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Potential Reduction of Swelling - Shrinkage of Deltaic Lateritic Soils using Plantain Rachis Fiber

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ABSTRACT

The research work observed the effectiveness and application of waste agricultural products from plantain rachis fibre as stabilizers for the modification of lateritic soils with unreliable and unstable attributes. The sampled soils are classified as A-2-6 SC and A-2-4 SM on the AASHTO classification schemes / Unified Soil Classification System with percentage (%) passing BS sieves #200; 38.46%, 39.40%, 36.85%, and 36.42% and soils are reddish brown in color (from wet to dry states) with plasticity index properties of 17.11%, 22.5%, 14.10%, and 18.51% respectively of Ogbogoro, Egbeda, Igwuruta and Aleto roads. The soil has California bearing values of unsoaked 9.25%, 9.48%, 7.85% and 8.65%, and soaked 7.40%, 8.05%, 6.65% and 6.65 %, unconfined compressive strength (UCS) values of 168kPa, 178kPa, 163kPa and 175kPa. Investigations showed soils are unsuitable for constructional use as road embankment materials. Comparative results of un-stabilized and stabilized soils showed decreased values of maximum dry density and increased optimum moisture content values of stabilized lateritic soils. Results of Un-stabilized and stabilized results showed increased California bearing ratio values in stabilized lateritic soils with optimum inclusion percentage ratio of 0.75%. Overturned values were noticed beyond optimum inclusion. Comparative results showed increased values of unconfined compressive strength test with corresponding percentages ratio inclusion as against un-stabilized soils. Results on comparison with un-stabilized soils showed decreased in values of plastic index parameters of stabilized soils with decrease values to percentages inclusion ratio. Entire results showed the potential use of plantain rachis as soil stabilizer.

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

1. INTRODUCTION

Niger Deltaic soils of laterite and clay are less matured with unique characteristics of swelling and shrinkage attributes and very sensitive to all forms of treatment and manipulation. They do not conform to the widely reported parent-rock-related gradation trend common to other lateritic soils (Ola [1]; Lohnes, Fish, and Daniel [2]; Tuncer and Lohnes [3]; Akpokodje [4]; Omotosho [5]; Leton and Omotosho [6]). Soil stabilization is the major and approved option to meet the desired highway pavement minimum requirements for soils or soil-based materials usable in road pavement structures have been indicated by the FMW Specifications [7]. Natural fibres have been used to reduce shrinkage cracks in clayey soils without the least environmental nuisances and at almost low performance costs (Sivakumar *et al.* [8]). They are obtained from the waste of palm fruits and have acceptable mechanical properties and durability in natural conditions (Marandi *et* al., [9]; Zare, [10]).

Charles *et al*. [11] 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.

Bouhicha *et al*. [12] used the shear box test method to evaluate the strength of compacted earth reinforced with barley straw.

Ghavami *et al*. [13] observed that the addition of 4 % coconut and sisal fibres to soil causes its deformability to increase significantly. Besides, the creation of cracks in dry seasons was highly lessened.

Prabakar and Sridhar [14] 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. 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.

2.2 Method

2.2.1 Sampling Locality

The soil sample used in this study were collected along Ogbogoro Town, (latitude 4.81° 33‘N and longitude 6.92° 18‘E), Egbeda 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‘N 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.

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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 [15]; Allam and Sridharan [16]; Omotosho and Akinmusuru [17]; Omotosho [5]). The soils are reddish brown 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

Investigated compaction test results of sampled roads at no additives to lateritic soils maximum dry density (MDD) are 1.755 KN/m^3, 1.838 KN/m^3, 1.924 KN/m^3, 1.865 KN/m^3, and Optimum moisture content(OMC), 14.85%, 14.40%, 15.03% and 16.05%. Plantain Rachis fibre modified lateritic soils maximum values with 0.25%. 0.5%. 0.75% and 1.0% inclusion to soil percentages ratio are MDD 1.642 KN/m^3, 1.725 KN/m^3, 1.725 KN/m^3, 1.805 KN/m^3, and OMC 16.15%, 17.43%, 15.28% and 16.15%. Comparative results of un-stabilized and stabilized soils showed decreased values MDD and increased OMC values of stabilized lateritic soils.

3.2 California Bearing Ratio (CBR) Test

Investigated results at preliminary stage of 100% lateritic soils California bearing ratio unsoaked values are 9.25%, 9.48%, 7.85% 8.65 % and soaked values are 7.40%, 8.05%, 6.65% and 6.65 %. Stabilized lateritic soils maximum values unsoaked are 17.85%, 16.35%, 17.83%, 14.65% and soaked values 15.80%, 14.95%, 16.20%, 12.96%. Results of Un-stabilized and stabilized results showed increased CBR values in stabilized lateritic soils with optimum inclusion percentage ratio of 0.75%. Reversed values were noticed beyond optimum inclusion.

3.3 Unconfined Compressive Strength Test

Investigated preliminary results of unconfined compressive strength test at no additives are 168kPa, 178kPa, 163kPa and 175kPa. Modified lateritic soils maximum values are 268kPa, 272kPa, 283kPa and 259kPa. Comparative results showed increased values of unconfined compressive strength test with corresponding percentages ratio inclusion as against un-stabilized soils.

3.4 Consistency Limits Test

Investigated results of consistency limits (plastic index) at no additives are 17.11 %, 22.50%, 14.1 0% and 18.51%. Plantain Rachis fibre modified lateritic soils maximum values are 15.86%, 17.18%, 21.03% and 12.85%. Results on comparison with un-stabilized soils showed decreased in values of plastic index parameters of stabilized soils with decrease values to percentages inclusion ratio.

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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	15.08	16.05
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 FIBRE PRODUCTS AT DIFFERENT PERCENTAGES

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SAMPLE LOCATION	SOIL + FIBRE PLANTAIN RACHIS	MDD (kN/m³)	OMC (%)	UNSOAKED CBR (%)	SOAKED CBR (%)	UCS(KPa)	LL(%)	PL(%)	PI(%)	SIEVE #200	AASHTO / USCS (Classification)	NOTES
LATERITE + PLANTAIN RACHIS FIBRE (PRF)												
OGOBOGORO ROAD OBIO/AKPOR L.G.A	100%	1.755	14.85	9.25	7.40	169	38.46	21.35	17.11	38.46	A–7–4/SM	POOR
	99.75+0.25%	1.734	15.10	11.85	10.35	198	38.08	21.23	16.85	38.46	A–7–4/SM	GOOD
	99.50+0.50%	1.705	15.55	14.50	13.45	225	37.83	21.70	16.38	38.46	A–7– 4/SM	GOOD
	99.25+0.75%	1.683	15.88	17.85	15.80	247	37.55	21.51	16.04	38.46	A –7–4/SM	GOOD
	99.0+1.0%	1.642	16.15	16.25	14.98	268	37.18	21.32	15.86	38.46	A –7–4/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 –7– 4/SC	POOR
	99.75+0.25%	1.822	16.38	10.87	8.79	204	38.65	20.02	18.22	39.40	A –7– 4/SC	GOOD
	99.50+0.50%	1.795	16.75	13.80	12.63	234	38.02	20.19	17.92	39.40	A–7–4 /SC	GOOD
	99.25+0.75%	1.765	17.05	16.35	14.95	250	37.83	20.29	17.54	39.40	A–7– 4/SC	GOOD
	99.0+1.0%	1.725	17.43	15.25	13.65	272	37.42	20.24	17.18	39.40	A–7– 4/SC	GOOD
EGBEDA ROAD EMUOHA L.G.A	100%	1.838	14.40	9.48	8.05	178	42.35	14.85	22.50	42.15	A–7– 4/SM	POOR
	99.75+0.25%	1.809	14.65	12.05	10.80	189	42.08	19.80	22.28	42.15	A–7– 4/SC	GOOD
	99.50+0.50%	1.786	14.88	14.85	13.40	238	41.85	19.90	21.95	42.15	A–7– 4/SC	GOOD
	99.25+0.75%	1.753	15.03	17.83	16.20	249	41.53	20.07	21.46	42.15	A–7– 4/SC	GOOD
	99.0+1.0%	1.725	15.28	16.15	15.67	283	41.33	20.30	21.03	42.15	A–7– 4/SC	GOOD
IGWURUTA ROAD IKWERE L.G.A	100%	1.924	15.03	7.85	6.65	163	35.15	21.05	14.10	36.35	A –7– 4/SC	POOR
	99.75+0.25%	1.903	15.34	9.65	8.15	184	34.85	20.99	13.86	36.35	A –7– 4/SC	GOOD
	99.50+0.50%	1.885	15.34	11.38	10.23	215	34.50	18.08	13.42	36.42	A –7– 4/SC	GOOD
	99.25+0.75%	1.842	15.85	14.65	12.96	245	34.18	21.10	13.08	36.35	A–7– 4/SM	GOOD
	99.0+1.0%	1.805	16.15	12.80	11.35	259	33.88	21.03	12.85	36.35	A–7– 4/SM	GOOD

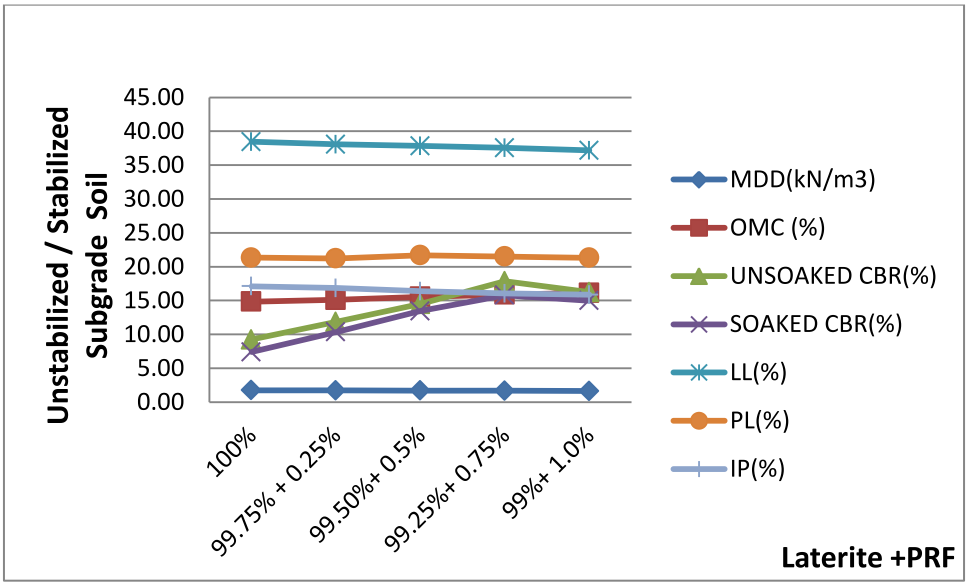

Figure 3.1: Subgrade Stabilization Test of Lateritic Soil from Ogbogoro in Obio/Akpor L.G.A of Rivers State with PRF at Different Percentages and Combination

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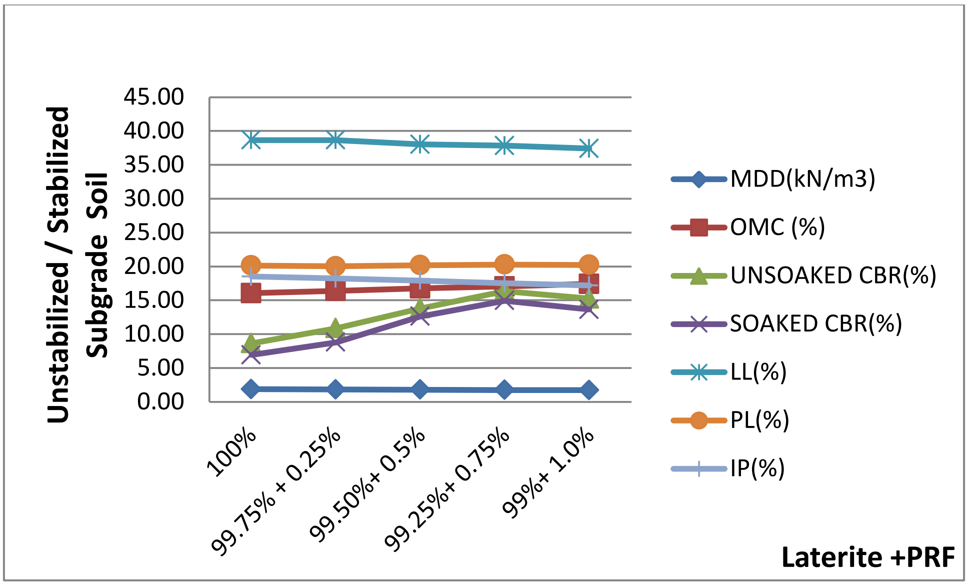

Figure 3.2: Subgrade Stabilization Test of Lateritic Soil from Aleto in Eleme L.G.A of Rivers State with PRF at Different Percentages and Combination

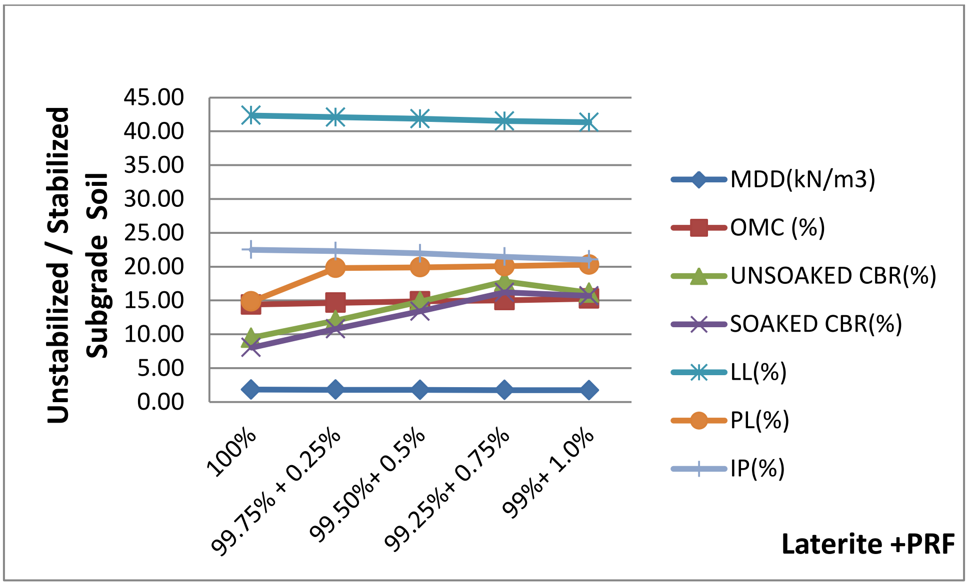

Figure 3.3: Subgrade Stabilization Test of Lateritic Soil from Egbeda in Emuoha L.G.A of Rivers State with PRF at Different Percentages and Combination

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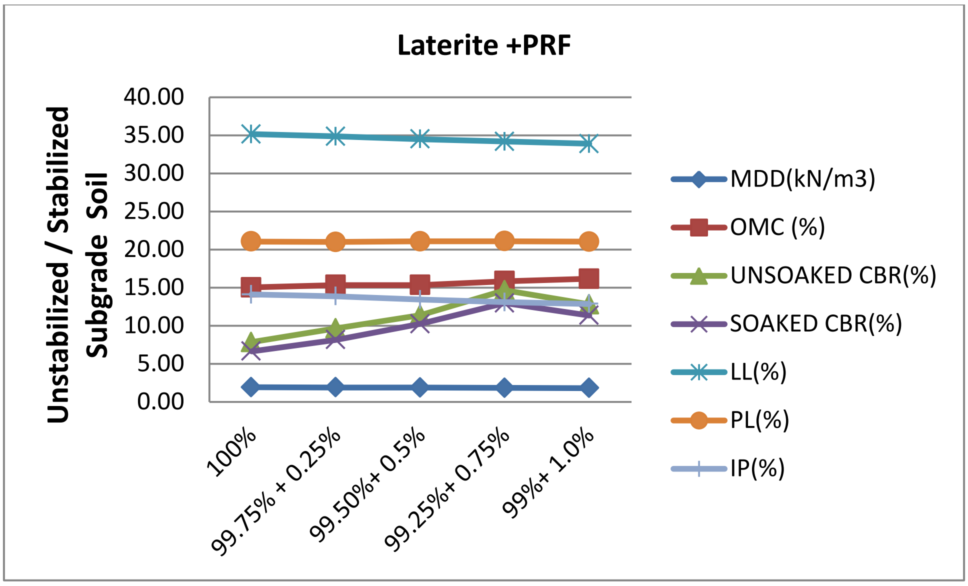

Figure 3.4: Subgrade Stabilization Test of Lateritic Soil from Igwuruta in Ikwerre L.G.A of Rivers State with PRF at Different Percentages and Combination

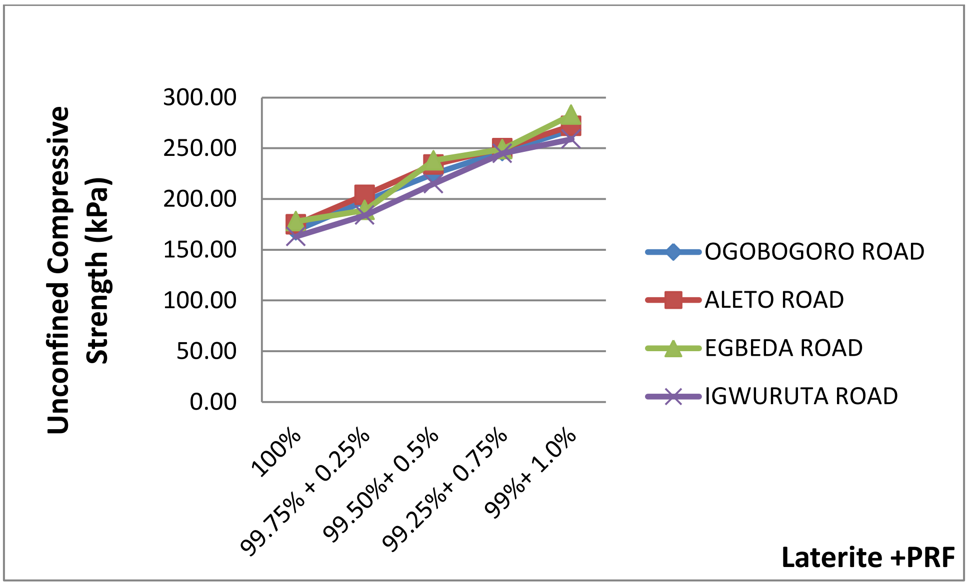

Figure 3.5: Unconfined Compressive Strength (UCS) of Niger Deltaic Laterite Soils Subgrade with PRF of (Ogbogoro, Aleto, Egbeda and Igwuruta Towns) all in Rivers State

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. Comparative results of un-stabilized and stabilized soils showed decreased values MDD and increased OMC values of stabilized lateritic soils.
iii. Results of Un-stabilized and stabilized results showed increased CBR values in stabilized lateritic soils with optimum inclusion percentage ratio of 0.75%. Reversed values were noticed beyond optimum inclusion.
iv. Comparative results showed increased values of unconfined compressive strength test with corresponding percentages ratio inclusion as against un-stabilized soils.
v. Results on comparison with un-stabilized soils showed decreased in values of plastic index parameters of stabilized soils with decrease values to percentages inclusion ratio.

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