Global Scientific JOURNALS
GSJ: Volume 6, Issue 10, October 2018, Online: ISSN 2320-9186
www.globalscientificjournal.com

STABILIZATION OF DELTAIC EXPANSIVE SOILS TREATED WITH PLANTAIN RACHIS FIBRE AND LIME

Dennis BUDU Eme[1], Charles Kennedy[2]

[1]Department of Civil Engineering, University of Port Harcourt, Port Harcourt, Nigeria.

[2]Faculty of Engineering, Department of Civil Engineering, Rivers State University, Nkpolu, Port Harcourt, Nigeria

Authors E-mail: [1]densobudueme@yahoo.com, [2]ken_charl@yahoo.co.uk,

ABSTRACT

An investigative study was carried out to ascertain the geotechnical properties of failed highway sections along Ogbogoro, Egbeda, Igwuruta and Aleto roads all in Niger Delta region of Nigeria and stabilized them with composite cementittious hybridized materials of plantain rachis fibre + lime with 0.25% + 2.5%, 0.5% + 5.0%, 0.75% + 7.5% and 1.0% + 10% to soils ratio inclusion. Investigated preliminary results at 100% lateritic soils classified the soils as A-2-6 SC and A-2-4 SM on the AASHTO classification schemes / Unified Soil Classification System and further results as outlined in table 3.1 classified soils as poor and unfit for road embankment constructional materials. Detailed investigated results of stabilized lateritic soils compaction test parameters of maximum dry density (MDD) and optimum moisture content (OMC) showed increased values to corresponding stabilizers increase. Computed results of California bearing ratio stabilized lateritic soils increased in both unsoaked and soaked with respect to additives inclusion percentages increase with optimum mixed ratio of 0.75% + 7.5%. Decrease / reversed values was noticed at mix ratio higher than optimum. Computed stabilized lateritic soils result of unconfined compressive strength test increased with respect to corresponding stabilizer percentage ratio inclusions. Results from stabilized lateritic soils decreased in plastic index properties with corresponding percentage ration increase to soils. Summarized results showed the use of investigated composite cementitious materials as soil stabilizer.

Key Words: Lateritic Soils, Plantain Rachis Fibre, Lime, CBR, UCS, Consistency, Compaction

1.0 Introduction

Cementitious additives of lime, cement, fly-ash and the likes are the most successfully used soil stabilization in singly dose or in combined state. They reduced soil plasticity with resultant effects on swelling, shrinking and similar behavior. Lime and soil mixed at the proper moisture content has been used increasingly in recent years to stabilize soils in special situations. The hardening process of lime stabilized soils happens immediately upon mixing soil with cement slurry as well lime. The hardening agent produces the hydrated calcium silicates, hydrated calcium aluminates, and calcium hydroxide and forms hardened cement bodies. Natural fibres and cementitious additives of cement, lime, fly-ash and others have been used to reduce shrinkage cracks in clayey soils without the least environmental nuisances and at almost low performance costs (Sivakumar *et al*. [1]). They are obtained from the waste of palm fruits and have acceptable mechanical properties and durability in natural conditions (Marandi *et al.*, [1]; Zare, [3]).

Charles *et al*. [4] 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.

Kalkan [5] stabilized expansive clay with red mud (a waste material generated during the production of alumina) and cement-red mud and found increase in strength and decrease in swelling percentage and hydraulic conductivity.

Lime stabilization results in higher bearing capacity and lower compressibility of the treated soil mass (Deboucha *et al*. [6] found increase in CBR value corresponded to increase of the additives content and curing period. Furthermore, the added lime reacts with the pore water, resulting in chemical bonding between soil particles, a reduction in water content and, in turn, an increase in undrained shear strength. While, according

Wahab *et al*. [7] used lime stabilization and creates a number of important engineering properties in soils to improved workability, providing a working platform for subsequent construction, reducing plasticity to meet specifications, conditioning the soil for further treatment.

Prabakar and Sridhar [8] 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.

2.0 Materials and Methods

2.1 Materials

2.1.1 Soil

The soils used for the study were collected from Ogbogoro Town Road, in Obio/Akpor Local Government, Egbeda Town Road, in Emuoha Local Government Area, Igwuruta Town Road, in Ikwerre Local Government Area and Aleto Town Road, in Eleme 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 Ogbogoro Town, (latitude 4.81° 33‘S and longitude 6.92° 18‘E), Egbeda a Town, (latitude 5.14° 15‘N and longitude 6.45° 23‘E), Igwuruta Town, latitude 4.97° 93‘N and longitude 6.99° 80‘E), and Aleto Town, latitude 4.81° 32‘S and longitude 7.09° 28‘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;

GSJ: Volume 6, Issue 10, October 2018
ISSN 2320-9186

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 17.11%, 22.5%, 14.10%, and 18.51% respectively for Ogbogoro, Egbeda, Igwuruta and Aleto Town Roads. The soil has unsoaked CBR values of 9.25%, 9.48%, 7.85% and 8.65 %, and soaked CBR values of 7.40%, 8.05%, 6.65% and 6.65 %, unconfined compressive strength (UCS) values of 168kPa, 178kPa, 163kPa and 175kPa when compacted with British Standard light (BSL), respectively.

3.1 Compaction Test Results

Table 3.1 outlined the investigated results of lateritic soils at 100% compaction test parameters of maximum dry density (MDD) as 1.755KN/m^3, 1.838KN/m^3, 1.924KN/m^3, 1.865KN/m^3, and Optimum moisture content (OMC), 14.85%, 14.40%, 15.03% and 16.05%. Plantain rachis fibre + lime stabilized soils at 0.25% + 2.5%, 0.5% + 5.0%, 0.75% + 7.5% and 1.0% + 10% to soils maximum values shown in table 3.2 are maximum dry density (MDD) 1.924KN/m^3, 2.1835KN/m^3, 2.0255KN/m^3, 2.368KN/m^3, and optimum moisture content (OMC) 16.45%, 17.55%, 15.75% and 16.75%. Detailed investigated results of stabilized lateritic soils compaction test parameters of maximum dry density (MDD) and optimum moisture content (OMC) showed increased values to corresponding stabilizers increase.

3.2 California Bearing Ratio (CBR) Test

Results obtained for from table 3.1 of investigated sampled roads lateritic soils at 100% California bearing ratio (CBR) test values of unsoaked are 9.25%, 9.48%, 7.85% 8.65 % and soaked are 7.40%, 8.05%, 6.65% and 6.65 %. Plantain rachis fibre + lime stabilized soils shown in table 3.2 and represented in figures 3.1 – 3.4, are maximum CBR values of unsoaked are 72.45%, 56.38%, 77.36%, 58.35% and soaked 66.40%, 51.75%, 74.80% and 53.30%. Computed results of California bearing ratio stabilized lateritic soils increased in both unsoaked and soaked with respect to additives inclusion percentage increases with optimum mixed ratio of 0.75% + 7.5%. Decrease/ reversed values was noticed at mix ratio higher than optimum.

3.3 Unconfined Compressive Strength Test

Results obtained of lateritic soils at preliminary test of 100% lateritic soils are 168kPa, 178kPa, 163kPa and 175kPa. Stabilized lateritic soils unconfined compressive strength test maximum obtained values from table 3.2 are 485kPa, 465kPa, 508kPa, and 437kPa. Computed stabilized lateritic soils result of unconfined compressive strength test increased with respect to corresponding stabilizer percentage ratio inclusions.

3.4 Consistency Limits Test

Results obtained of consistency limits (plastic index) preliminary test at natural lateritic soils are 17.11 %, 22.50%, 14.1 0% and 18.51%. Plantain rachis fibre + lime stabilized soils at 0.25% + 2.5%, 0.5% + 5.0%, 0.75% + 7.5% and 1.0% + 10% to soils maximum values are 15.98%, 16.85%, 21.03% and 12.65%. Results from stabilized lateritic soils decreased in plastic index properties with corresponding percentage ration increase to soils.

Table 3.1: Engineering Properties of Soil Samples

Location Description	Ogobogoro Road Obio/Akpor L.G.A	Egbeda Road Emuoha L.G.A	Igwuruta Road Ikwere L.G.A	Aleto Road Eleme L.G.A
Depth of sampling (m)	1.5	1.5	1.5	1.5
Percentage(%) passing BS sieve #200	38.35	42.15	36.35	39.40
Colour	Reddish	Reddish	Reddish	Reddish
Specific gravity	2.59	2.78	2.77	15.35
Natural moisture content (%)	22.6	19.48	10.95	15.35
		Consistency		
Liquid limit (%)	38.46	42.35	35.15	38.65
Plastic limit (%)	21.35	19.85	21.05	20.14
Plasticity Index	17.11	22.50	14.1 0	18.51
AASHTO soil classification	A-2-4/SM	A-2-4/SM	A-2-4/SC	A-2-4/SC
Unified Soil Classification System				
Optimum moisture content (%)	14.85	14.40	15.08	16.05

GSJ: Volume 6, Issue 10, October 2018
ISSN 2320-9186

Maximum dry density (kN/m^{3})	1.755	1.883	1.924	1.865
Gravel (%)	3.25	2.85	3.83	2.35
Sand (%)	38.65	36.50	32.58	39.45
Silt (%)	23.85	38.75	33.45	37.85
Clay (%)	34.25	22.90	30.14	20.35
Unconfined compressive strength (kPa)	168	178	163	175
California Bearing Capacity (CBR)				
Unsoaked (%) CBR	9.25	9.48	7.85	8.65
Soaked (%) CBR	7.40	8.05	6.65	6.93

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

SAMPLE LOCATION	SOIL + FIBRE PLANTAIN RACHIS + LIME	MDD (kN/m^3)	OMC (%)	UNSOAKED CBR (%)	SOAKED CBR (%)	UCS(KPa)	LL(%)	PL(%)	PI(%)	SIEVE #200	AASHTO / USCS (Classification)	NOTES
LATERITE + PLANTAIN RACHIS FIBRE (PRF) + LIME												
OGOBOGORO	100%	1.755	14.85	9.25	7.40	168	38.46	21.35	17.11	38.46	A–2–4/SM	POOR
ROAD	97.25+0.25+2.5%	1.793	15.28	38.30	33.61	243	39.06	22.13	16.93	38.46	A–2–4/SM	GOOD
OBIO/AKPOR	94.5+0.5+5.0%	1.815	15.67	50.35	47.30	316	39.76	23.08	16.28	38.46	A–2– 4/SM	GOOD
L.G.A	91.75+0.75+7.5%	1.878	15.93	72.45	66.40	405	40.86	24.62	16.24	38.64	A –2–4/SM	GOOD
	89.9+1.0+10%	1.924	16.45	61.25	57.25	485	41.65	25.67	15.98	38.64	A –2–4/SM	GOOD
ALETO ROAD	100%	1.865	16.05	8.65	6.93	175	38.65	20.14	18.51	39.40	A –2– 4/SC	POOR
ELEME	97.25+0.25+2.5%	1.895	16.52	33.76	27.80	219	38.98	20.84	18.14	39.40	A –2– 4/SC	GOOD
L.G.A	94.5+0.5+5.0%	1.945	16.93	43.83	38.3	283	39.58	21.83	17.75	39.40	A–2– 4/SC	GOOD
	91.75+0.75+7.5%	1.987	17.24	56.38	51.75	356	39.93	22.68	17.25	39.40	A–2– 4/SC	GOOD
	89.9+1.0+10%	2.183	17.55	48.63	42.15	465	40.28	23.43	16.85	39.40	A–2– 4/SC	GOOD
EGBEDA	100%	1.883	14.40	9.48	8.05	178	42.35	19.85	22.50	42.15	A–2– 4/SM	POOR
ROAD	97.25+0.25+2.5%	1.883	14.68	36.75	31.30	231	42.68	20.63	22.05	42.15	A–2– 4/SM	GOOD
EMUOHA	94.5+0.5+5.0%	1.928	14.93	52.85	48.65	305	43.16	21.33	21.83	42.15	A–2– 4/SM	GOOD
L.G.A	91.75+0.75+7.5%	1.975	15.23	77.36	74.80	388	43.65	22.19	21.46	42.15	A–2– 4/SM	GOOD
	89.9+1.0+10%	2.025	15.75	69.80	62.45	508	44.08	23.05	21.03	42.15	A–2– 4/SM	GOOD
IGWURUTA	100%	1.924	15.08	7.85	6.65	168	35.15	21.05	14.10	36.35	A –2– 4/SC	POOR
ROAD	97.25+0.25+2.5%	1.967	15.56	22.85	21.33	198	35.53	21.70	13.83	36.35	A –2– 4/SC	GOOD
IKWERE	94.5+0.5+5.0%	2.035	15.83	39.34	32.85	263	35.89	22.04	13.35	36.35	A –2– 4/SC	GOOD
L.G.A	91.75+0.75+7.5%	2.245	16.28	58.35	53.30	339	36.23	23.28	12.95	36.35	A–2– 4/SC	GOOD
	89.9+1.0+10%	2.368	16.75	49.67	43.86	437	36.72	24.07	12.65	36.35	A–2– 4/SC	GOOD

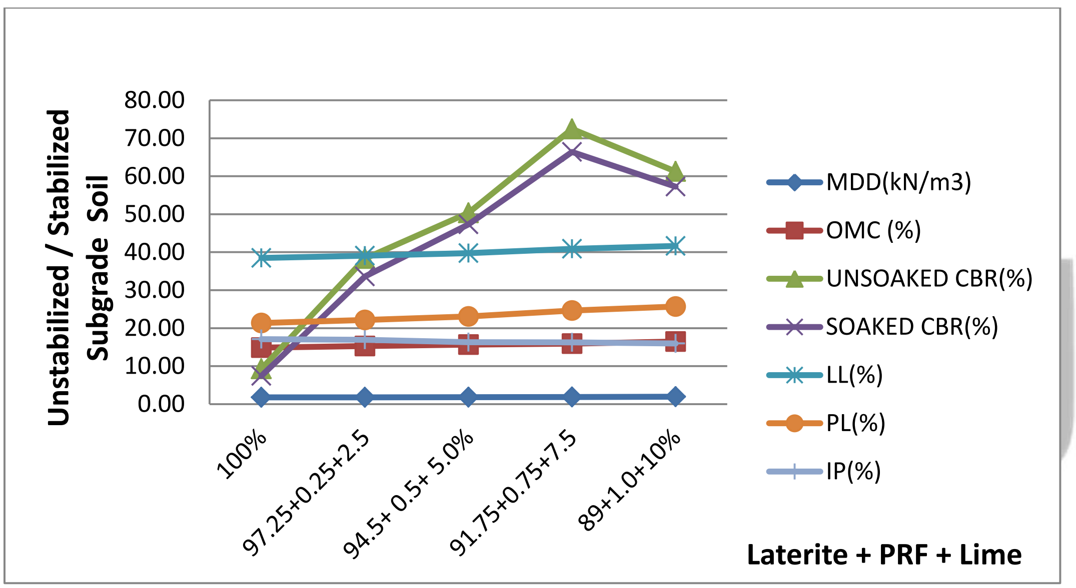

Figure 3.1: Subgrade Stabilization Test of Lateritic Soil from Ogbogoro in Obio/Akpor L.G.A of Rivers State with PRF + Lime at Different Percentages and Combination

GSJ: Volume 6, Issue 10, October 2018
ISSN 2320-9186

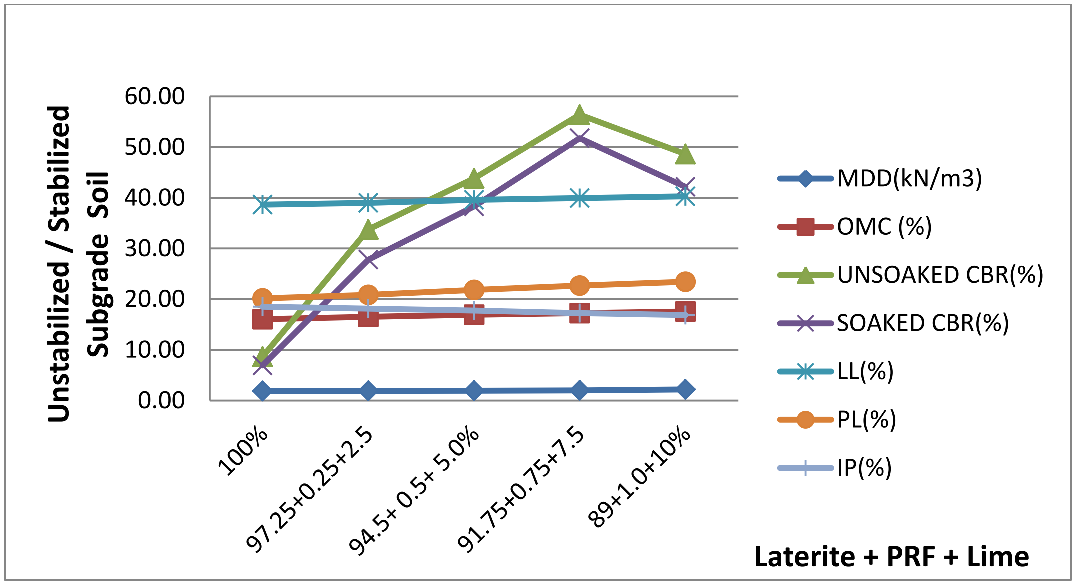

Figure 3.2: **Subgrade Stabilization Test of Lateritic Soil from Aleto in Eleme L.G.A of Rivers State with PRF + Lime at Different Percentages and Combination**

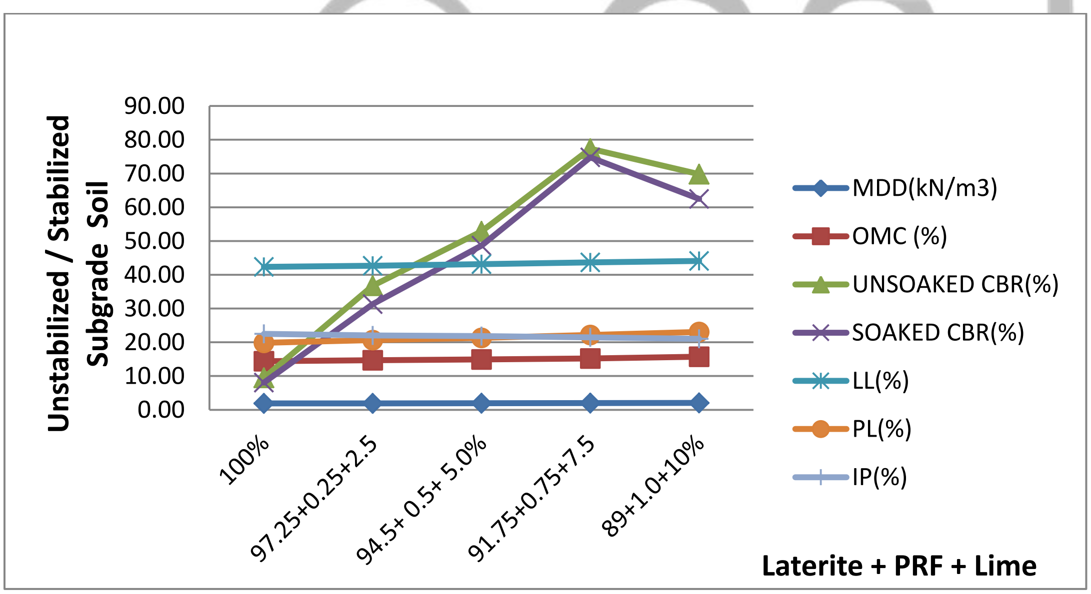

Figure 3.3: **Subgrade Stabilization Test of Lateritic Soil from Egbeda in Emuoha L.G.A of Rivers State with PRF + Lime at Different Percentages and Combination**

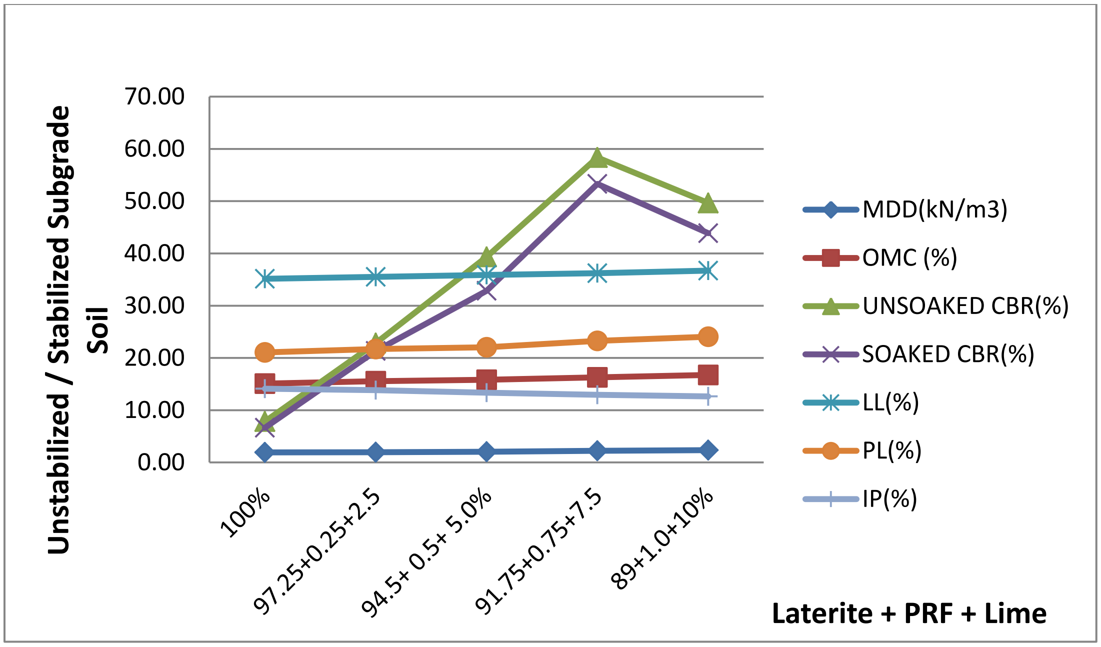

Figure 3.4: Subgrade Stabilization Test of Lateritic Soil from Igwuruta in Ikwerre L.G.A of Rivers State with PRF + Lime at Different Percentages and Combination

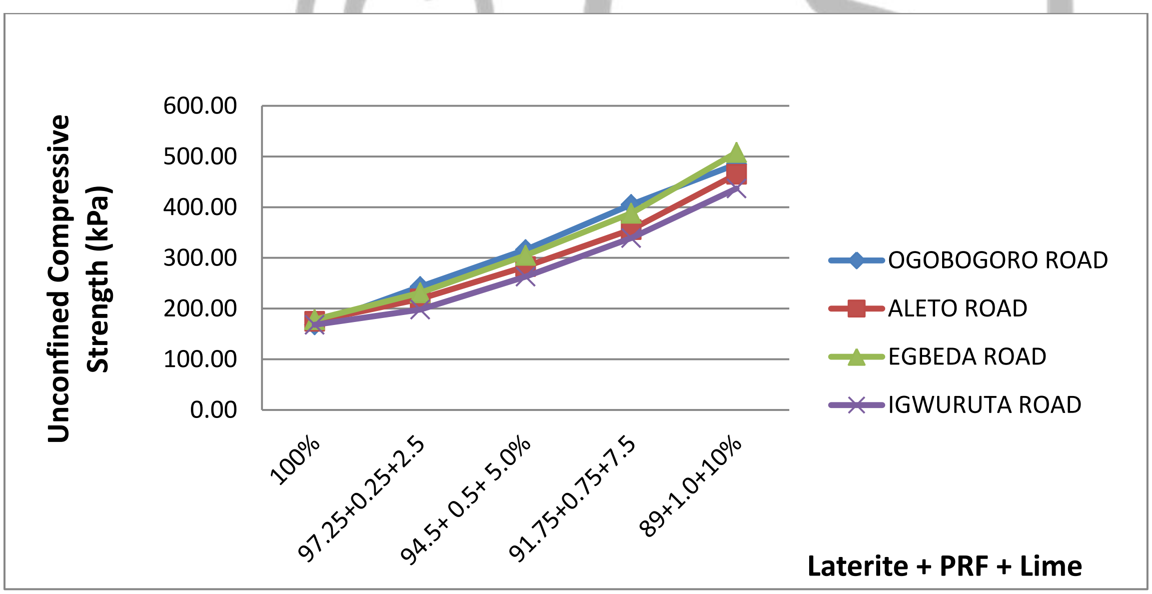

Figure 3.5: Unconfined Compressive Strength (UCS) of Niger Deltaic Laterite Soils Subgrade with PRF + Lime of (Ogbogoro, Aleto, Egbeda andIgwuruta Towns) all in Rivers State

4.0 Conclusions

The following conclusions were made from the experimental research results.

i. Soils are classified as A-2-6 SC and A-2-4 SM on the AASHTO classification schemes / Unified Soil Classification System.

ii. Detailed investigated results of stabilized lateritic soils compaction test parameters of maximum dry density (MDD) and optimum moisture content (OMC) showed increased values to corresponding stabilizers increase.

iii. Computed results of California bearing ratio stabilized lateritic soils increased in both unsoaked and soaked with respect to additives inclusion percentage increases with optimum mixed ratio of 0.75% + 7.5%. Decrease/ reversed values was noticed at mix ratio higher than optimum.

iv. Computed stabilized lateritic soils result of unconfined compressive strength test increased with respect to corresponding stabilizer percentage ratio inclusions.

v. Results from stabilized lateritic soils decreased in plastic index properties with corresponding percentage ration increase to soils.

References

[1] J. L. Sivakumar Babu ", Use of Coir Fibers for Improving the Engineering Properties of Expansive Soils", *Journal of Natural Fibers*, vol. 5, no. 1, pp. 61-75, 2008.

[2] S. M., Marandi, M. H. Bagheripour, R. Rahgozar, H. Zare, "Strength and Ductility of Randomly Distributed Palm Fibers Reinforced Silty-Sand Soils", *American Journal of Applied Science*, vol. 5, no. 3, pp. 209-220, 2008.

[3] H. Zare, "Laboratory Study on Mechanical Characteristics and Bearing Capacity of Natural Fiber Reinforced Sand. M.Sc. Thesis submitted to Shahid Bahonar University of Kerman. 2006.

[4] K.. Charles, U. Essien, S. K. Gbinu, "Stabilization of Deltaic Soils using Costus Afer Bagasse Fiber", *International Journal of Civil and Structural Engineering Research*. Vol.6, no.1, pp. 148-156, 2018

[5] E. Kalkan, "Utilization of Red Mud as a Stabilization Material for the Preparation of Clay Liners", *Engineering Geology*, vol. 87, no.3-4, pp. 220-229, 2006.

[6] S. Deboucha, R Hashim., and A. Alwi, "Engineering Properties of Stabilized Tropical Peat Soils", *Electronic Journal of Geotechnical Engineering*, Vol 3, 1-11, 2008. Department of Civil Engineering, Democritus University of Thrace, GR-67100 Xanth L Greece "Stabilization of swelling clays by Mg(OH)2. Factors affecting hydroxy-Mg-inter layering in swelling clays", Engineering Geology, no. 44, pp. 93-106, 1999.

[7] S. F. Wahab, W. M. Nazmi and W. A. Rahman, " Stabilization Assessment of Kuantan Clay Using Lime, Portland

Cement, Fly Ash, And Bottom Ash", National Conference on Road Engineering of Indonesian Road Development Association (IRDA), (Unpublished), 2011.

[8] J. Prabakar, and R.S. Sridhar, "Effect of Random Inclusion of Sisal Fibre on Strength Behavior of Soil. Construction and Building Materials, no. 16, pp. 123–131, 2002.

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

[10] M. M. Allam, and A Sridharan, "Effect of Repeated Wetting and Drying on Shear strength", .*Journal of Geotechnical Engineering, ASCE, vol.* 107, no, 4, pp. 421–438, 1981.
.
[11] P .O. Omotosho, and J .O. Akinmusuru, "Behaviour of soils (lateritic) subjected to multi-cyclic compaction", *Engineering Geology*, no.32, pp. 53–58, 1992.

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