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IMPROVEMENT OF EXPANSIVE PROBLEMATIC LATERITIC SOILS WITH FIBRE ASH AND LIME AS STABILIZERS

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ABSTRACT
Odiokwu, Oyigba, Anakpo, Upatabo and Ihubuluko unity linked roads, all in Rivers State, Niger Delta of Nigeria are faced with unusual settlement, degradation, susceptible to many cracks and potholes along the stretches that has led to their abandoned state. The research work examined the application of irvinga gabonesis fibre ash + lime as stabilizers to put the roads to useable state. Preliminary investigations of the engineering Properties of soils at natural state of 100% are percentage (%) passing BS sieves #200; 28.35%, 40.55 %, 36.85%, 33.45% and 39.25%. California bearing ratio values of unsoaked 8.7%, 8.5%, 7.8%, 9.4%, and 10.6% and soaked of 8.3%, 7.8%, 7.2%, 8.5% and 9.8 %. Consistency limits (plastic index) of the soils at 100% natural state are 17.30%, 14.23%, 15.20%, 15.50% and 16.10%. Maximum dry density (MDD), 1.954KN/m^3, 1.857 KN/m^3, 1.943 KN/m^3, 1.758 KN/m^3 and 2.105 KN/m^3 and for Optimum moisture content (OMC), 12.39%, 14.35%, 13.85%, 11.79% and 10.95%. The soils classified as A-2-6 SC and A-2-4 SM on the AASHTO classification schemes / Unified Soil Classification System. Results obtained showed increased values of both MDD and OMC to percentage ratio increase of inclusion. UCS results illustrated corresponding increased of stabilizers percentage ratio to lateratic soils. The entire results showed the potential of using irvinga gabonesis fibre ash + lime as admixtures in treated soils Swelling potential of treated soil decreased with the inclusion of fibre ash + lime up to 0.75% +7.5% for lateritic soils

Keywords:
Lateritic soils, Irvinga Gabonesis Fibre Ash, Lime, CBR, UCS, Consistency, Compaction

INTRODUCTION

The over dependence on the use of industrially manufactured soil improving additives (cement, lime, bitumen etc.) have kept the cost of construction of stabilized road financially high. This has deterred accessible roads of the rural developers and other urban centers as well. The hunger to obtain cheaper additives which can be used to substitute these expensive industrially manufactured soil improving additives (bitumen, cement, lime etc) leads to the consideration of agricultural waste resources. Hence, the use of cheap admixtures to replace or supplement cement or lime stabilized soils especially wastes from agricultural products will eventually reduce the cost of construction works where expansive soils are found. This study matches the need for safe and environmental disposal of waste, for the society and the engineers need for better and cost effective construction materials (Collins and Ciesiellski, [1]); Phanikumar and Sharma [2]; Malhotra and Metha [3]; Cokca [4]).
Charles *et al.* [5] 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.

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Sabat [6] 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.

Ramakrishna and Pradeep [7] 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.

(Deboucha *et al*. [8] 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.

Sharma *et al*. [9] 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 % was found to be the optimum. In expansive soil – RHA mixes, 4% lime and 1% calcium chloride were also found to be optimum.

Wahab *et al*. [9] 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, conditioning the soil for further treatment. Lime stabilization results in higher bearing capacity and lower compressibility of the treated soil mass.

MATERIALS AND METHODS

Materials

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.

Irvinga Gabonesis Fibre

The Irvinga Gabonesis, popularly called Bush mango, with Nigerian native name (Egbono) are widely spread plants across Nigerian bushes and farm land with edible fruits that bears the fibre , they are collected from at Olokuma village, a river side area in Ubie Clan, Ahoada-West, Rivers State, Nigeria.

Lime

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

METHOD

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.

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;

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.

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.

Consistency Limits

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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.

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.

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

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.

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 17.30%, 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.

Compaction Test Results

From table 3.1, the investigated lateritic soils preliminary results of lateritic are maximum dry density (MDD), 1.954KN/m^3, 1.857 KN/m^3, 1.943 KN/m^3, 1.758 KN/m^3 and 2.105 KN/m^3 and for Optimum moisture content (OMC), 12.39%, 14.35%, 13.85%, 11.79% and 10.95% at 100% natural state for Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Town Roads. Stabilized soils at 2.5% + 2.5%, 5.0% +5.0%, 7.5% + 7.5% and 10% +10% irvinga gabonesis fibre ash + lime to lateritic soils percentage ratios yielded the following maximum results of MDD, 2.095KN/m^3, 1.908KN/m^3, 1.985KN/m^3, 2.105KN/m^3, 2.153KN/m^3, and OMC 13.35%, 15.35%, 14.78%, 10.95%, 11.68%. Results obtained showed increased values of both MDD and OMC to percentage ratio increase of inclusion.

California Bearing Ratio (CBR) Test

Obtained preliminary results of California bearing ratio at 100% natural state are unsoaked 8.7%, 8.5%, 7.8%, 9.4%, and 10.6% and soaked of 8.3%, 7.8%, 7.2%, 8.5% and 9.8 %. At stabilized state, results lateritic soils are unsoaked 74.18%, 69.15%, 68.35%, 81.30%, 83.30% and soaked of 69.85%, 66.35%, 64.75%, 76.25%, and 79.83%. Moderately, results indicated increased values of CBR percentages with additives inclusion at recorded maximum mix ratio of 7.5% + 7.5% to soil. Reduction in values and cracks noticed beyond maximum ratio.

Unconfined Compressive Strength Test

Preliminary results from table 3.1 at 100% natural state of UCS are 178kPa, 145kPa, 165kPa, 158kPa and 149kPa. Treated lateritic soils result at 2.5% + 2.5%, 5.0% +5.0%, 7.5% + 7.5% and 10% +10% irvinga gabonesis fibre ash + lime to lateritic soils percentage are 585kPa, 564kPa, 581kPa, 578kPa, and 573kPa. Results illustrated corresponding increased of stabilizers percentage ratio to lateratic soils.

Consistency Limits Test

Obtained plastic index results at 100% lateritic soils are 17.30%, 14.23%, 15.20%, 15.50%, and 16.10%. Stabilized lateritic soils are 16.61%, 13.42%, 14.53%, 16.72%, and 15.42%. Results demonstrated decreased in plastic index to corresponding values as shown graphically in figures 3.1 – 3.5.

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Table 3.1: Engineering Properties of Soil Samples

Location Description	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 (CH10+150)
	(Laterite)	(Laterite)	(Laterite)	(Laterite)	(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 Unified Soil Classification System	A-2-6 SC	A-2-4 SM	A-2-4 SM	A-2-6 SC	A-2-4 SM
Compaction Characteristics					
Optimum moisture content (%)	12.39	14.35	13.85	11.79	10.95
Maximum dry density ($kN/m^{3)}$	1.954	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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Table 3.4: Results of Subgrade Soil Laterite) Test Stabilization with Binding Cementitious Products at Different Percentages and Combination

SAMPLE LOCATION	SOIL + FIBRE IRVINGA GABONESIS ASH + LIME	MDD (kNm^{-3})	OMC (%)	UNSOAKED CBR (%)	SOAKED CBR (%)	UCS(KPa)	LL(%)	PL(%)	PI(%)	SIEVE#200	AASHTO / USCS (Classification)	NOTES
	LATERITE + IRVINGA GABONESIS FIBRE ASH (IGFA) + 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
	95 +2.5+2.5%	1.957	12.65	27.30	22.85	195	40.25	23.13	17.12	28.35	A-2-6/SC	GOOD
	90 + 5.0 + 5.0%	1.968	12.79	41.50	38.60	315	40.41	23.51	16.90	28.35	A-2-6/SC	GOOD
	85 + 7.5 + 7.5%	1.990	12.95	74.18	69.85	408	40.28	24.06	16.72	28.35	A-2-6/SC	GOOD
	80 + 10 + 10%	2.095	13.35	68.65	65.85	585	41.15	24.54	16.61	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
	95 +2.5+2.5%	1.865	14.68	24.35	21.60	169	37.18	23.10	14.08	40.55	A-2-4/SM	GOOD
	90 + 5.0 + 5.0%	1.883	14.85	36.35	28.40	278	37.32	23.44	13.88	40.55	A-2-4/SM	GOOD
	85 + 7.5 + 7.5%	1.895	15.05	69.15	66.35	378	37.65	24.02	13.63	40.55	A-2-4/SM	GOOD
	80 + 10 + 10%	1.908	15.35	63.80	58.17	564	38.80	24.66	13.42	40.55	A-2-4/SM	GOOD
Anakpo Town Road (CH6+950)	100%	1.943	13.85	7.80	7.20	165	36.75	21.45	15.30	36.85	A-2-4/SM	GOOD
	95 +2.5+2.5%	1.950	14.12	22.25	18.95	182	36.86	21.75	15.11	36.85	A-2-4/SM	GOOD
	90 + 5.0 + 5.0%	1.958	14.38	33.60	30.62	295	37.19	22.32	14.87	36.85	A-2-4/SM	GOOD
	85 + 7.5 + 7.5%	1.966	14.45	68.35	64.75	395	37.41	22.81	14.60	36.85	A-2-4/SM	GOOD
	80 + 10 + 10%	1.985	14.78	57.30	54.18	581	37.67	23.14	14.53	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-2-4/SM	GOOD
	95 +2.5+2.5%	1.760	11.92	30.15	28.63	178	37.22	19.84	17.38	33.45	A-2-6/SC	GOOD
	90 + 5.0 + 5.0%	1.778	11.97	52.68	48.80	286	37.56	20.44	17.12	33.45	A-2-6/SC	GOOD
	85 + 7.5 + 7.5%	1.982	12.23	81.30	76.25	377	37.83	20.96	16.87	33.45	A-2-6/SC	GOOD
	80 + 10 + 10%	1.798	12.26	72.45	67.80	578	38.10	21.38	16.72	33.45	A-2-6/SC	GOOD
Ihubuluko Town Road (CH10+150)	100%	2.105	10.95	11.60	10.30	145	37.65	21.55	16.10	39.25	A-2-6/SC	GOOD
	95 +2.5+2.5%	2.108	11.21	33.85	29.45	172	38.06	22.23	15.83	39.25	A-2-6/SC	GOOD
	90 + 5.0 + 5.0%	2.127	11.32	58.10	55.20	262	38.48	22.82	15.66	39.25	A-2-6/SC	GOOD
	85 + 7.5 + 7.5%	2.138	11.40	83.30	79.83	383	38.87	23.24	15.63	39.25	A-2-6/SC	GOOD
	80 + 10 + 10%	2.153	11.68	77.25	72.33	573	39.15	23.73	15.42	39.25	A-2-6/SC	GOOD

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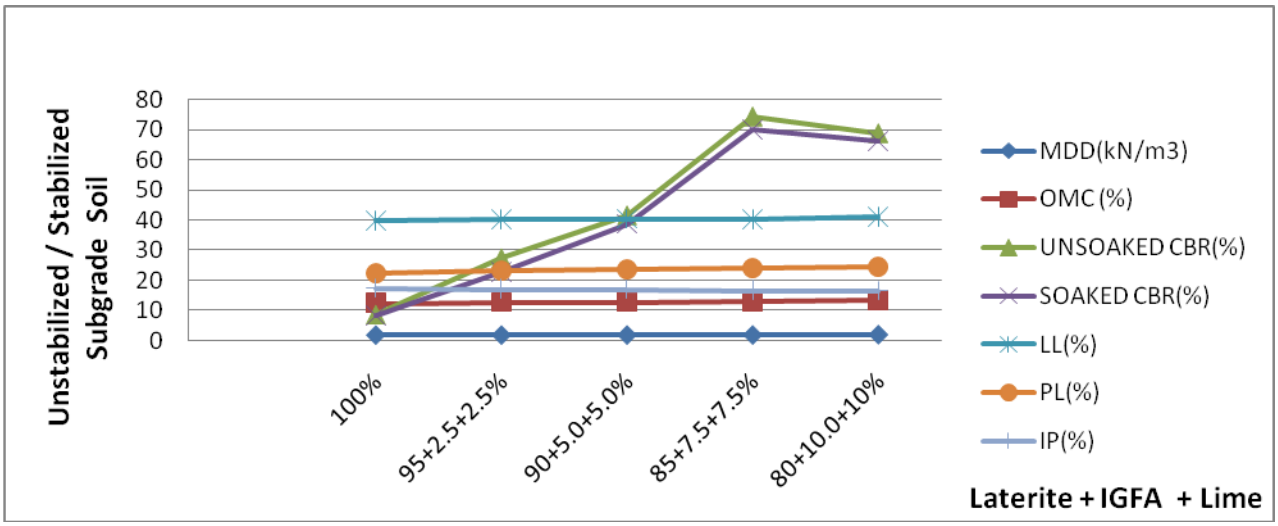

Figure 3.1: Subgrade Stabilization Test of Lateritic Soil from Odioku in Ahoada-West L.G.A of Rivers State with IGFA + Lime at Different Percentages and Combination

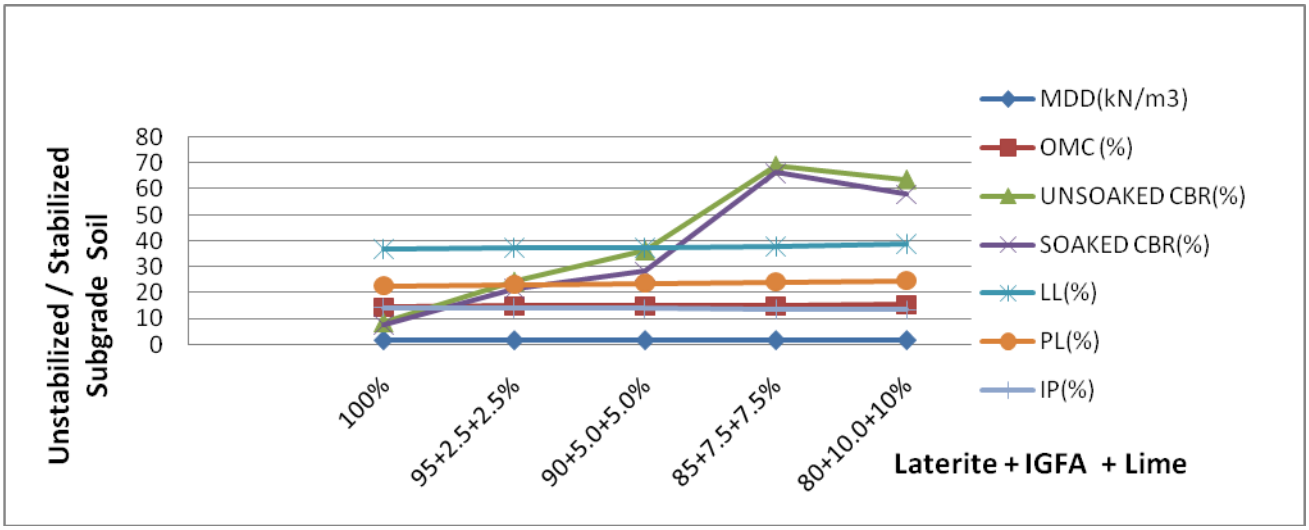

Figure 3.2: Subgrade Stabilization Test of Lateritic Soil from Oyigba in Ahoada-West L.G.A of Rivers State with IGFA + Lime at Different Percentages and Combination

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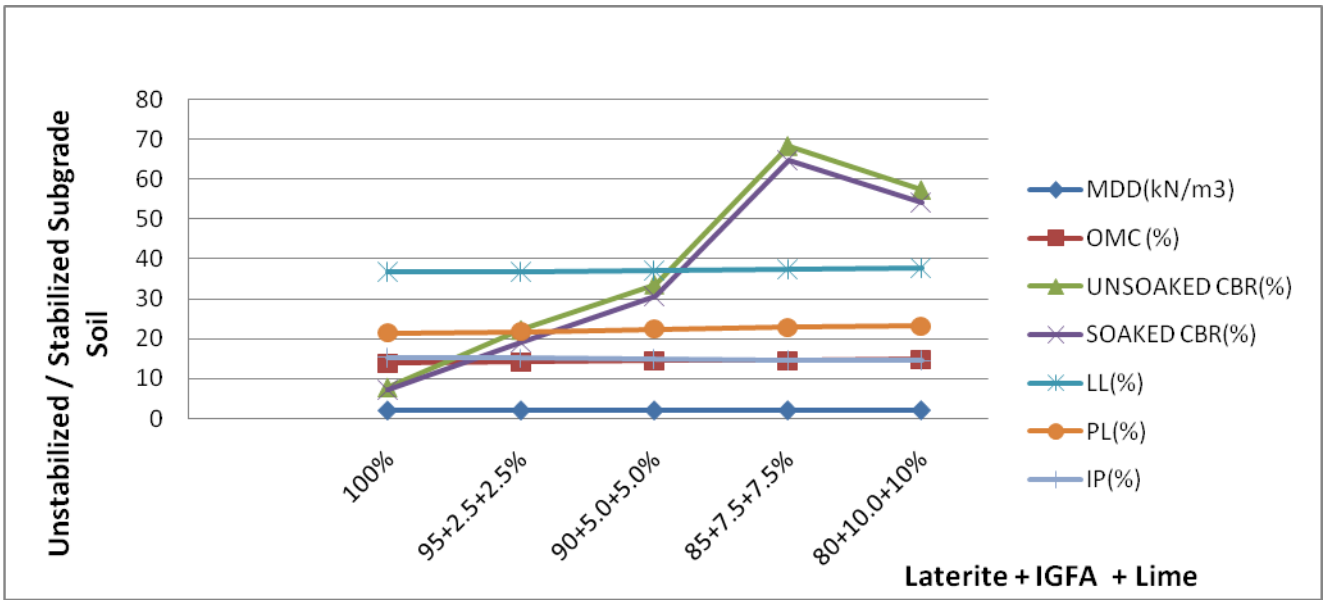

Figure 3.3: Subgrade Stabilization Test of Lateritic Soil from Anakpo in Ahoada-West L.G.A of Rivers State with IGFA + Lime at Different Percentages and Combination

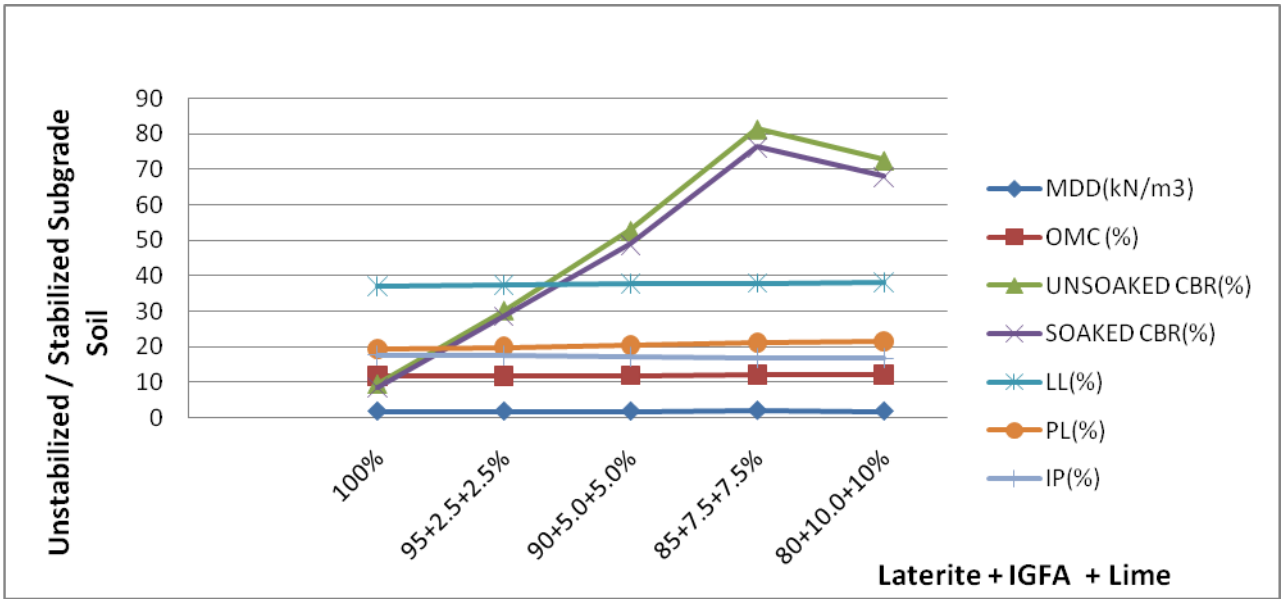

Figure 3.4: Subgrade Stabilization Test of Lateritic Soil from Upatabo in Ahoada-West L.G.A of Rivers State with IGFA + Lime at Different Percentages and Combination

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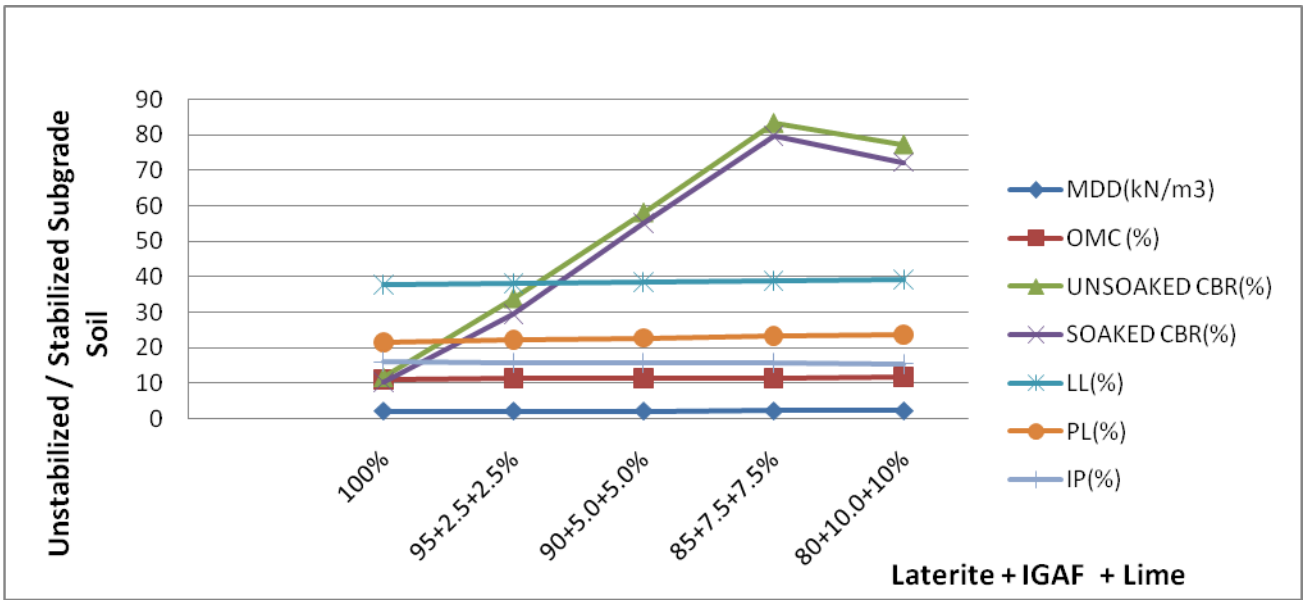

Figure 3.5: Subgrade Stabilization Test of Lateritic Soil from Ihubuluko in Ahoada-West L.G.A of Rivers State with IGFA + Lime at Different Percentages and Combination

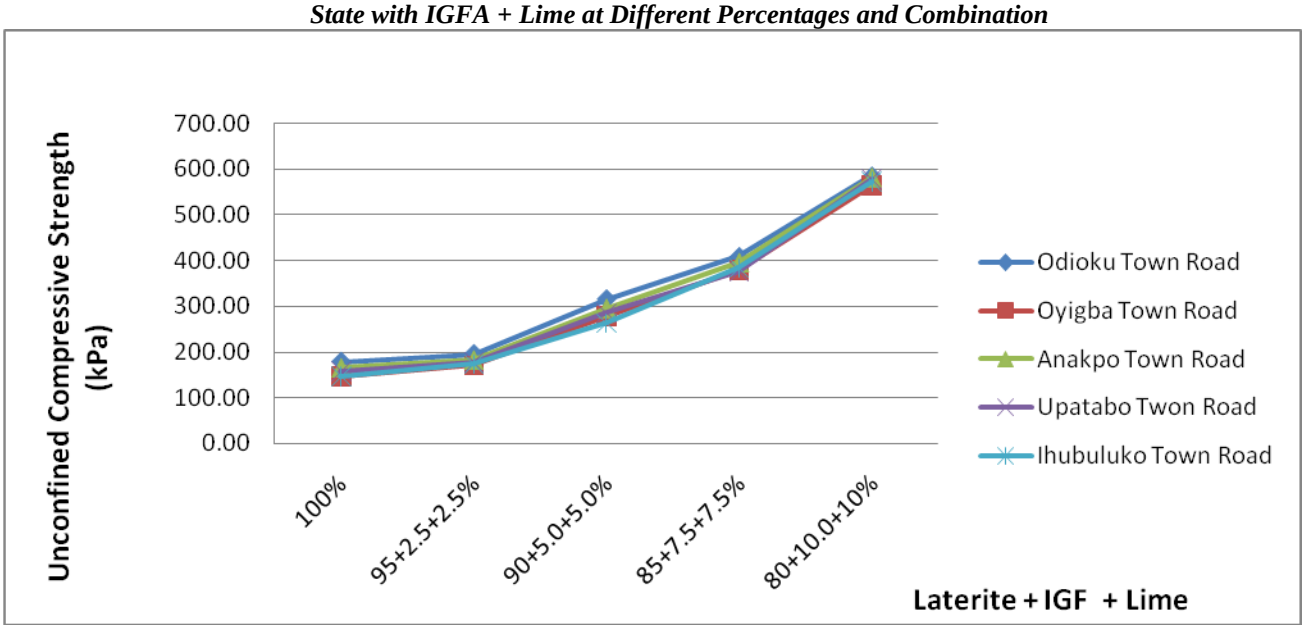

Figure 3.6: Unconfined Compressive Strength (UCS) of Niger Deltaic Laterite Soils Subgrade with IGFA + Lime of (Odioku, Oyigba, Anakpo, Upatabo and Ihubuluko Towns), Ahoad-West L.G.A, Rivers State

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CONCLUSIONS

The following conclusions were made from the experimental research results.

[1] The soils classified as A-2-6 SC and A-2-4 SM on the AASHTO classification schemes / Unified Soil Classification System
[2] Preliminary investigations of the engineering Properties of soils at natural state are percentage (%) passing BS sieves #200, 28.35%, 40.55 %, 36.85%, 33.45% and 39.25%.
[3] Consistency limits (plastic index) of the soils at 100% natural state are 17.30%, 14.23%, 15.20%, 15.50% and 16.10%
[4] Results obtained showed increased values of both MDD and OMC to percentage ratio increase of inclusion.
[5] UCS results illustrated corresponding increased of stabilizers percentage ratio to lateratic soils.
[6] The entire results showed the potential of using irvinga gabonesis fibre ash + lime as admixtures in treated soils
[7] Swelling potential of treated soil decreased with the inclusion of fibre ash + lime up to 0.75% +7.5% for lateritic soils

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