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Swelling - Shrinkage Potential Reduction of Expansive Soils Stabilized with Irvinga Gabonesis Fibre

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ABSTRACT: *The study evaluated the performance of expansive problematic lateritic soils of unstable and deceptive characteristics stabilized with 0.25%, 0.50%, 0.75% and 1.0% irvinga gabonesis fibre . The lateritic soils on preliminary investigations fell below the approved standard of embankment materials for road pavement structures as indicated by the federal ministry of works (FMW) Specifications (1997). The soils are classified as A-2-6 SC and A-2-4 SM on the AASHTO classification schemes / Unified Soil Classification System, at natural state the percentage (%) passing BS sieves #200; 28.35%, 40.55 %, 36.85%, 33.45% and 39.25%. Consistency limits (plastic index) are 17.30%, 14.23%, 15.20%, 15.50% and 16.10%. Results showed a decreased in maximum dry density values and increased in optimum moisture content as percentages of inclusion vary. Results showed increased values of California bearing ratio to percentages rise with an optimum at 0.75% inclusion. Results showed an increased in unconfined compressive strength values with an increase in fibre percentages as illustrated graphically. Results showed decreased values in the plastic index for an increase in fibre ratio content as demonstrated in figures The entire results showed the potential of using irvinga gabonesis fibre as admixtures in treated soils. The swelling potential of treated soil decreased with the inclusion of bagasse fibre up to 0.75% to soils ratio.*

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

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I. INTRODUCTION

The application of appropriate elements in the soil improves/stabilizes its engineering properties such as strength and deformation. Materials used for reinforcement are usually made of metal, geosynthetics or natural materials such as plant roots and stems. Currently, investigations confirm that natural fibers such as kenaf, choir, banana, jute, flax, sisal, palm, reeds, bamboo and wood fibers are used for soil strengthening and stabilization [1]. [2] on soil samples reinforced with sisal fibers, both the ratio showed significant effects on the shear strength parameters (C, Ø).

[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 the inclusion of fibre percentage, CRB values increased tremendously with optimum values percentage inclusion at 0.75%, beyond this value, the crack was formed which resulted to a potential failure state.

[4] Studied the combined effects of RHA and cement on the engineering properties of black cotton soil. From a strength characteristics perspective, they recommended 8% cement and 10% RHA as the optimum dose for stabilization.

[2] Studied the effect of reinforced soil with sisal fibers and found that both fiber content and aspect ratio had significant effects on shear strength parameters (C, Ø). They note that the optimum value for fiber content is that the shear strength decreases with increasing fiber content than this optimum value.

[5] Conducted tensile tests on soil samples reinforced with sisal fibers and concluded that fibers, length and tensile strength are the most important factors affecting the tensile strength of the soil mixture.

[6] used the shear box test method to estimate the strength of the compact earth reinforced with barley grass. Their work is part of an extensive study of the physical and mechanical properties of fiber-reinforced compressed earth blocks. Their test results showed that the apparent cohesion increased by 50% (from 330 to 493 kPa) with the addition of grass at 1.5 and 3.5% (by soil weight), but reduced the internal friction angle.

[7] Evaluate the agricultural waste variability of banana rachis fiber, hybridized with cement and lime, to adjust the engineering properties of abundant lateritic soils. The comparative strength of un-stabilized and stabilized soils with compaction testing of composite materials, maximum dry density (MDD) and optimum moisture content (OMC) of stabilized soils of sampled roads, and mixing of stabilizers with binding agents showed increasing percentage values. With different percentage ratios. Unconfined compressive strength test effects of soils immobilized with cementitious binding agents of cement/lime + PRF showed increasing percentage values as a proportion of additives to soil growth. The computed effects of the California bearing ratio (CBR) of un-soaked and soaked soils stabilized with the binding agents of cement, lime and PRF showed a significant increase for the respective additives, especially for the mix ratio.

[8] Estimated the engineering behavior of expansive lateritic soils stabilized with cement, lime and irvinga gabonensis fiber for their combined strength properties. The results obtained for unconfined compressive strength from sample roads stabilized with cement/lime + IGF confirmed the increasing percentage of composite materials to the soil. Stabilized California bearing ratio (CBR) results of sampling roads with cement, lime and IGF composite materials showed increasing percentage values with ratio variation. The result of comparative, un-stabilized and mixed stabilized soils; the maximum dry density (MDD) and the optimum moisture content (OMC) of the compaction parameters showed a percentage increase in the ratio of composite stabilizers to the soil.

[9] Examined the increasing percentage values of California bearing ratio (CBR) stabilized soils with cement, lime and CLBF confirm a very optimum percentage ratio at 91.75 + 0.75 + 7.5%. Stabilized soils establish increasing percentage values with the addition of very dry density (MDD) and optimum moisture (OMC) composite percentage stabilizers. The unconfined compressive strength of soils immobilized with cement/lime + CLBF has largely been attributed to the increasing proportion of stabilizers and soils to ratios. The result of the extracted stabilized soils confirms the increasing percentage value of cement and lime + costus afer bagasse fiber.

[10] Analyzed the composite materials applications of cement + plantain rachis fiber and lime + plantain rachis fiber and their overall performance characteristics for the alteration of expansive clay soils. The comparative results of the unconfined compressive strength test of cementitious composite reactions show an increasing percentage of values, resulting in the increase of composite materials to the soil ratio, with the overall performance of cement at higher values of lime. The comparative results of soil natural conditions and the compaction test results of mixed stabilized clay soils of maximum dry density (MDD) and an increasing percentage of optimum moisture content (OMC). The results confirmed the difference in the strength of cement and lime with PRF composition at a higher performance.

[11] Explored the advantageous use of composite soil stabilizers of irvinga gabonesis fibre + lime in blended action to improve the performance of challenging soils with swelling and shrinkage potentials and make trivial soils meet required widespread of subgrade pavement materials. Comparatively, the compaction results of the stabilized soils showed high values for each of the MDD and OMC's constant proportions. The use of Irvinga gabonensis fiber + lime composite in treated soils confirmed the overall effects. The CBR results were determined to be within the samples stabilized with an ultimate share ratio of 0.75 + 7.5% per soil. The addition of fiber + lime 0.75% + 7.5% to lateral soils is practicable for dealing with clay. The results obtained are multiplied by the UCS values in proportion to the components. It was determined that the results were reduced in the plastic index to the corresponding percentage ratio of the additives.

[12] Investigated the feasibility of hybridized composite materials of plantain rachis fiber + cement in a mixed ratio for the manipulation/modification of problematic sensitive clay soils along with failed areas of dual carriageway subgrade soils in the Niger Delta region of Nigeria. The final consistency thresholds of composite materials (plastic index) reduced the value of stabilized clay soils to varying proportions of aggregates. Proportionally, the California bearing ratio extends by adding a ratio of 0.75% + 7.5% of each un-soaked and soaked value, exceeding this value, to a crack shape, resulting in an achievable failure state. Final results of composite testing of mixed stabilized clay soils at maximum dry density (MDD) and optimum moisture content (OMC). The effects of compaction testing confirm the high maximum dry density (MDD) and the optimum moisture content (OMC) values of Oyigba, Oyigba, in fiber + cement percentage alloys. , Anakpo, Upatabo and Ihubuluko Town roads.

[13] Investigated difficult soils engineered properties with the characteristic features of swelling, contraction and crack potentials of the highway road subgrade pavement and stabilized costaceae lacerus bagasse fibre + cement in mixed operations. The full effects ensure proper combination of laterite + costaceae lacerus bagasse fibre + Cement mixed in soil stabilization. The results showed an increase in the CBR of soils

stabilized with a maximum mix ratio with a combination of 0.75% + 7.5%. Decreased values were obtained with fracture formation and failure state. The addition of bagasse fiber + cement reduced the swelling of the potential of soils.

[14]) Evaluated the use of costaceae lacerus bagasse fibre (CLBF) and cement as soil stabilizers in the mixed state. The results obtained confirmed the increase in UCS, the higher the fiber percentage to the soil-related ratio. The inclusion of additives has led to a decrease in the values of plastic index properties. The results were tested with the increase of the percentage of fiber and cement in the UCS to the soil relative ratio. The results for both un-soaked and soaked in CBR values were combined with a highly reliable ratio combination of 0.75% + 7.5% for the soil-related ratio. Composite use of CLBF + cement in the treatment of clay soils confirmed the full results.

II. 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, besides the 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 is located on the most recent coastal plain of the North-Western of the Rivers State of the Niger Delta.

Irvinga Gabonesis Fibre

Irvinga gabonensis, also known as the bush mango with the Nigerian native name (Egbono), is widely grown in Nigerian shrubs and farmland, with edible fruits containing fiber, which are collected from the village of Olokuma, on the riverside of the Ubie Clan, Ahoada-West, Rivers State, Nigeria

METHOD

Sampling Locality

The soil samples used in this study was Odioku Town Road, (latitude 5.07 ° 14'S and longitude 6.65 ° 80'E), Oyigba Town Road, (latitude 7.33 ° 24'S and longitude 3.95 ° 48'E), Oishika Town Road, latitude 4.05 ° 03'S and longitude 5.02 ° 50'E), Upatabo Town Road, (latitude 5.35 ° 34'S and longitude 6.59 ° 80'E) and Ihubuluko Town Road, latitude 5.37 ° 18'S and longitude 7.91 ° 20'E) All in Rivers State, Nigeria.

Test Conducted

Conducted test included (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;

Moisture Content Determination

The natural moisture content of the soil obtained from the site was determined by BS 1377 (1990) Part 2. The freshly collected sample was crushed and kept loose in containers and the containers with samples were weighed close to 0.01g.

Grain Size Analysis (Sieve Analysis)

This test is performed to determine the percentage of different grain sizes contained within the soil. The mechanical or sieve analysis is performed to determine the distribution of the coarser, larger-sized particles.

Consistency Limits

The liquid limit (LL) is defined as the arbitrary water content in which a portion of the soil in a standard cup and the groove with a standard measurement groove flows together at the base of the groove for a distance of 13 mm. (1 / 2in.). A standard fluid-limiting apparatus that operates at a rate of two shocks per second when exposed to 10 shocks from 10 mm cup to 25 shocks.

Moisture – Density (Compaction) Test

This laboratory test is performed to determine the relationship between moisture content and dry density of the soil for the specified experimental effort.

Unconfined Compression (UC) Test

The unconfined compressive strength is the maximum load per unit area, or 15% axial strain load per unit area, whichever occurs first in the performance of the test. The primary purpose of this test is to determine the unconfined compressive strength, which is then used to calculate the unified untreated shear strength of the soil under non-compressible conditions.

California Bearing Ratio (CBR) Test

The California Bearing Ratio (CBR) test was developed by the California Division of Highways to expel and assess ground-subgrade and base course materials for flexible pavements

III. RESULTS AND DISCUSSIONS

As seen in the detailed test results presented in Tables 5, the preliminary results on the lateritic soils show that the physical and engineering properties of such applications exceed the minimum requ rements and require stabilization to improve its properties. 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 are less mature in the vertical profile of the soils and are more sensitive to all types of other deltaic soils [15] Ola 1974;[16] Omotosho and Akinmusuru 1992; [17]Omotosho 1993). The soils are reddish-brown and dark gray (from wet to dry states) and the plasticity index is 17.30%, 14.23%, 15.20%, 15.50%, and 16.10% for Odiokwu, Oyigba, Anakpo, Upatabo, and Ihubulko Town Roads, respectively. The soil has 8.7%, 8.5%, 7.8%, 9.4%, and 10.6% CBR values, and the soaked CBR values are 8.3%, 7.8%, 7.2%, 8.5% and 9.8%, while the unconfined compressive strength (UCS) values are 178kPa, 145kPa, 165kPa, 158kPa and 149kPa when compacted with British Standard Light (BSL) respectively.

Compaction Test Results

The compaction test results of lateritic soils of the sampled road at preliminary investigations are 1.954KN/m3, 1.857 KN/m3, 1.943 KN/m3, 1.758 KN/m3 and 2.105 KN/m3 with percentile values decreased and increased of 97.12%, 98.10%, 98.73%, 99.15%, 99.67% at 100% soils of maximum dry density (MDD) and 12.39%, 14.35%, 13.85%, 11.79% and 10.95% of percentile values of 98.26%, 98.29%, 97.81%, 97.60%, 97.33% of optimum moisture content (OMC). Stabilized lateritic sampled soils with 0.25%, 0.50%, 0.75% and 1.0% of irvinga gabonesis fibre percentages with peak MDD values of 1.804 KN/m3, 1.725KN/m3, 17.95KN/m3, 1.602KN/m3 and 1.836KN/m3 and OMC 13.57%, 15.75%, 15.08%, 13.08%, and 12.15%. Obtained MDD and OMC at stabilized states are 110.44%, 109.42%, 105.30%, 107.91%, 102.71% and 109.52%, 109.756%%, 108.88%, 110.94%, 110.96% percentiles decreased and increased of MDD and OMC. Results showed a decreased in MDD values and increased in OMC as percentages of inclusion vary.

California Bearing Ratio (CBR) Test

Results obtained at preliminary investigation for lateritic soils at 100% soils CBR values are unsoaked 8.7%, 8.5%, 7.8%, 9.4%, 10.6% with percentile values of 68.78%, 83.50%, 79.19%, 66.90%, 71.38% and soaked of 8.3%, 7.8%, 7.2%, 8.5% and 9.8 % with 69.81%, 77.61%, 86.23%, 64.64%, 69.85% percentile values. Stabilized lateritic soil peak results are unsoaked 18.75%, 17.85%, 15.68%, 23.85% with percentile incremental values of 215.52%, 210%, 201.03%, 253.72%, 210.38% and while soaked are 16.75%, 16.65%, 14.45%, 21.85% , 18.40% with percentile incremental values at peaks of 201.81%, 213.46%, 200.69%, 257.06%, 187.76%. Results showed increased values of CBR to percentages rise with an optimum at 0.75% inclusion.

Unconfined Compressive Strength Test

Results obtained of lateritic soils at preliminary engineering soil properties are 178kPa, 145kPa, 165kPa, 158kPa and 149kPa respectively for sampled roads with percentile values of 90.36%, 84.30%, 92.18%, 89.77%, 85.80% at 100% natural state. Stabilized soils unconfined compressive strength test results at peak are 304kPa, 279kPa, 287kPa, 297kPa and 269kPa with incremental percentile values of 170.79%, 192.41%, 173.94%, 187.98%, 185.52%. Results showed an increased in UCS values with increase in fibre percentages as illustrated graphically in figures 3.5

Consistency Limits Test

Results of consistency limits (Plastic index) properties at 100% soils are 17.30%, 14.23%, 15.20%, 15.50% and 16.10% with percentile values of 100.52%, 101.07%, 100.92%, 101.69%, 101.58%. Stabilized lateritic soils optimum values are 16.52%, 13.18%, 14.565, 16.29% and 14.87% with percentile decreased values of 95.49%, 92.62%, 95.16%, 93.09%, and 92.36%. Results showed decreased values in plastic index with respect to increase in fibre ratios content as demonstrated in figures 3.3

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

Table 3.2: Results of Subgrade Soil (laterite) Test Stabilization with Fibre

SAMPLE LOCATION	SOIL + FIBRE IRVINGA GABONENSIS %	MDD (KN/m³)	OMC (%)	UNSOAKED CBR (%)	SOAKED CBR (%)	UCS(KPa)	LL(%)	PL(%)	PI(%)	SIEVE #200	AASHTO / USCS (Classification)	Notes
	LATERITE + IRVINGA GABONESIS FIBRE (IGF) (BUSH MANGO)											
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
	99.75+0.25%	2.012	12.61	12.65	11.89	197	39.61	22.40	17.21	28.35	A-2-6/SC	GOOD
	99.50+0.50	2.022	12.97	15.60	14.35	223	39.23	22.15	17.08	28.35	A-2-6/SC	GOOD
	99.25+0.75	2.062	13.16	18.75	16.75	268	39.08	22.31	16.75	28.35	A-2-6/SC	GOOD
	99.00+1.0	2.158	13.57	16.25	14.87	304	38.45	21.93	16.52	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	GOOD
	99.75+0.25%	1.893	14.60	10.18	10.05	172	36.40	22.32	14.08	40.55	A-2-4/SM	POOR
	99.50+0.50	1.907	14.92	13.45	13.08	208	36.06	22.31	13.75	40.55	A-2-4/SM	GOOD
	99.25+0.75	2.001	15.25	17.85	16.65	235	35.15	21.88	13.32	40.55	A-2-6/SM	GOOD
	99.00+1.0	2.032	15.75	15.40	14.85	279	35.06	21.88	13.18	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
	99.75+0.25%	1.968	14.16	9.85	8.35	179	36.21	21.05	15.16	36.85	A-2-4/SM	GOOD
	99.50+0.50	2.003	14.38	12.08	11.75	212	35.97	20.9	15.01	36.85	A-2-4/SM	GOOD
	99.25+0.75	2.034	14.72	15.68	14.45	241	35.62	20.79	14.83	36.85	A-2-4/SM	GOOD
	99.00+1.0	2.046	15.08	14.45	13.85	287	35.18	20.62	14.56	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
	99.75+0.25%	1.773	12.08	14.05	13.15	176	36.25	19.04	17.21	33.45	A-2-6/SC	GOOD
	99.50+0.50	1.783	12.45	18.35	15.75	225	36.08	18.99	17.09	33.45	A-2-6/SC	GOOD
	99.25+0.75	1.887	12.82	23.85	21.85	257	35.15	18.96	16.79	33.45	A-2-6/SC	GOOD
	99.00+1.0	1.897	13.08	21.25	18.80	297	35.18	18.90	16.29	33.45	A-2-6/SC	GOOD
Ihubuluko Town Road (CH10+150)	100%	2.105	10.95	10.60	9.80	145	37.65	21.55	16.10	39.25	A-2-6/SC	GOOD
	99.75+0.25%	2.112	11.25	14.85	14.03	169	37.23	21.38	15.85	39.25	A-2-6/SC	GOOD
	99.50+0.50	2.124	11.60	17.84	15.35	215	36.68	21.17	15.51	39.25	A-2-6/SC	GOOD
	99.25+0.75	2.138	11.97	22.30	18.40	245	36.25	21.17	15.08	39.25	A-2-6/SC	GOOD
	99.00+1.0	2.162	12.15	19.30	15.95	269	35.85	20.98	14.87	39.25	A-2-6/SC	GOOD

Table 3.3: Percentile Combination of Laterite + Irvinga Gabonesis Fibre (IGF) (Bush Mango)

RATIO %	1.000	99.75% + 0.25%	99.50%+ 0.5%	99.25%+ 0.75%	99%+ 1.0%
MAXIMUM DRY DENSITY (MDD(kN/m3)					
Odioku Town Road MDD(kN/m3)	1.954	2.012	2.022	2.062	2.158
Oyigba Town Road MDD(kN/m3)	1.857	1.893	1.907	2.001	2.032
Anakpo Town Road MDD(kN/m3)	1.943	1.968	2.003	2.034	2.046
Upatabo Twon Road MDD(kN/m3)	1.758	1.773	1.783	1.877	1.897
Ihubuluko Town Road MDD(kN/m3)	2.105	2.112	2.124	2.138	2.162
OPTIMUM MOISTURE CONTENT (%)					
Odioku Town Road OMC (%)	12.390	12.610	12.970	13.160	13.570
Oyigba Town Road OMC (%)	14.350	14.600	14.920	15.250	15.750
Anakpo Town Road OMC (%)	13.850	14.160	14.380	14.720	15.080
Upatabo Twon Road OMC (%)	11.790	12.080	12.450	12.820	13.080
Ihubuluko Town Road OMC (%)	10.950	11.250	11.600	11.970	12.150
CONSISTENCY LIMITS (%)					
Odioku Town Road LL(%)	39.750	39.610	39.230	39.080	38.450
Odioku Town Road PL(%)	22.450	22.400	22.150	22.310	21.930
Odioku Town Road IP(%)	17.300	17.210	17.080	16.750	16.520
Oyigba Town Road LL(%)	36.900	36.400	36.060	35.150	35.060
Oyigba Town Road PL(%)	22.670	22.320	22.310	21.880	21.880
Oyigba Town Road IP(%)	14.230	14.080	13.750	13.320	13.180
Anakpo Town Road LL(%)	36.750	36.210	35.970	35.620	35.180
Anakpo Town Road PL(%)	21.450	21.050	20.900	20.790	20.620
Anakpo Town Road IP(%)	15.300	15.160	15.010	14.830	14.560
Upatabo Twon Road LL(%)	36.850	36.250	36.080	35.150	35.180
Upatabo Twon Road PL(%)	19.350	19.040	18.990	18.960	18.900

Upatabo Twon Road IP(%)	17.500	17.210	17.090	16.790	16.290
Ihubuluko Town Road LL(%)	37.650	37.230	36.680	36.250	35.850
Ihubuluko Town Road PL(%)	21.550	21.380	21.170	21.170	20.980
Ihubuluko Town Road IP(%)	16.100	15.850	15.510	15.080	14.870
CALIFORNIA BEARING RATIO (%)					
Odioku Town Road UNSOAKED CBR(%)	8.700	12.650	15.600	18.750	16.250
Odioku Town Road SOAKED CBR(%)	8.300	11.890	14.350	16.750	14.870
Oyigba Town Road UNSOAKED CBR(%)	8.500	10.180	13.450	17.850	15.400
Oyigba Town Road SOAKED CBR(%)	7.800	10.050	13.080	16.650	14.850
Anakpo Town Road UNSOAKED CBR(%)	7.800	9.850	12.080	15.680	14.450
Anakpo Town Road SOAKED CBR(%)	7.200	8.350	11.750	14.450	13.850
Upatabo Twon Road UNSOAKED CBR(%)	9.400	14.050	18.350	23.850	21.250
Upatabo Twon Road SOAKED CBR(%)	8.500	13.150	15.750	21.850	18.800
Ihubuluko Town Road UNSOAKED CBR(%)	10.600	14.850	17.840	22.300	19.300
Ihubuluko Town Road SOAKED CBR(%)	9.800	14.030	15.350	18.400	15.950
UNCONFINED COMPRESSIVE STRENGTH (KPa)					
Odioku Town Road UCS (Kpa)	178.000	197.000	223.000	268.000	304.000
Oyigba Town Road UCS (Kpa)	145.000	172.000	208.000	235.000	279.000
Anakpo Town Road UCS (Kpa)	165.000	179.000	212.000	241.000	287.000
Upatabo Twon Road UCS (Kpa)	158.000	176.000	225.000	257.000	297.000
Ihubuluko Town Road UCS (Kpa)	145.000	169.000	215.000	245.000	269.000

Table 3.4: Percentile Decrease / Increase of Laterite + Irvinga Gabonesis Fibre (IGF) (Bush Mango)

RATIO %	1.000	99.75% + 0.25%	99.50%+ 0.5%	99.25%+ 0.75%	99%+ 1.0%
MAXIMUM DRY DENSITY (MDD(kN/m3)					
Odioku Town Road MDD(kN/m3)	97.117	102.968	103.480	105.527	110.440
Oyigba Town Road MDD(kN/m3)	98.098	101.939	102.693	107.754	109.424
Anakpo Town Road MDD(kN/m3)	98.730	101.287	103.088	104.683	105.301
Upatabo Twon Road MDD(kN/m3)	99.154	100.853	101.422	106.769	107.907
Ihubuluko Town Road MDD(kN/m3)	99.669	100.333	100.903	101.568	102.708
OPTIMUM MOISTURE CONTENT (%)					
Odioku Town Road OMC(kN/m3)	98.255	101.776	104.681	106.215	109.524
Oyigba Town Road OMC(kN/m3)	98.288	101.742	103.972	106.272	109.756
Anakpo Town Road OMC(kN/m3)	97.811	102.238	103.827	106.282	108.881
Upatabo Twon Road OMC(kN/m3)	97.599	102.460	105.598	108.736	110.941
Ihubuluko Town Road OMC(kN/m3)	97.333	102.740	105.936	109.315	110.959
CONSISTENCY LIMITS (%)					
Odioku Town Road LL(%)	100.353	99.648	98.692	98.314	96.730
Odioku Town Road PL(%)	100.223	99.777	98.664	99.376	97.684
Odioku Town Road IP(%)	100.523	99.480	98.728	96.821	95.491
Oyigba Town Road LL(%)	101.374	98.645	97.724	95.257	95.014
Oyigba Town Road PL(%)	101.568	98.456	98.412	96.515	96.515
Oyigba Town Road IP(%)	101.065	98.946	96.627	93.605	92.621
Anakpo Town Road LL(%)	101.491	98.531	97.878	96.925	95.728
Anakpo Town Road PL(%)	101.900	98.135	97.436	96.923	96.131
Anakpo Town Road IP(%)	100.923	99.085	98.105	96.928	95.163
Upatabo Twon Road LL(%)	101.655	98.372	97.910	95.387	95.468
Upatabo Twon Road PL(%)	101.628	98.398	98.140	97.984	97.674
Upatabo Twon Road IP(%)	101.685	98.343	97.657	95.943	93.086
Ihubuluko Town Road LL(%)	101.128	98.884	97.424	96.282	95.219
Ihubuluko Town Road PL(%)	100.795	99.211	98.237	98.237	97.355
Ihubuluko Town Road IP(%)	101.577	98.447	96.335	93.665	92.360
CALIFORNIA BEARING RATIO (%)					
Odioku Town Road UNSOAKED CBR(%)	68.775	145.402	179.310	215.517	186.782
Odioku Town Road SOAKED CBR(%)	69.807	143.253	172.892	201.807	179.157
Oyigba Town Road UNSOAKED CBR(%)	83.497	119.765	158.235	210.000	181.176
Oyigba Town Road SOAKED CBR(%)	77.612	128.846	167.692	213.462	190.385

Anakpo Town Road UNSOAKED CBR(%)	79.188	126.282	154.872	201.026	185.256
Anakpo Town Road SOAKED CBR(%)	86.228	115.972	163.194	200.694	192.361
Upatabo Twon Road UNSOAKED CBR(%)	66.904	149.468	195.213	253.723	226.064
Upatabo Twon Road SOAKED CBR(%)	64.639	154.706	185.294	257.059	221.176
Ihubuluko Town Road UNSOAKED CBR(%)	71.380	140.094	168.302	210.377	182.075
Ihubuluko Town Road SOAKED CBR(%)	69.850	143.163	156.633	187.755	162.755
UNCONFINED COMPRESSIVE STRENGTH (KPa)					
Odioku Town Road UCS (Kpa)	90.355	110.674	125.281	150.562	170.787
Oyigba Town Road UCS (Kpa)	84.302	118.621	143.448	162.069	192.414
Anakpo Town Road UCS (Kpa)	92.179	108.485	128.485	146.061	173.939
Upatabo Twon Road UCS (Kpa)	89.773	111.392	142.405	162.658	187.975
Ihubuluko Town Road UCS (Kpa)	85.799	116.552	148.276	168.966	185.517

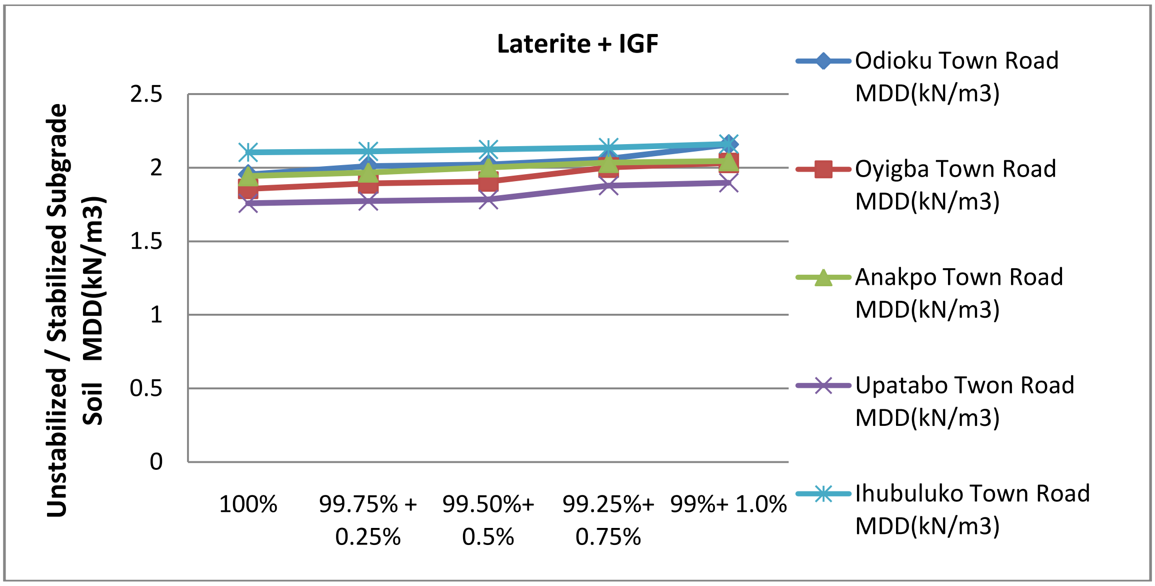

Figure 3.1: Maximum Dry Density of Subgrade Stabilization Test of Lateritic Soil from Odioku, Oyigba, Anakpo, Upatabo and Ihubuluko Towns), Ahoad-West L.G.A, Rivers State with IGF at Different Percentages and Combinations

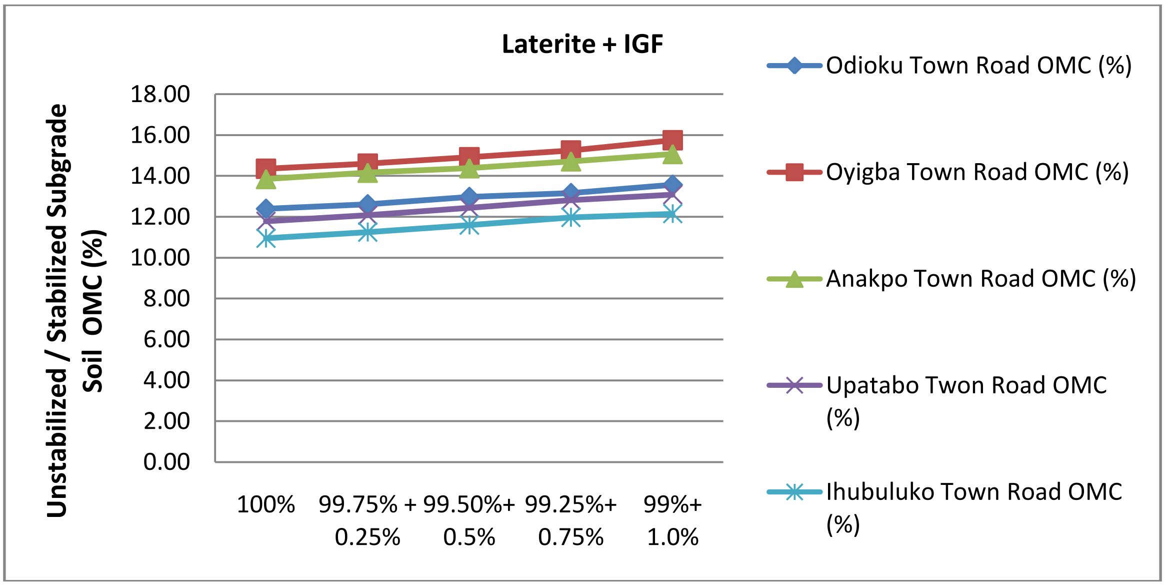

Figure 3.2: Optimum Moisture Content of Subgrade Stabilization Test of Lateritic Soil from Odioku, Oyigba, Anakpo, Upatabo and Ihubuluko Towns), Ahoad-West L.G.A, Rivers State with IGF at Different Percentages and Combinations

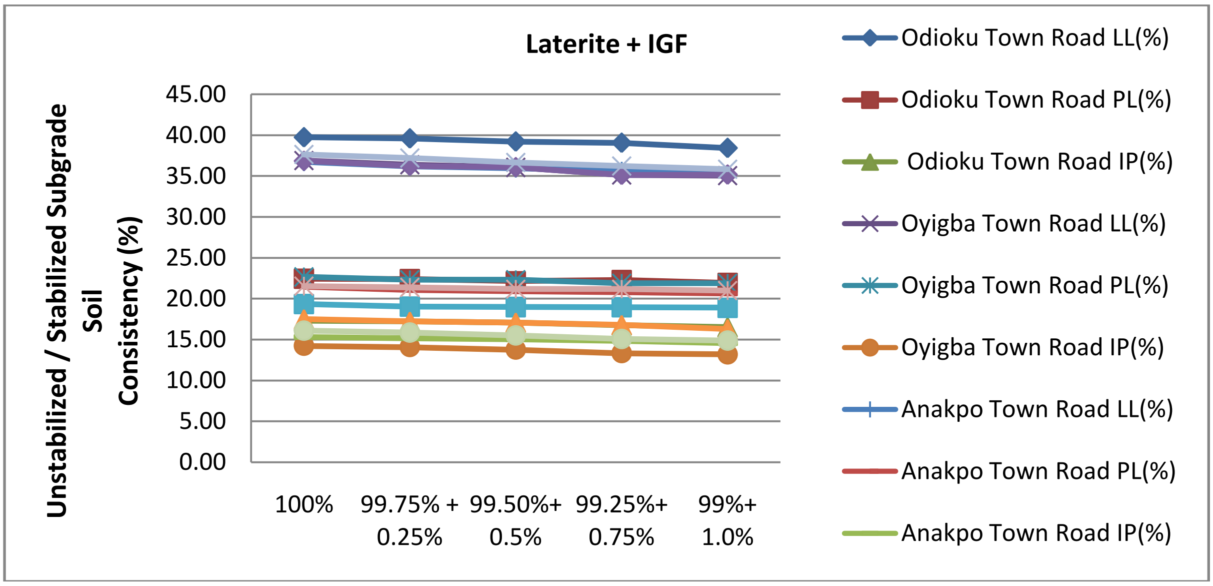

Figure 3.3: Consistency Limits of Subgrade Stabilization Test of Lateritic Soil from Odioku, Oyigba, Anakpo, Upatabo and Ihubuluko Towns), Ahoad-West L.G.A, Rivers State with IGF at Different Percentages and Combinations

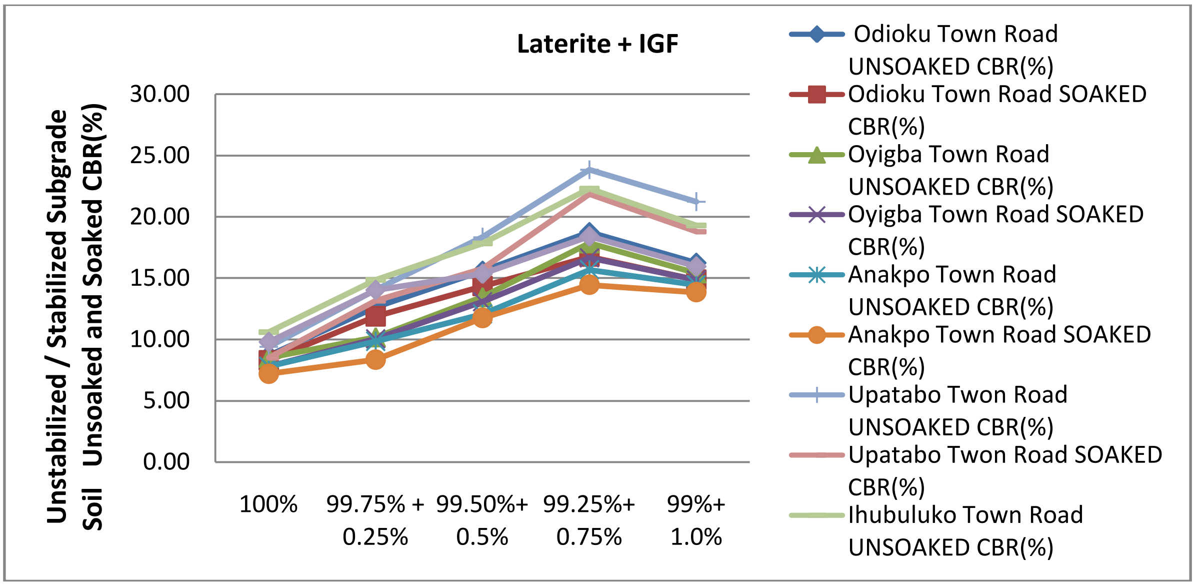

Figure 3.4: California Bearing Ratio of Subgrade Stabilization Test of Lateritic Soil from Odioku, Oyigba, Anakpo, Upatabo and Ihubuluko Towns), Ahoad-West L.G.A, Rivers State with IGF at Different Percentages and Combinations

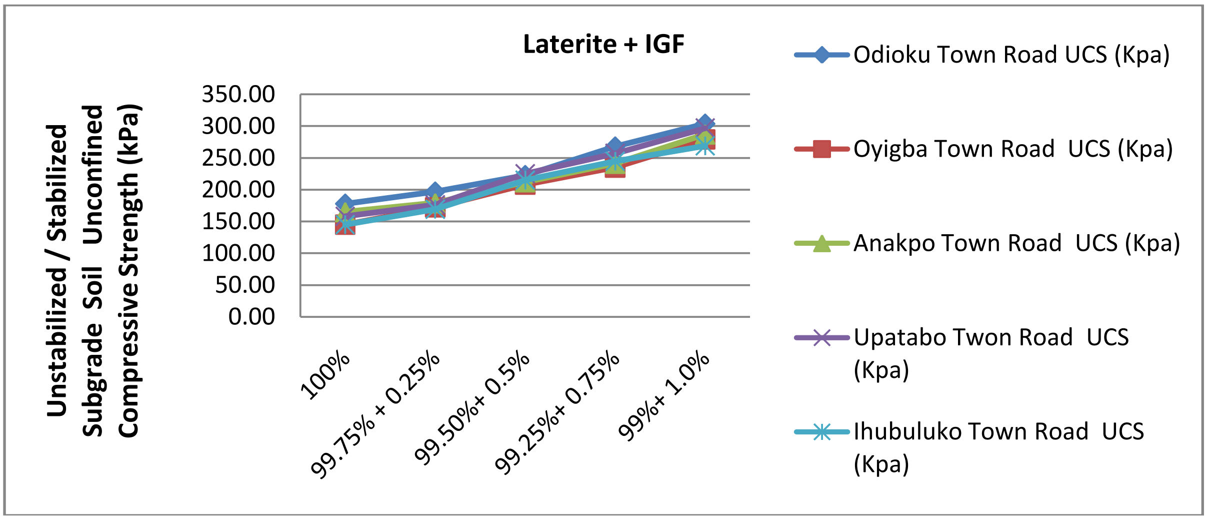

Figure 3.5: Unconfined Compressive Strength (UCS) of Subgrade Stabilization Test of Lateritic Soil from Odioku, Oyigba, Anakpo, Upatabo and Ihubuluko Towns), Ahoad-West L.G.A, Rivers State with IGF at Different Percentages and Combinations

IV. CONCLUSION

The following conclusions were made from the experimental research results.

i. The soils classified as A-2-6 SC and A-2-4 SM on the AASHTO classification schemes / Unified Soil Classification System
ii. 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%.
iii. Consistency limits (plastic index) of the soils at 100% natural state are 17.30%, 14.23%, 15.20%, 15.50% and 16.10%
iv. The entire results showed the potential of using irvinga gabonesis fibre as admixtures in treated soils
v. The swelling potential of treated soil decreased with the inclusion of fibre up to 0.75% for lateritic soils

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