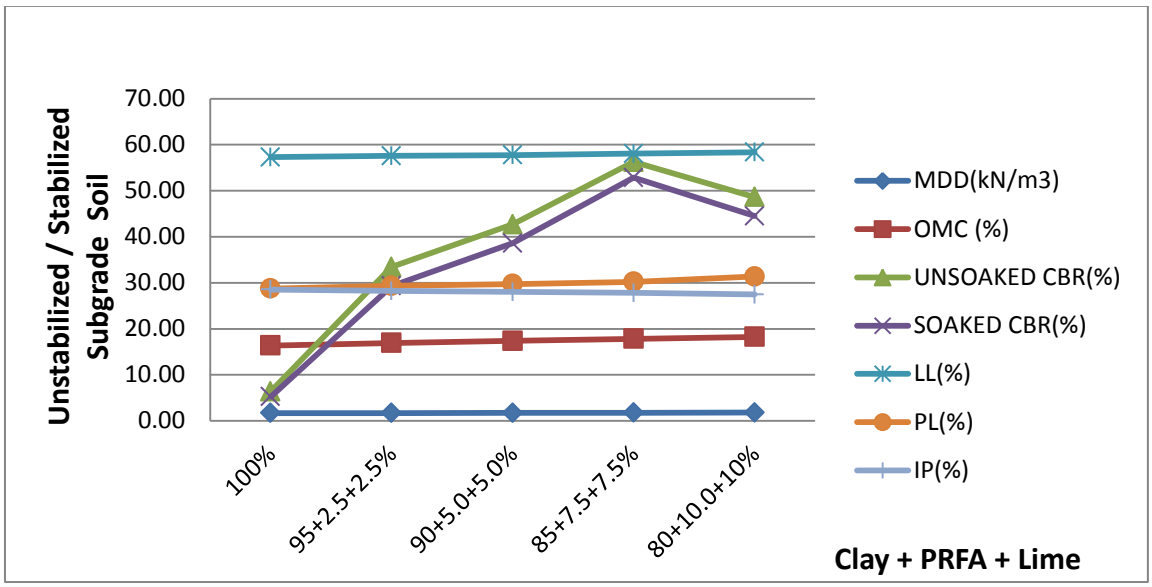

Figure 3.1: Subgrade Stabilization Test of Clay Soil from Ebiriba in Ahoada - West L.G.A of Rivers State with PRFA + Lime at Different Percentages and Combination

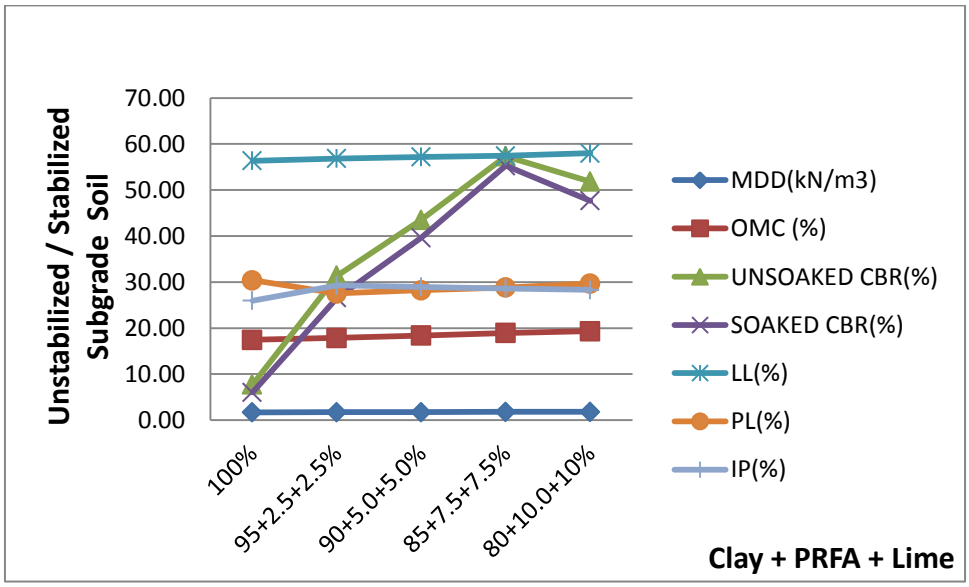

Figure 3.2: Subgrade Stabilization Test of Clay Soil from Ochigba in Ahoada - East L.G.A of Rivers State with PRFA + Lime at Different Percentages and Combination

DOI: 10.31695/IJASRE.2018.32940

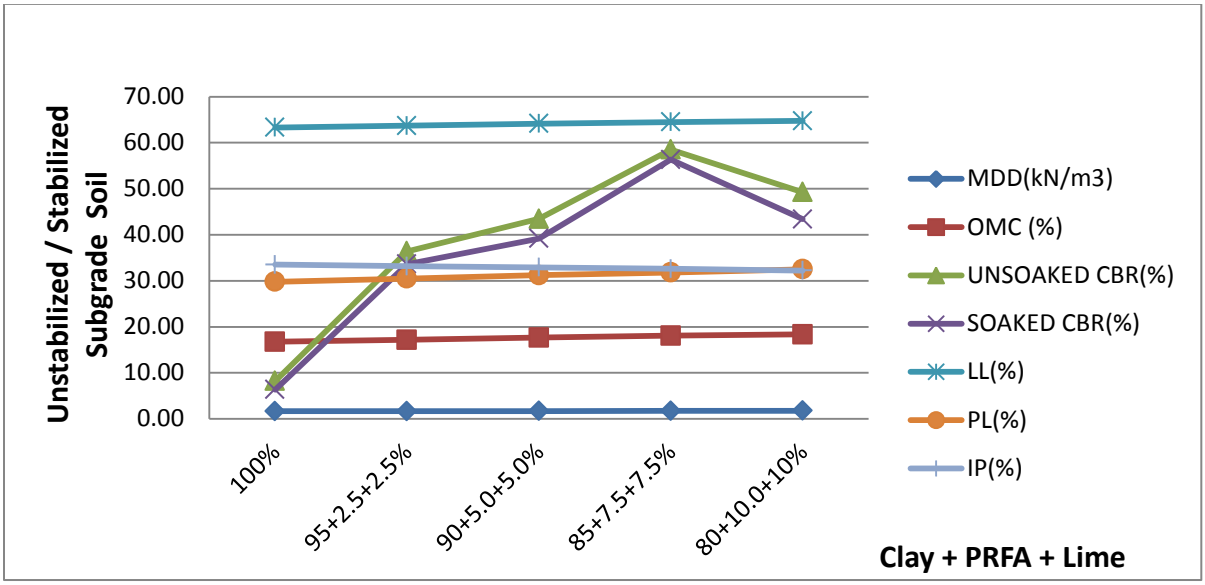

Figure 3.3: Subgrade Stabilization Test of Clay Soil from Eneka in Obio/Akpor L.G.A of Rivers State with PRFA + Lime at Different Percentages and Combination

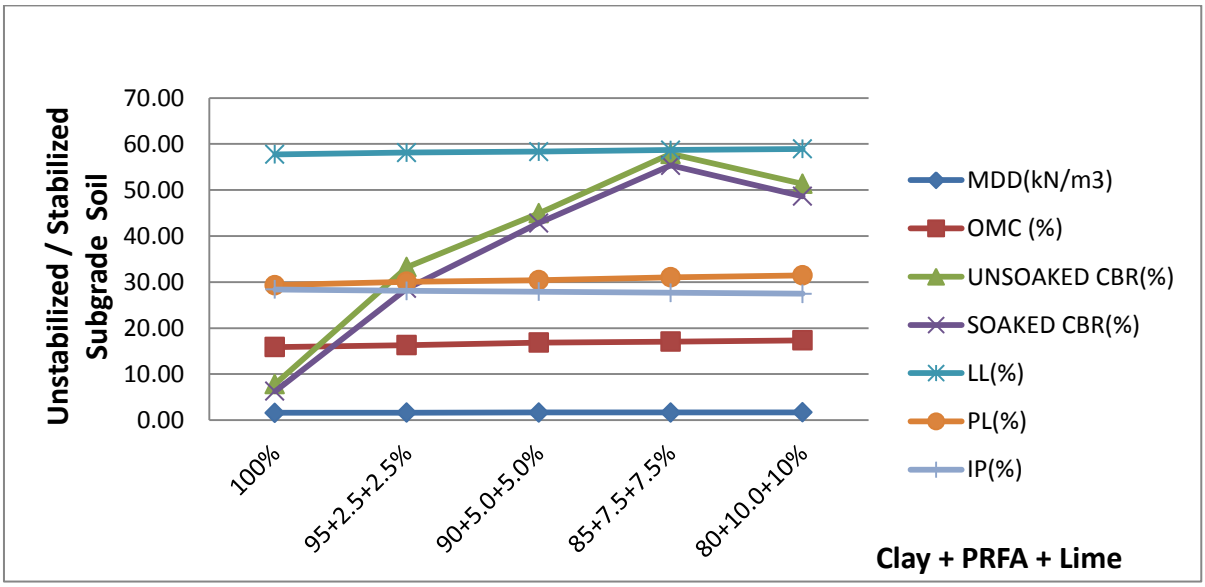

Figure 3.4: Subgrade Stabilization Test of Clay Soil from Isiokpo in Ikwerre L.G.A of Rivers State with PRFA + Lime at Different Percentages and Combination

DOI: 10.31695/IJASRE.2018.32940

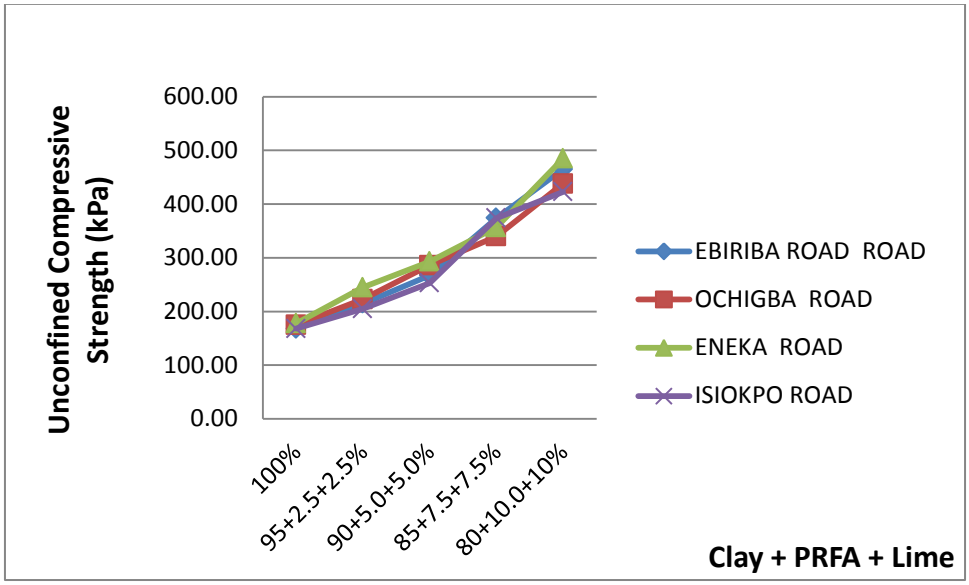

Figure 3.5: Unconfined Compressive Strength (UCS) of Niger Deltaic Clay Soils Subgrade with PRFA + Lime of

(Ebiriba, Ochigba, Eneka and Isiokpo Towns) **all in Rivers State**

4.0 CONCLUSIONS

The following conclusions were made from the experimental research results.

i. Soils are classified as A-7-6/CH on the AASHTO classification schemes / Unified Soil Classification System.

ii. Comparatively, results shown in table 3.1 and 3.2 on compaction test parameters indicated increased values of maximum dry density (MDD) and optimum moisture content (OMC) relatively to percentage inclusion increase.

iii. In contrast to results of tables 3.1 and 3.2, stabilized clay soils California bearing ratio of unsoaked and soaked values increased with respect to composite materials of plantain rachis fibre + lime percentile ratio with optimum percentage of 0.75% + 7.5%. Cracks and values reduction were confirmed outside optimum percentile.

iv. Comparative results shown in table 3.2 and figure 3.5 illustrated unconfined compressive strength tests increased relative to inclusion percentile increase.

v. Comparative results shown in table 3.1, 3.2 and figures 3.1 – 3-4 showed decreased values of plastic index with respect to additives inclusion percentages.

REFERENCES

[1] S. Horpibulsuk, N. Miura, andD.T. Bergado, "Undrained Shear Behavior of Cement Admixed Clay at High Water Content", *Journal of Geotechnical and Geoenvironmental Engineering, 2004.*

[2] K. Charles, L. P. Letam, O. Kelechi, "Comparative on Strength Variance of Cement / Lime with Costus Afer Bagasse Fibre Ash Stabilized Lateritic Soil", *Global Scientific Journal,* 2018, vol.6, no.5, pp. 267-278.

[3] R.S. Sharma,, B. R. Phanikumar, and B.V. Rao, "Engineering Behaviour of a Remolded Expansive Clay Blended with Lime, Calcium Chloride and Rice-Husk Ash", *Journal of Materials in Civil Engineering, 2008* vol. 20, no. 8, pp. 509-515.

[4] A.N. Ramakrishna, and A.V. Pradeepkumar, "Stabilization of Black Cotton Soil using Rice Husk Ash and Cement, Proc. of National Conference", Civil Engineering Meeting the Challenges of Tomorrow, 2006, pp. 215-220.

DOI: 10.31695/IJASRE.2018.32940

[5] A. K. Sabat, "Effect of Polypropylene Fiber on Engineering Properties of Rice Husk Ash – Lime Stabilized Expansive Soil", *Electronic Journal of Geotechnical Engineering,* 2012, no. 17(E), pp. 651-660.

[6] S. A. Ola, "Need for Estimated Cement Requirements for Stabilizing Lateritic Soils", *Journal of Transportation Engineering, ASCE*, 1974, vol.100, no. 2, 379–388.

[7] M. M. Allam, and A Sridharan, "Effect of Repeated Wetting and Drying on Shear strength", *Journal of Geotechnical Engineering, ASCE,* 1981,vol. 107, no, 4, pp. 421–438.

[8] P .O. Omotosho, and J .O. Akinmusuru, "Behaviour of Soils (Lateritic) Subjected Multi -Cyclic Compaction", *Engineering Geology,* 1992, no.32, pp. 53–58.

[9] P. O. Omotosho, "Multi-Cyclic Influence on Standard laboratory Compaction of Residual soils", *Engineering Geology.* 1993, no. 36, pp. 109–115.

.

DOI: 10.31695/IJASRE.2018.32940