Subgrade Stabilization Evaluation Using Plantain Rachis Fibre Ash and Lime as Soil Stabilizer

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ABSTRACT

The study investigated strength improvement of expansive lateritic soils with notable high plasticity, high swelling, high shrinkage and crack potentials with the application of composite materials of plantain rachis fibre ash and lime in combined actions. Early investigations grouped the soils as A-2-6 SC and A-2-4 SM on the AASHTO classification schemes / Unified Soil Classification System with other characteristics shown in table 3.1. Generally, sampled soils do not meet standards for road subgrade and embankment materials. Summarized computed results of plantain rachis fibre ash + lime stabilized lateritic soils with 2.5% + 2.5%, 5.0% + 5.0%, 7.5% + 7.5% and 10% + 10% of compaction test parameters of maximum dry density (MDD) and optimum moisture content (OMC) increased in values with composite stabilizer inclusion accordingly to percentages increase. Final recapitulated results of stabilized California bearing ratio values of both unsoaked and soaked increased uniformly to percentages addition with optimum mix of 7.5% + 7.5%. Further results showed declined values after optimum with noticed crack signs. Summarized results of unconfined compressive strength test of composite stabilizer modified lateritic soils increased remarkably with percentage variations increase. Results obtained from modified lateritic soils showed plastic index increased as percentages of inclusion vary. The entire results showed good potential of using plantain rachis fibre ash and cement as soil stabilizer.

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

1.0 Introduction

Lime with other additives of fibre bagasse and ash in mixed status used in soil stabilization results in higher bearing capacity and lower compressibility of the treated soil mass. They found, increase in CBR value corresponded to increase of the additives content and curing period. 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.

Wahab *et al*. [1] stated that lime stabilization creates a number of important engineering properties in soils to improved workability, providing a working platform for subsequent construction, reducing plasticity to meet specifications.

Charles *et al*. [2] evaluated the engineering properties of soil with the inclusion of costus afer (Bush sugarcane bagasse fiber ash (BSBFA) at varying percentages. Results of compaction of soil between the relationship of optimum moisture content (OMC) and maximum dry density (MDD) of soil and bagasse ash inclusion increased with increase in BSBFA percentages of 7.5% and decreased at 2.5% to 10% bagasse ash inclusion. Stabilization was found to satisfy subgrade requirements. Their results showed the potential of using BSBFA as admixture in soils of clay and laterite. Swelling of treated soil decreased with the inclusion of bagasse fibre ash up to 7.5% for both soils.

Charles *et al*. [3] 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.

Charles *et al*. [4] 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% and termed poor on remarks required subgrade and strength fo constructional works. 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.

Other additives, such as geofiber and geogrid, depend on their physical effects to improve soil properties (Alawaji, [5]; Viswanadham *et al*. [6]). In addition, it can be combined both of chemical and physical stabilization, for example, by using lime and geofiber or geotextile together (Yang *et al*. [7]; Chong and Kassim,[8]). Lime is the oldest traditional chemical stabilizer used for soil stabilization (Mallela *et al*. [9]).

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;

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 [10]; Allam and Sridharan [11]; Omotosho and Akinmusuru [12]; Omotosho [13]). 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

Compaction test parameters result of sampled roads at 100% natural lateritic soils are 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 ash + lime stabilized soils with 2.5% + 2.5%, 5.0% + 5.0%, 7.5% + 7.5% and 10% + 10% percentages to soils ratio yielded optimum values of maximum values shown in table 3.2 are maximum dry density (MDD) 1.858KN/m^3, 1.997KN/m^3, 1.945KN/m^3, 2.215KN/m^3, and optimum moisture content (OMC) 16.69%, 17.85%, 16.08% and 16.85%. Summarized computed results of compaction test parameters of maximum dry density (MDD) and optimum moisture content (OMC) increased in values with composite stabilizer inclusion accordingly to percentages increase.

3.2 California Bearing Ratio (CBR) Test

Summarized preliminary investigations of sampled roads lateritic soils test results of 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 % at 100% natural state. Plantain rachis fibre ash + lime stabilized lateritic soils with 2.5% + 2.5%, 5.0% + 5.0%, 7.5% + 7.5% and 10% + 10% produced maximum CBR values of unsoaked are 67.85%, 53.85%, 70.53%, 49.85% and soaked 61.30%, 48.75%, 66.35% and 47.25%. Final recapitulated results of stabilized California bearing ratio values of both unsoaked and soaked increased uniformly to percentages addition with optimum mix of 7.5% + 7.5%. Further results showed declined values after optimum with noticed crack signs.

3.3 Unconfined Compressive Strength Test

Results of unconfined compressive strength test of sampled roads at preliminary investigations arat 100% lateritic soils are 168kPa, 178kPa, 163kPa and 175kPa. Modified lateritic soils results with mix ratios in table 3.1 yielded maximum values of 465kPa, 438kPa, 485kPa and 423kPa. Summarized results of unconfined compressive strength test of composite stabilizer modified lateritic soils increased remarkably with percentage variations increase.

3.4 Consistency Limits Test

Table 3.1 results of consistency limits (Plastic index) of sampled roads at natural lateritic soils state are 17.11 %, 22.50%, 14.1 0% and 18.51%. Modified lateritic soils have maximum values of 15.67%, 16.15%, 20.98% and 12.55%. Results obtained from modified lateritic soils showed plastic index increased as percentages of inclusion vary.

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 Unified Soil Classification System	A-2-4/SM	A-2-4/SM	A-2-4/SC	A-2-4/SC
Optimum moisture content (%)	14.85	14.40	15.03	16.05
Maximum dry density (kN/m^{3})	1.755	1.838	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 (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
LATERITE + PLANTAIN RACHIS FIBRE ASH (PRFA) + LIME												
OGOBOGORO ROAD OBIO/AKPOR L.G.A	100%	1.755	14.85	9.25	7.40	168	38.46	21.35	17.11	38.46	A–2–4/SM	POOR
	95+2.5+2.5%	1.786	15.38	31.35	28.85	215	39.18	22.15	17.03	38.46	A–2–4/SM	GOOD
	90+2.5+2.5%	1.798	15.58	52.45	48.37	267	39.87	23.09	16.76	38.46	A–2– 4/SM	GOOD
	85+7.5+7.5%	1.823	16.15	67.85	61.30	374	40.73	24.65	16.08	38.64	A –2–4/SM	GOOD
	80+10+10%	1.858	16.69	58.60	53.35	465	41.25	25.58	15.67	38.64	A –2–4/SM	GOOD
ALETO ROAD ELEME L.G.A	100%	1.865	16.05	8.65	6.93	175	38.65	20.14	18.51	39.40	A –2– 4/SC	POOR
	95+2.5+2.5%	1.885	16.68	29.30	26.31	223	39.18	21.13	18.05	39.40	A –2– 4/SC	GOOD
	90+2.5+2.5%	1.905	16.98	40.15	38.35	286	39.67	21.82	17.85	39.40	A–2– /SC	GOOD
	85+7.5+7.5%	1.963	17.33	53.85	48.75	340	40.05	22.40	17.65	39.40	A–2– 4/SC	GOOD
	80+10+10%	1.997	17.85	47.30	43.70	438	40.45	24.30	16.15	39.40	A–2– 4/SC	GOOD
EGBEDA ROAD EMUOHA L.G.A	100%	1.883	14.40	9.48	8.05	178	42.35	19.85	22.50	42.15	A–2– 4/SM	POOR
	95+2.5+2.5%	1.863	14.85	36.45	33.65	245	42.85	20.77	22.08	42.15	A–2– 4/SM	GOOD
	90+2.5+2.5%	1.887	15.25	53.40	49.95	293	43.15	21.44	21.71	42.15	A–2– 4/SM	GOOD
	85+7.5+7.5%	1.905	15.65	70.53	66.35	357	43.95	22.70	21.25	42.15	A–2– 4/SM	GOOD
	80+10+10%	1.945	16.08	62.18	57.82	485	44.35	23.37	20.98	42.15	A–2– 4/SM	GOOD
IGWURUTA ROAD IKWERE L.G.A	100%	1.924	15.08	7.85	6.65	168	35.15	21.05	14.10	36.35	A –2– 4/SC	POOR
	95+2.5+2.5%	1.956	15.38	25.17	22.10	205	35.85	22.03	13.82	36.35	A –2– 4/SC	GOOD
	90+2.5+2.5%	1.990	15.89	33.65	29.65	253	36.35	23.00	13.35	36.35	A –2– 4/SC	GOOD
	85+7.5+7.5%	2.108	16.34	49.85	47.25	374	36.87	24.00	12.95	36.35	A–2– 4/SC	GOOD
	80+10+10%	2.215	16.85	42.70	38.65	423	37.15	26.60	12.55	36.35	A–2– 4/SC	GOOD

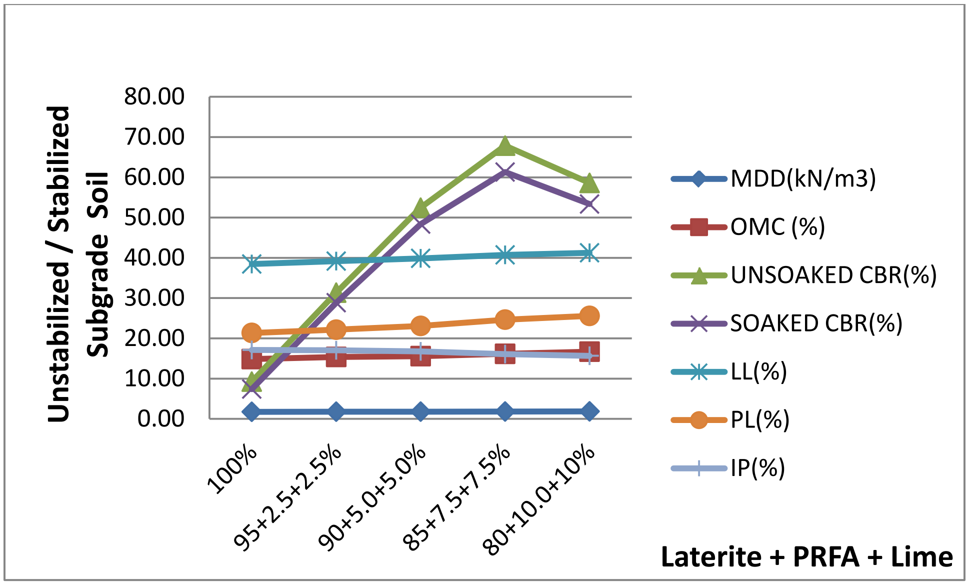

Figure 3.1: Subgrade Stabilization Test of Lateritic Soil from Ogbogoro in Obio/Akpor L.G.A of Rivers State with PRFA + Lime at Different Percentages and Combination

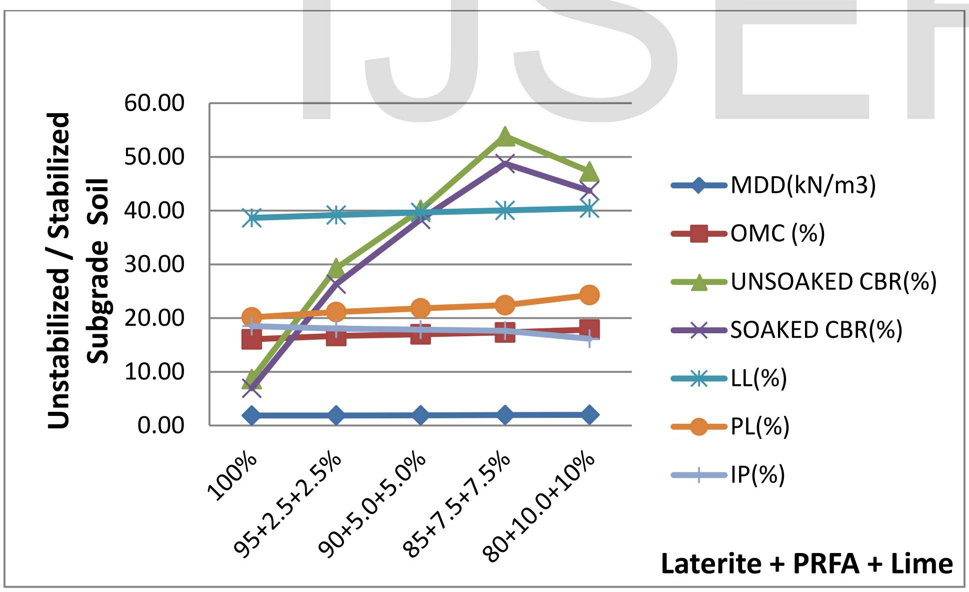

Figure 3.2: Subgrade Stabilization Test of Lateritic Soil from Aleto in Eleme L.G.A of Rivers State with PRFA + Lime at Different Percentages and Combination

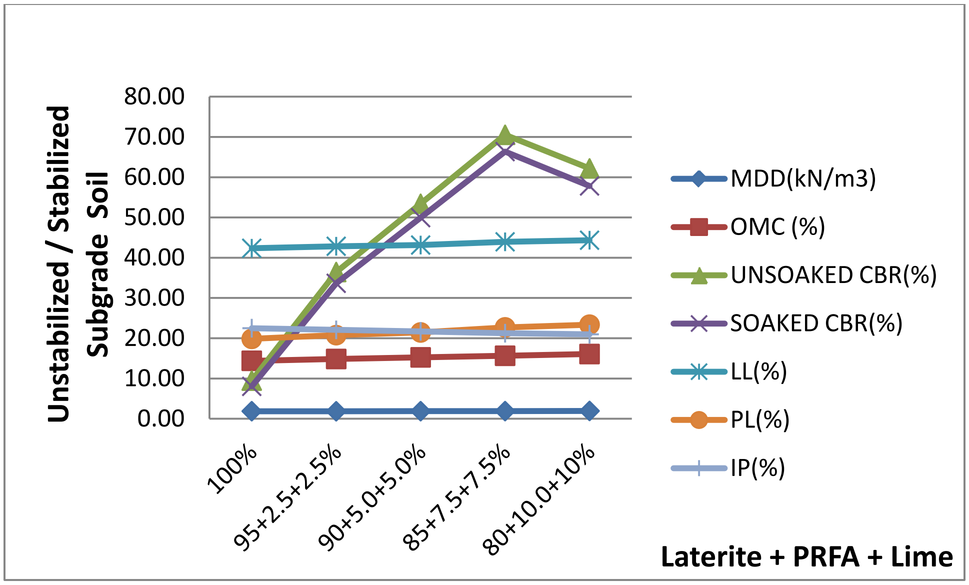

Figure 3.3: Subgrade Stabilization Test of Lateritic Soil from Egbeda in Emuoha L.G.A of Rivers State with PRF A+ Lime at Different Percentages and Combination

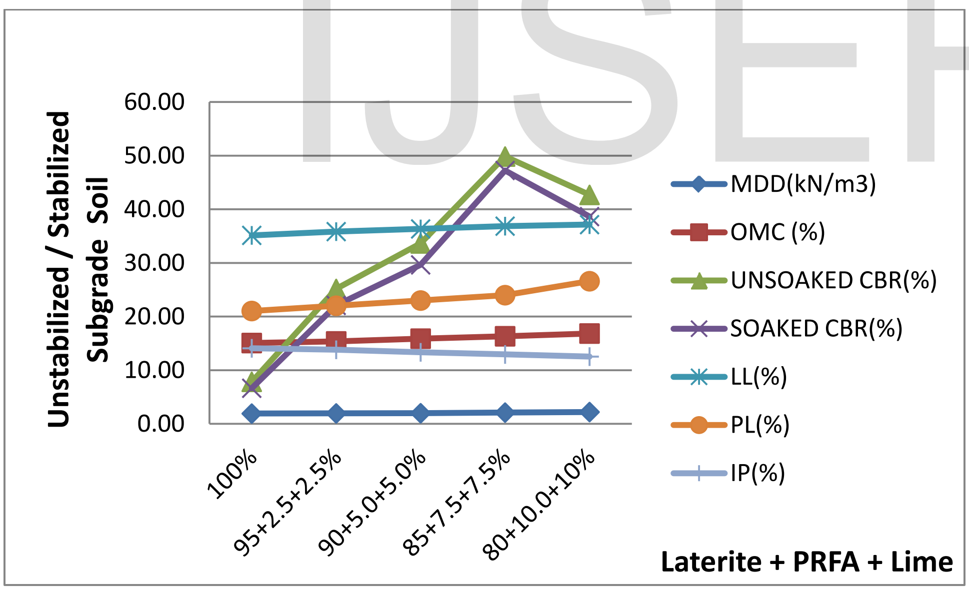

Figure 3.4: Subgrade Stabilization Test of Lateritic Soil from Igwuruta in Ikwerre L.G.A of Rivers State with PRFA + Lime at Different Percentages and Combination

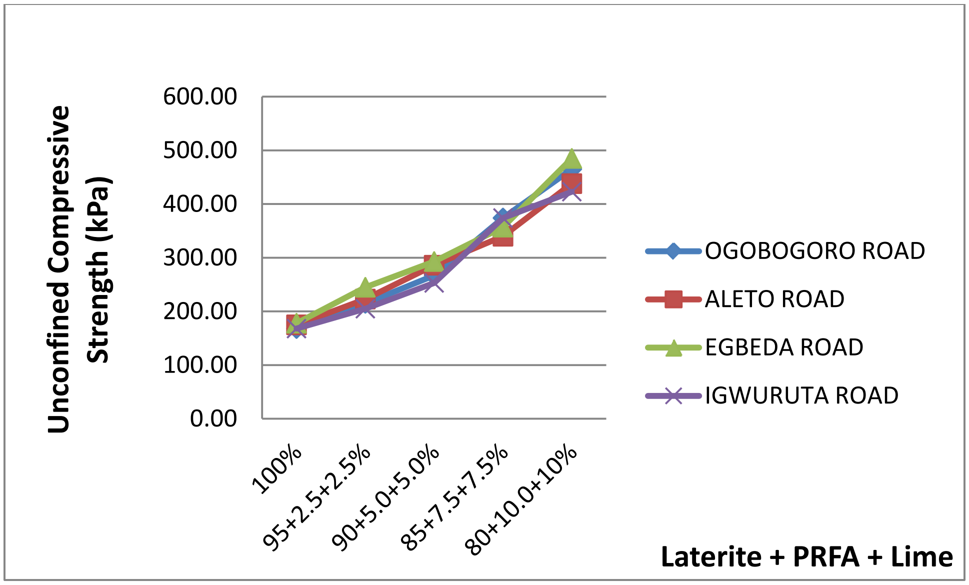

Figure 3.5: Unconfined Compressive Strength (UCS) of Niger Deltaic Laterite Soils Subgrade with PRFA + Lime of (Ogbogoro, Aleto, Egbeda andIgwuruta Towns) all in Rivers State

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. Summarized computed results of compaction test parameters of maximum dry density (MDD) and optimum moisture content (OMC) increased in values with composite stabilizer inclusion accordingly to percentages increase.

iii. Final recapitulated results of stabilized California bearing ratio values of both unsoaked and soaked increased uniformly to percentages addition with optimum mix of 7.5% + 7.5%. Further results showed declined values after optimum with noticed crack signs

iv. Summarized results of unconfined compressive strength test of composite stabilizer modified lateritic soils increased remarkably with percentage variations increase.

v. Results obtained from modified lateritic soils showed plastic index increased as percentages of inclusion vary.

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