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COMPOSITE HYBRIDIZATION OF IRVINGA GABONESIS FIBRE ASH AND CEMENT IN STABILIZATION PROCESS OF EXPANSIVE SOILS

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ABSTRACT

The research is an investigative experimental work on the effective stabilization of black cotton lateritic soils from Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Town Roads in Ahoada East and West local Government Areas with irvinga gabonesis fibre ash and cement in combine actions. Results showed, the soils belong to A-2-6 SC and A-2-4 SM families on the AASHTO classification schemes / Unified Soil Classification System. Percentage (%) passing BS sieves #200;, 28.35%, 40.55 %, 36.85%, 33.45% and 39.25%. The soil has California bearing ratio of unsoaked values of 8.7%, 8.5%, 7.8%, 9.4%, and 10.6% and soaked values of 8.3%, 7.8%, 7.2%, 8.5% and 9.8 % are remarked poor for its application as road constructional materials. Consistency limits test decreased in plastic index properties of soils with incremental ratio of additives to soil. Results showed increased in both maximum dry density and optimum moisture content values increased to corresponding fibre ash and cement percentage inclusion. Results showed an increase in California bearing ratio of values of stabilized soils to an optimum mix ratio 7.5% + 7.5% to soils. Results showed increased in nconfined compressive strength test. Swelling potential of treated soil decreased with the inclusion of fibre ash up to 7.5% + 7.5% of soils. The entire results showed the potential of using irvinga gabonesis fibre ash + cement as admixtures in treated soils

Key Words: lateritic soils, irvinga gabonesis fibre ash , cement, CBR, UCS, Consistency, Compaction

1.0 Introduction

Expansive soil formations, especially those with high in situ water contents, are susceptible to large settlements and possess low shear strength unless they are naturally cemented or stabilized/reinforced with cementitious agents of cement, lime and fly-ash. The principle mechanism of ground improvement is done by forming chemical bonds between the soil particles. When the soil particles are bonded, it will be strengthened and become more stable physically and mechanically. Expansive soils, when mixed with cement, will be stabilized because cement and water react to form cementitious calcium silicate and aluminate hydrates, which bind the soil particles together.

Charles *et al.* [1] evaluated the geotechnical properties of an expansive clay soil found along Odioku – Odiereke road in Ahoada-West, Rivers State, in the Niger Deltaic region. The application of two cementitious agents of cement and lime, hybridized with costus afer bagasse fiber to strengthen the failed section of the road. The preliminary investigation values indicated that the soils are highly plastic. The results showed the potential of using bagasse, BSBF as admixtures in cement and lime treated soils of clay and laterite with optimum values of 8 % cement and lime and 7.5% +7.5 % of cement / lime + BSBF.

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.

Wahab *et al*. [3] 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.

(Deboucha *et al*. [4] found an 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

Charles *et al.* [5] investigated the problematic engineering properties of soils with high plasticity level, high swelling and shrinkage potentials used in pavement design in the Nigerian Niger Delta region. The application of stabilizing agents of cement and costus afer bagasse fibre (Bush Sugarcane Bagaase Fibre) were mixed in single and combines actions to improved their unique properties. Results showed that inclusion stabilizing material improved strength properties of the soils. Results of tests carried out show that the optimum moisture content increased with increasing cement ratios to both soils (clay) and (laterite). Treated soils with Cement decreased in liquid limits and increased in plastic limits. Soils with Cement and fibre products in combinations increased CBR values appreciably both at soaked and unsoaked conditions. At 8% of lime, CBR values reached optimum, beyond this range, cracks exist and 7.5% cement + 0. 75% BSBF, optimum value are reached.

Sabat [7] 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.

Sharma *et al*. [8] 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.

2.0 Materials and Methods

2.1 Materials

2.1.1 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.

2.1.2 Irvinga Gabonesis Fibre Ash

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.

2.1.3 Cement

The cement used was Portland Cement, purchased in the open market at Mile 3 market road, Port Harcourt, Rivers State.

2.2 Method

2.2.1 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.

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 [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 17.30%, 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.

3.1 Compaction Test Results

The results of lateritic soils at 100% of maximum dry density (MDD) are 1.954KN/m^3, 1.857 KN/m^3, 1.943 KN/m^3, 1.758 KN/m^3, 2.105KN/m^3 and optimum moisture content (OMC), 12.39%, 14.35%, 13.85%, 11.79% and 10.95% at 100% lateritic soils. Stabilized sampled soils with irvinga gabonesis fibre (IGFA) + cement of 2.5% + 2.5%, 5.0% + 5.0%, 7.5% + 7.5% and 10% +10% to soils ratio recorded highest values of 2.220KN/m^3, 1.952KN/m^3, 2.105KN/m^3, 1.835KN/m^3 and 2.685KN/m^3 of MDD and OMC, 12.79%, 15.18%, 14.75%, 12.77% and 11.94%. Results showed increased in both MDD and OMC values to corresponding fibre ash + cement percentage inclusion.

3.2 California Bearing Ratio (CBR) Test

Results obtained of sampled roads lateritic soils are unsoaked values of 8.7%,8.5%, 7.8%, 9.4%, and 10.6% and soaked values of 8.3%, 7.8%, 7.2%, 8.5% and 9.8 %, at 100% and stabilized soils with ratio shown in table 3.4 are unsoaked, 88.40%, 73.85%, 69.95%, 83.85 and 90.25% and soaked, 75.53%, 69.85%, 66.75%, 80.15% and 85.73%. Results showed an increase in CBR values of stabilized soils to an optimum mix ratio 7.5% + 7.5% to soils.

3.3 Unconfined Compressive Strength Test

Obtained preliminary investigation results at 100% lateritic soils are are unconfined compressive strength (UCS) values of 178kPa, 145kPa, 165kPa, 158kPa and 149kPa at 100% soils. Comparative results of stabilized lateritic soils with irvinga gabonesis fibre (IGFA) + cement of 2.5% + 2.5%, 5.0% + 5.0%, 7.5% + 7.5% and 10% +10% peak results are 635kPa, 574kPa, 625kPa, 597kPa and 597kPa. Results showed increased in nconfined compressive strength test combined with irvinga gabonesis fibre (IGFA) + cement to soils ratio as shown in table 3.4 and figure 3.6

3.4 Consistency Limits Test

Obtained results at 100% soils of plastic index are 17.30%, 14.23%, 15.20%, 15.50% and 16.10%. Results of treated lateritic soils with IGFA) + cement to soils ratio are 16.74%, 14.34%, 15.07%, 17.00% and 15.78%, peak values. Results in comparison showed decreased values in plastic index with increase in additives percentage ratio to soils.

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})	1.953	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

Table 3.5: Results of Subgrade Soil (Clay) Test Stabilization with Binding Cementitious Products at Different percentages and Combination

SAMPLE LOCATION	SOIL + FIBRE IRVINGA GABONESIS ASH CEMENT	MDD (kN/m^3)	OMC (%)	UNSOAKED CBR (%)	SOAKED CBR (%)	UCS(KPa)	LL(%)	PL(%)	PI(%)	SIEVE #200	AASHTO / USCS (Classification)	NOTES
	LATERITE + IRVINGA GABONESIS FIBRE ASH (IGFA) + CEMENT											
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%	1.962	12.45	32.45	29.45	215	39.95	23.08	16.87	28.35	A-2-6/SC	GOOD
	90 + 5.5 + 5.5%	1.978	12.58	54.35	49.73	265	40.15	23.35	16.80	28.35	A-2-6/SC	GOOD
	85 + 7.5 + 7.5%	1.995	12.79	88.40	75.53	414	40.35	23.61	16.74	28.35	A-2-6/SC	GOOD
	80 + 10 + 10%	2.220	12.79	73.33	69.53	635	40.35	23.61	16.74	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%	1.867	14.58	29.35	28.15	174	37.18	22.87	14.31	40.55	A-2-4/SM	GOOD
	90 + 5.5 + 5.5%	1.894	14.83	43.08	39.35	265	37.32	22.93	14.39	40.55	A-2-4/SM	GOOD
	85 + 7.5 + 7.5%	1.928	14.97	73.85	69.85	398	37.58	23.21	14.37	40.55	A-2-4/SM	GOOD
	80 + 10 + 10%	1.952	15.18	67.78	63.58	574	37.82	23.48	14.34	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	POOR
	95 + 2.5 + 2.5%	1.957	13.93	27.10	25.65	210	36.94	21.72	15.22	36.85	A-2-4/SM	GOOD
	90 + 5.5 + 5.5%	1.973	14.23	39.85	37.38	246	37.21	21.99	15.22	36.85	A-2-4/SM	GOOD
	85 + 7.5 + 7.5%	1.989	14.58	69.95	66.75	334	37.52	22.23	15.19	36.85	A-2-4/SM	GOOD
	80 + 10 + 10%	2.105	14.75	61.45	58.85	625	37.88	22.81	15.07	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-2-6/SC	POOR
	95 + 2.5 + 2.5%	1.767	11.92	31.45	30.80	208	36.96	19.71	17.25	33.45	A-2-6/SC	GOOD
	90 + 5.5 + 5.5%	1.794	12.18	63.17	58.14	253	37.25	20.18	17.07	33.45	A-2-6/SC	GOOD
	85 + 7.5 + 7.5%	1.805	12.43	83.85	80.15	328	37.44	20.38	17.06	33.45	A-2-6/SC	GOOD
	80 + 10 + 10%	1.835	12.77	77.81	70.85	597	37.85	20.85	17.00	33.45	A-2-6/SC	GOOD
Ihubuluko	100%	2.105	10.95	10.60	9.80	145	37.65	21.55	16.10	39.25	A-2-6/SC	POOR
	95 + 2.5 + 2.5%	2.115	11.23	38.43	34.30	182	37.93	21.84	16.09	39.25	A-2-6/SC	GOOD

Town Road (CH10+150)	90 + 5.5 + 5.5%	2.235	11.48	61.85	59.35	245	38.25	22.35	15.90	39.25	A-2-6/SC	GOOD
	85 + 7.5 + 7.5%	2.450	11.80	90.25	85.73	356	38.57	22.78	15.59	39.25	A-2-6/SC	GOOD
	80 + 10 + 10%	2.685	11.94	86.15	81.55	597	38.83	23.78	15.78	39.25	A-2-6/SC	GOOD

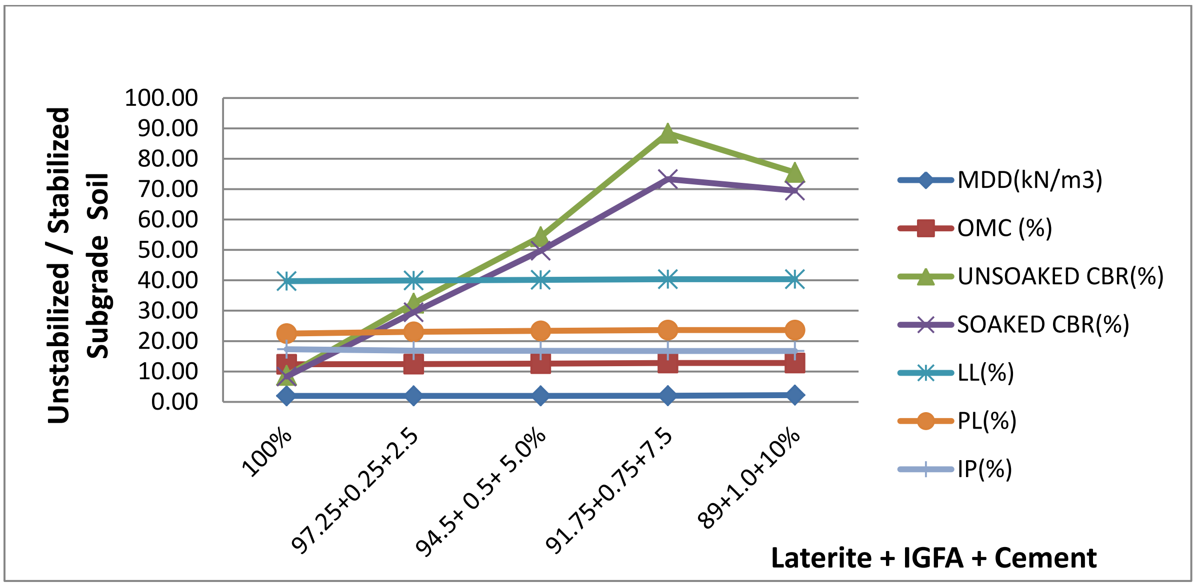

Figure 3.1: Subgrade Stabilization Test of Lateritic Soil from Odioku in Ahoada-West L.G.A of Rivers State with IGFA + Cement at Different Percentages and Combination

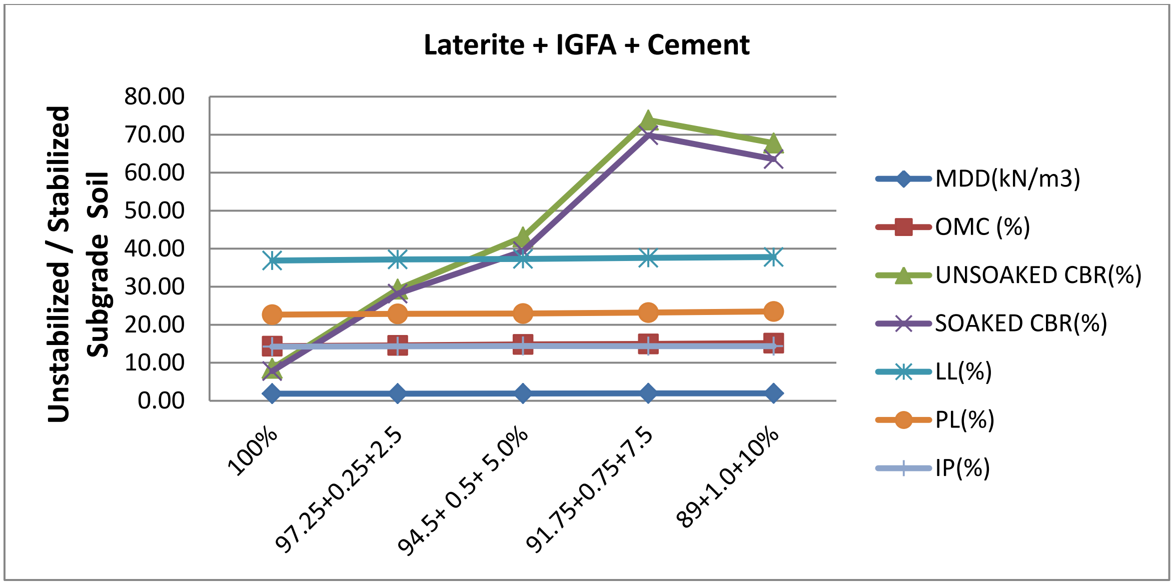

Figure 3.2: **Subgrade Stabilization Test of Lateritic Soil from Oyigba in Ahoada-West L.G.A of Rivers State with IGFA + Cement at Different Percentages and Combination**

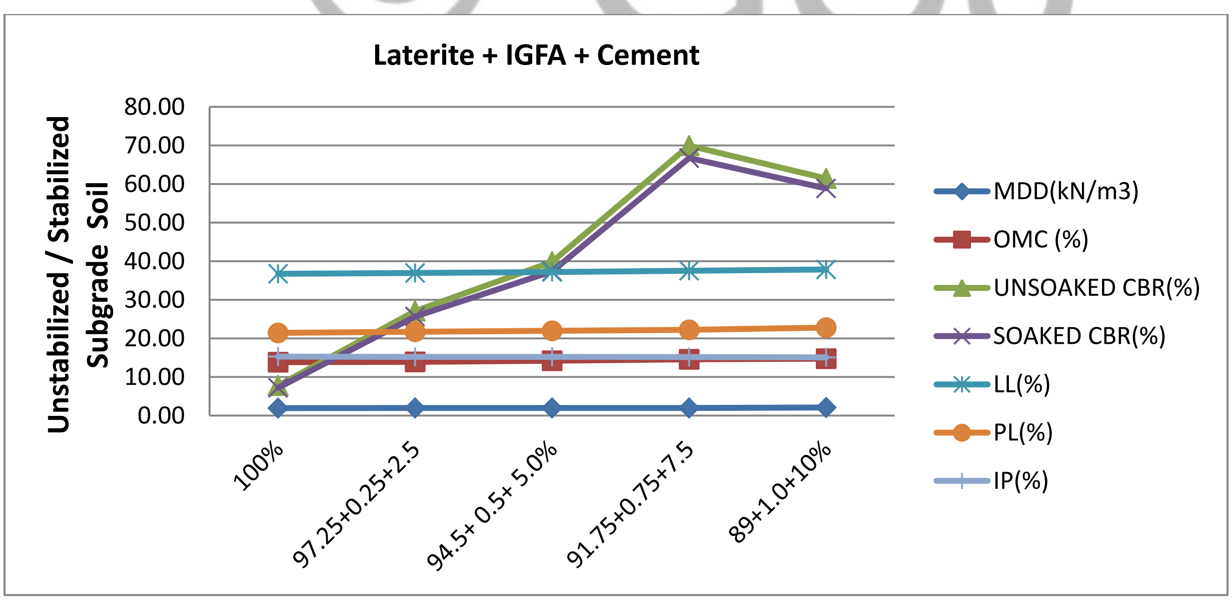

Figure 3.3: **Subgrade Stabilization Test of Lateritic Soil from Anakpo in Ahoada-West L.G.A of Rivers State with IGFA + Cement at Different Percentages and Combination**

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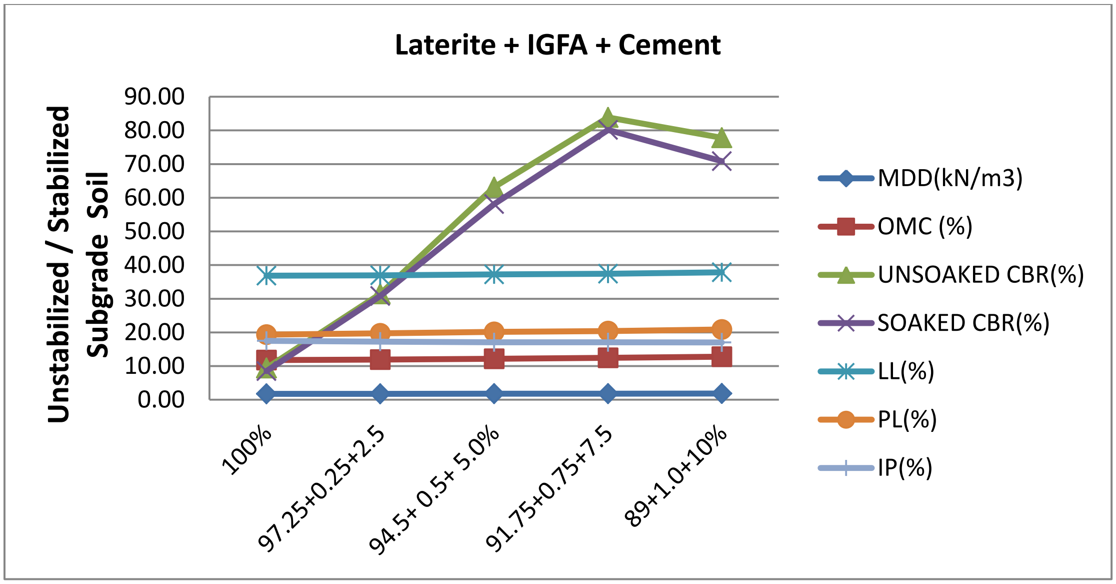

Figure 3.4: **Subgrade Stabilization Test of Lateritic Soil from Upatabo in Ahoada-West L.G.A of Rivers State with IGFA + Cement at Different Percentages and Combination**

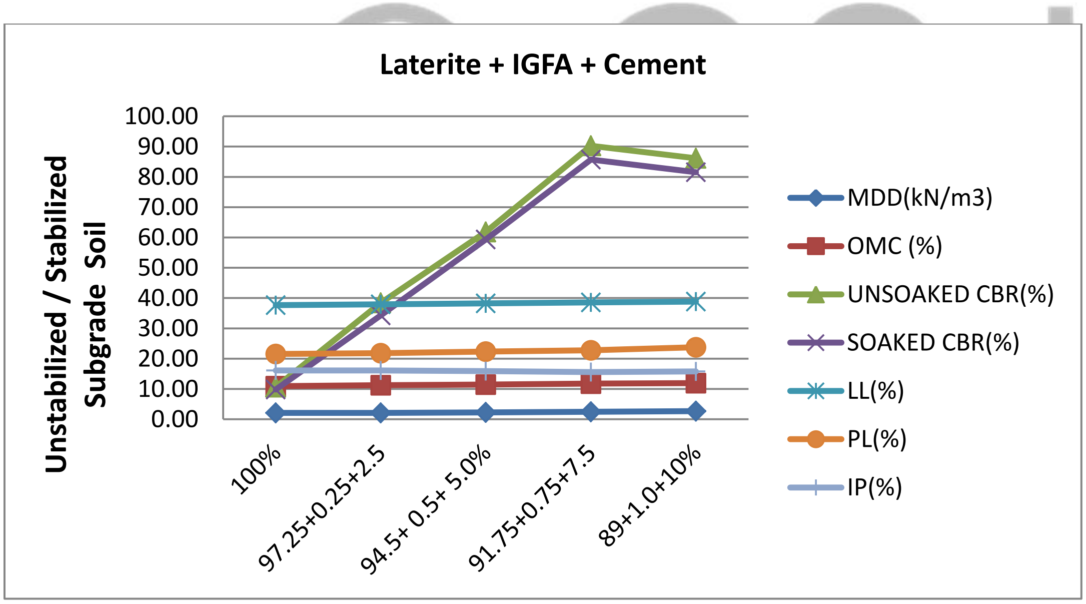

Figure 3.5: **Subgrade Stabilization Test of Lateritic Soil from Ihubuluko in Ahoada-West L.G.A of Rivers State with IGFA + Cement at Different Percentages and Combination**

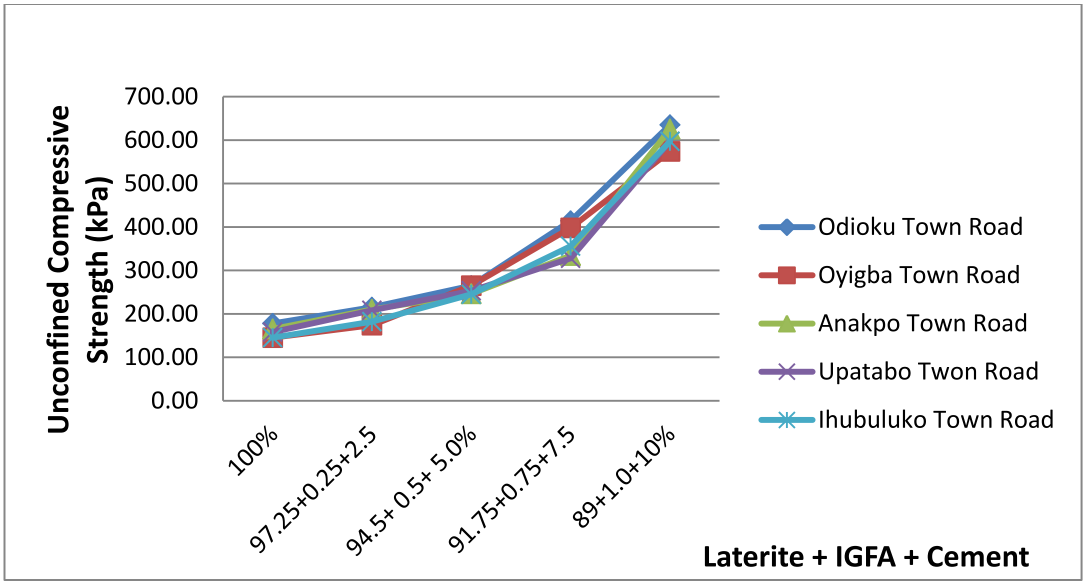

Figure 3.6: Unconfined Compressive Strength (UCS) of Niger Deltaic Laterite Soils Subgrade with IGFA of (Odioku, Oyigba, Anakpo, Upatabo and Ihubuluko Towns), Ahoad-West L.G.A, Rivers State

4.0 Conclusions

The following conclusions were made from the experimental research results.

i. 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%.

ii. The soils classified as A-2-6 SC and A-2-4 SM on the AASHTO classification schemes / Unified Soil Classification System

iii. Consistency limits (plastic index) of the soils at 100% natural state are 17.30%, 14.23%, 15.20%, 15.50% and 16.10%. Decreased in plastic index properties of soils were recorded with incremental ratio of additives to soil

iv. Swelling potential of treated soil decreased with the inclusion of fibre ash up to 7.5% + 7.5% for both soils

v. The entire results showed the potential of using irvinga gabonesis fibre ash + cement as admixtures in treated soils

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