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Utilization of Irvinga Gabonesis Fibre Ash as Soil Stabilizer for Highway Road Subgrade

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Abstract

The study investigates the use of irvinga gabonesis fibre ash as admixture in the modification of soils with prone to settlement and degradation characteristics. 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%. Consistency limits (plastic index) of the soils at 100% natural state are 17.30%, 14.23%, 15.20%, 15.50% and 16.10%. California bearing ration values of are 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 %. The soils classified as A-2-6 SC and A-2-4 SM on the AASHTO classification schemes / Unified Soil Classification System. Results indicated the need to stabilize the soils as to meet required standard for pavement structures have been indicated by the FMW Specifications (1997). The entire results showed the potential of using irvinga gabonesis fibre ash as admixtures in treated soils. The swelling potential of treated soil decreased with the inclusion of fibre ash up to 7.5% for soils. Comparative results showed maximum dry density decreased while optimum moisture content increased with increase in percentage ratio as represented in figures. Results showed increased California bearing ration values of both unsoaked and soaked. Cracks were noticed

beyond peak inclusion percentage of 7.5% to soils ratio. Results of the comparison showed increased in unconfined compressive strength values corresponding to percentages inclusion with peak values above.

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

INTRODUCTION

Natural fibers used as soil reinforcements and stabilizers are effective agents in the ability of shrinkage, cracks, and swelling with diffuse soils without the minimal environmental nuisance and with almost low-performance costs. Natural fibers such as hey, wood, and bamboo were used for the improvement of building materials (Khedari et al. 2001). The use of suitable elements in the soil improves its engineering properties such as strength, hardness, and deformation, the use of natural fibers such as kenaf, coir, banana, jute, flax, palm, reed, bamboo and wood fiber reinforcement of the soil and Stabilization is done. (Ramakrishna and Sundararajan, 2005).

Charles et al. (2018) investigated the effectiveness of natural fiber, Cotus afer bagasse (stabilizer / reinforcement in bush cane bagasse fiber (BSBF) soils with inclusion of 0.25%, 0.50%, 0.75% and 1.0% fiber). MDD and OMC decreased in both soils with the inclusion of fiber percentages, CBR values increased significantly with the optimum value percent inclusion of 0.75%, beyond this value, cracks were formed, resulting in potential failure states.

Charles et al. (2018) evaluated soil engineering properties with the inclusion of costus afer (Bush Sugarcane bagasse fiber ash (BSBFA) at varying percentages. The inclusion of soil and bagasse fiber ash increased with BSBFA increasing by 7.5% and reduced from 2.5% to 10% bagasse fiber ash stabilized to satisfy the sub-requirements. Their results showed the utility of BSBFA in clay soil. The swelling of treated soil decreased with the inclusion of bagasse fibre ash up to 7.5% for both soils.

Ghavami et al. (1999) observed that the addition of 4% coconut and sisal fiber to the soil significantly increases its deformation. Also, cracks were greatly reduced in the dry season.

Charles et al. (2018) evaluated the geotechnical properties of a cosmic soil determined along the Odioku – Odiereke road in Ahoada-West in the Niger Delta region. Utilization of two cemented binders of cement and lime, hybridized with costus afer bagasse fiber to stabilize the failing section of the road. The first-stage determination established that the soil is relatively plastic. The results proved the potential for the use of bagasse, as BSBF in cement and lime amended soils and subsequently soils with a ratio of 8% cement and lime and 7.5% + 7.5% cement/lime / BSBF.

Barisua et al. (2018) evaluated the obtained strength of expansionary clay soils with swelling - in addition to the two-cementite stable addition of cement and lime binding agent in a mixture with bagasse fibre ash of pozzolanic from waste agricultural products of costaceous lacrus. The results validated an incremental percentile CBR values for each unsoaked and soaked soil corresponding to a peak of the composite ratio of 0.75% + 7.5%. The unconfined compressive checks have incremental percentage values with composite ratios for the cement/lime + CLBFA combination with cement in superior values to lime composition respectively of sampled roads of Ogoda, Bodo, Ogbogu, Ula-Ikata, and Kaani, all in Rivers State, Nigeria. Comparative yields showed cement + CLBFA dominance over lime + CLBFA mixed actions.

Terence et al. (2018) investigated and evaluated the use of costaceae lacerus bagasse fibre ash in varying proportions in mixed percentages in combination with cement and lime. The results confirmed that it is possible to use additives as soil stabilizers with cement. California bearing ratios of unsoaked and soaked stabilized soils with a mixed content of cement, lime and CLBFA were found to contain incremental percentage values to include the percentage ratio with the most appropriate mixing ratio of 2.5 + 7.5 + 7.5%. The results of unconfined compressive strength investigation of un-stabilized and stabilized soils with cement/lime + CLBFA as a ratio of soil growth factors are confirmed.

Charles et al. (2018) evaluated the utility of cemented stabilizing bindings to mixed agents of cemented / lime and plantain rachis fiber ash in mixed ratios and compared their strength to clay soil in comparison. Consistency limits yield effects proven percentile diminished in plastic index properties to stabilizers inclusion percentages to soils. Condensation residues of clay soil were obtained

from the results obtained by incorporating composites into clay soil. The California bearing ratio (CBR) confirmed the incremental percentage values for the corresponding cemented binder with PRFA inclusion, with a most pleasing combination ratio of 2.5 percent + 7.5 + 7.5% compared to mixed and mixed stabilized clay clay-soaked cement.

Charles et al. (2018) Hybridization characteristics of Irving gabonisis fiber ash and cement as composite materials in susceptible massive clay soil changes found in the roads of Iwofe, Chokocho, Ndoni, and Ogbele Town Roads in the Niger Delta region of the south-south parts of Nigeria investigated. The experimental results have been analyzed in the compaction test parameters of MDD and OMC with the expansion of additives in the same percentage ratio for clay soils. The results of un-soaked and soaked CBR results showed increased values with recognition for the same percentage, with the most notable inclusion being a soil ratio of 7.5% + 7.5%. The comparative result was validated with an appreciation for the percentage in unconfined compressive strength of relatively stabilized clay soils. The overall effects established the use of Irving gabonis fiber (bush mango) ash and cement as soil stabilizer products.

Letam et al. (2018) evaluated the trend of failure of associated susceptibility along the sample roads of Ebiriba, Ochigba, Eneka and Isiokpo in the Niger Delta of Nigeria as a soil stabilizer with the utility of plantain rachis fiber ash + lime blend to strengthen the failed sections. In comparison, the effect on compaction test parameters indicates the accelerated values of the maximum dry density and optimum moisture content to inclusion increase. In contrast to the results, the California bearing ratio of soils stabilized and the ratio of soaked values advanced with composite materials to the percentage content of plantain rachis fiber + lime with the most appropriate ratio of 0.75% + 7.5%. The comparative effects examine illustrated unconfined compressive strength checks relative to inclusion percentile increase. The comparative effect showed appreciation of aspects of the inclusion of decreasing values of the plastic index. The complete result suggests that the use of plantain rachis fibre ash + lime applied to stabilize the soil is reasonable feasibility.

Prabhakar and Sridhar (2002) conducted studies on soil samples reinforced with sisal fibers showing that both fiber content

and aspect ratio have significant effects in shear strength parameters (C, Ø). They observed that optimal value for the fiber content exists such that the shear strength decreases with increasing fiber content above this optimal value.

Mesbah et al. (2004) carried out tensile tests on soil samples that were reinforced with fibers and concluded that the fibers, length and tensile strength are the most important factors affecting the overall tensile strength of the soil.

MATERIALS AND METHODS

Materials

Soil

Studied soil was collected from Ubie, Upata and Igbuduya Districts of Ekpeye, Ahoada- East and Ahoada-West Local Government of Rivers State, besides 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

Irvinga Gabonesis, are collected from Olokuma village, a riverside area in Ubie Clan, Ahoada-West, Rivers State, Nigeria.

METHOD

Sampling Locality

Sample soil were from 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), Oshika 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

Performed tests are (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 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 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 percentage, at which a portion of the soil in the standard cup and a groove of standard dimensions is cut, for a distance of 13 mm Will flow simultaneously at the base of the drain (1 / 2in.) When subjected to 25 shocks being dropped 25 mm from the cup in a standard fluid limit mechanism operated at a rate of two shocks per second

Moisture – Density (Compaction) Test

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

Unconfined Compression (UC) Test

Unconfined compressed power is taken as the maximum load achieved per unit area, or loaded at 15% axial stress per unit area, whichever occurs during the performance of a test. The primary objective of this test is to determine the unconfined compressive strength, which is then used to calculate the unconsolidated undrained shear strength of the soil under unconfined conditions.

California Bearing Ratio (CBR) Test

The California Bearing Ratio (CBR) test was developed by the California Division of Highways as a way to reevaluate and evaluate soil-suburb and base course materials for flexible pavements

RESULTS AND DISCUSSIONS

The detailed test results given in Tables: 5 show that the initial result on later soils showed that physical and engineering properties fall below the minimum requirement for such application and stabilization was required to improve its properties. Soils classified as A-2-6 SC and A-2-4 SM on the AASHTO classification schemes / integrated soil classification system are shown in Table 3.1 and are less mature in the soil vertical profile and possibly more susceptible to all forms Huh. Manipulations that are known for other fragile lateritic soils (Ola 1974; Allam and Sreedharan 1981; Omotoshu and Akimusaru 1992; Omotosho 1993). Soils are brown and dark brown (in deep wet to dry states) to 17.30%, 14.23%, 15.20%, 15.50%, and 16.10%, respectively, to Odiekwu, Oigaba, Anakpo, Uptabo, Ihbuluko Town Road. Soils have CBR values of 8.7%, 8.5%, 7.8%, 9.4% and 10.6% and unconfined compressive strength (UCS) values 178kPa, 145kPa, of CBR values of 8.3%, 7.8%, 7.2%, 8.5% and 9.8%, 165kPa, 158kPa and 149kPa when compressed with British Standard Light (BSL) respectively.

Compaction Test Results

The results of lateritic soils at 100% of maximum dry density (MDD) at preliminary test are 1.954KN/m3, 1.857 KN/m3, 1.943 KN/m3, 1.758 KN/m3 and 2.105 KN/m3 having percentile values of 99.09%, 98.25%, 97.39%, 99.27%, 96.92% and 12.39%, 14.35%, 13.85%, 11.79% and 10.95% of percentile values of 97.25%, 97.69%, 97.19%, 98.01%, 96.82% optimum moisture content (OMC) at 100% soils. Irvinga gabonesis fibre ash (IGFA) treated soils with 2.5%, + 5.0%, 7.5% and 10% values at peak are 1.847 KN/m3, 1.738 KN/m3, 1.809 KN/m3, 1.629 KN/m3 and 1.885 KN/m3 (MDD) having percentile rise of 108.34%, 104.36%, 112.46%, 104.04%, 108.55%, while 13.65%, 15.74%, 15.15%, 13.08% and 12.15% (OMC) with peak rise of percentile values of 110.17%, 109.69%, 109.39%, 110.94%, 110.96%. Comparatively,

results showed that both compaction parameters increased with increase in percentage ratio as represented in figures 3.1 and 3.2

California Bearing Ratio (CBR) Test

Preliminary investigation of CBR results obtained for lateritic soils at 100% are 8.7%,8.5%, 7.8%, 9.4%, and 10.6% unsoaked and soaked CBR values of 8.3%, 7.8%, 7.2%, 8.5% and 9.8 %, indicating percentile values of 77.33%, 81.34%, 85.06%, 71.87%, 76.92% and 76.22%, 76.62%, 80.27%, 67.19%, 76.26% respectively for unsoaked and soaked at plain states. For fibre ash inclusion of percentages in shown in tables 3.2 – 3.5, are 17.75%, 15.58%, 14.88%, 19.35% and 21.30% unsoaked and soaked 15.45%, at 13.97%, 13.98%, 17.65% and 18.18% at peak percentages of 7.5% fibre ash inclusion with percentile values of 204.02%, 183.29%, 190.77%, 205.85%, 200.94% and 186.15%, 179.10%, 194.17%, 207.65%, 185.51% respectively of unsoaked and soaked at stabilized states. Results showed increased CBR values of both unsoaked and soaked. Cracks were noticed beyond peak inclusion percentage of 7.5%.

Unconfined Compressive Strength Test

Results obtained of lateritic soils at preliminary engineering soil properties of unconfined compressive strength (UCS) values are 178kPa, 145kPa, 165kPa, 158kPa and 149kPa to corresponding sampled roads at plain stabilization of 100% soil percentile values are 93.19%, 89.51%, 88.24%, 84.95%, 85.80%. Fibre stabilized soils increased at optimum of 278kPa, 259kPa, 268kPa, 253kPa and 233kPa indicating percentile values of 156.18%, 178.62%, 162.42%, 160.13%, 160.69%. Results in comparison showed increased in UCS values correspond to percentages inclusion with peak values.

Consistency Limits Test

Results of consistency limits (plastic index) at 100% soils are 17.30%, 14.23%, 15.20%, 15.50% and 16.10% with percentile values range of 100.23%, 101.28%, 101.46%, 99.94%, 102.03%. Stabilized sampled soils values are 16.46%, 13.06%, 14.04%, 16.85% and 14.96% with percentile reduction values of 95.15%, 91.78%, 91.77%, 96.29%, and 92.92%. Plastic index results decreased with increase in fibre ash percentages ratio.

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 3.2: Results of Subgrade Soil (Laterite) Test Stabilization with Binding Fibre ash

SAMPLE LOCATION	SOIL + FIBRE IRVINGA GABONENSIS BURNT ASH %	MDD (KN/m³)	OMC (%)	UNSOAKED CBR (%)	SOAKED CBR (%)	UCS(KPa)	LL(%)	PL(%)	PI(%)	SIEVE #200	AASHTO / USCS (Classification)	NOTES
LATERITE + IRVINGA GABONESIS FIBRE ASH (IGFA)(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+2.5%	1.972	12.74	11.25	10.89	191	39.68	22.42	17.26	28.35	A-2-6/SC	GOOD
	99.50+5.0%	1.989	12.92	13.80	12.30	208	39.40	22.36	17.04	28.35	A-2-6/SC	GOOD
	99.25+7.5%	2.11	13.27	17.75	15.45	238	39.18	22.33	16.85	28.35	A-2-6/SC	GOOD
	99.0+10%	2.117	13.65	15.25	14.84	278	38.68	22.22	16.46	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
	99.75+2.5%	1.908	14.69	10.45	10.18	162	36.68	22.63	14.05	40.55	A-2-4/SM	GOOD
	99.50+5.0%	1.908	14.97	12.85	11.66	187	36.58	22.83	13.75	40.55	A-2-4/SM	GOOD
	99.25+7.5%	1.928	15.26	15.58	13.97	215	336.03	22.79	13.24	40.55	A-2-6/SM	GOOD
	99.0+10%	1.938	15.74	14.30	12.45	259	35.75	23.47	13.06	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+2.5%	1.995	14.25	9.17	8.97	187	36.53	21.42	15.08	36.85	A-2-4/SM	GOOD
	99.50+5.0%	2.085	14.47	12.75	12.08	202	36.15	21.32	14.83	36.85	A-2-4/SM	GOOD
	99.25+7.5%	2.145	15.08	14.88	13.98	231	35.85	21.32	14.53	36.85	A-2-4/SM	GOOD
	99.0+10%	2.185	15.15	14.08	12.45	268	35.48	21.44	14.04	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+2.5%	1.771	12.03	13.08	12.65	186	36.57	19.66	17.51	33.45	A-2-6/SC	GOOD
	99.50+5.0%	1.783	12.44	16.75	15.25	217	36.32	19.08	17.24	33.45	A-2-6/SC	GOOD
	99.25+7.5%	1.805	12.79	19.35	17.65	228	35.93	18.87	17.06	33.45	A-2-6/SC	GOOD
	99.0+10%	1.829	13.08	17.16	16.65	253	35.67	18.82	16.85	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+2.5%	2.172`	11.31	13.78	12.85	169	37.38	21.16	15.78	39.25	A-2-6/SC	GOOD
	99.50+5.0%	2.208	11.55	17.80	15.25	203	37.08	21.47	15.61	39.25	A-2-6/SC	GOOD
	99.25+7.5%	2.228	11.89	21.30	18.18	226	36.70	21.39	15.25	39.25	A-2-6/SC	GOOD
	99.0+10%	2.285	12.15	19.21	16.35	233	36.38	21.42	14.96	39.2	A-2-6/SC	GOOD

Table 3.3: Percentile Combination of Laterite + Irvinga Gabonesis Fibre Ash (IGFA)(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)	1.95	1.97	1.99	2.11	2.12
Oyigba Town Road MDD(kN/m3)	1.86	1.89	1.91	1.93	1.94
Anakpo Town Road MDD(kN/m3)	1.94	2.00	2.09	2.15	2.19
Upatabo Twon Road MDD(kN/m3)	1.76	1.77	1.78	1.81	1.83
Ihubuluko Town Road MDD(kN/m3)	2.11	2.17	2.21	2.23	2.29
OPTIMUM MOISTURE CONTENT (%)					
Odioku Town Road OMC (%)	12.39	12.74	12.92	13.27	13.65
Oyigba Town Road OMC (%)	14.35	14.69	14.97	15.26	15.74
Anakpo Town Road OMC (%)	13.85	14.25	14.47	15.08	15.15
Upatabo Twon Road OMC (%)	11.79	12.03	12.44	12.79	13.08
Ihubuluko Town Road OMC (%)	10.95	11.31	11.55	11.89	12.15
CONSISTENCY LIMITS (%)					
Odioku Town Road LL(%)	39.75	39.68	39.40	39.18	38.68
Odioku Town Road PL(%)	22.45	22.42	22.36	22.33	22.22
Odioku Town Road IP(%)	17.30	17.26	17.04	16.85	16.46
Oyigba Town Road LL(%)	36.90	36.68	36.58	36.03	35.75
Oyigba Town Road PL(%)	22.67	22.63	22.83	22.79	23.47
Oyigba Town Road IP(%)	14.23	14.05	13.75	13.24	13.06
Anakpo Town Road LL(%)	36.75	36.53	36.15	35.85	35.48
Anakpo Town Road PL(%)	21.45	21.42	21.32	21.32	21.44
Anakpo Town Road IP(%)	15.30	15.08	14.83	14.53	14.04
Upatabo Twon Road LL(%)	36.85	36.57	36.32	35.93	35.67
Upatabo Twon Road PL(%)	19.35	19.66	19.08	18.87	18.82
Upatabo Twon Road IP(%)	17.50	17.51	17.24	17.06	16.85
Ihubuluko Town Road LL(%)	37.65	37.38	37.08	36.70	36.38
Ihubuluko Town Road PL(%)	21.55	21.16	21.47	21.39	21.42
Ihubuluko Town Road IP(%)	16.10	15.78	15.61	15.25	14.96
CALIFORNIA BEARING RATIO (%)					
Odioku Town Road UNSOAKED CBR(%)	8.70	11.25	13.80	17.75	15.25
Odioku Town Road SOAKED CBR(%)	8.30	10.89	12.30	15.45	14.84
Oyigba Town Road UNSOAKED CBR(%)	8.50	10.45	12.85	15.58	14.30
Oyigba Town Road SOAKED CBR(%)	7.80	10.18	11.66	13.97	12.45
Anakpo Town Road UNSOAKED CBR(%)	7.80	9.17	12.75	14.88	14.08

Anakpo Town Road SOAKED CBR(%)	7.20	8.97	12.08	13.98	12.45
Upatabo Twon Road UNSOAKED CBR(%)	9.40	13.08	16.75	19.35	17.16
Upatabo Twon Road SOAKED CBR(%)	8.50	12.65	15.25	17.65	16.65
Ihubuluko Town Road UNSOAKED CBR(%)	10.60	13.78	17.80	21.30	19.21
Ihubuluko Town Road SOAKED CBR(%)	9.80	12.85	15.25	18.18	16.35
UNCONFINED COMPRESSIVE STRENGTH (KPa)					
Odioku Town Road UCS(kN/m3)	178.00	191.00	208.00	238.00	278.00
Oyigba Town Road UCS(kN/m3)	145.00	162.00	187.00	215.00	259.00
Anakpo Town Road UCS(kN/m3)	165.00	187.00	202.00	231.00	268.00
Upatabo Twon Road UCS(kN/m3)	158.00	186.00	217.00	228.00	253.00
Ihubuluko Town Road UCS(kN/m3)	145.00	169.00	203.00	226.00	233.00

Table 3.4: Percentile Decrease / Increase of Laterite + Irvinga Gabonesis Fibre Ash (IGFA) (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)	99.087	100.921	101.791	107.881	108.342
Oyigba Town Road MDD(kN/m3)	98.254	101.777	102.746	103.823	104.362
Anakpo Town Road MDD(kN/m3)	97.393	102.676	107.308	110.396	112.455
Upatabo Twon Road MDD(kN/m3)	99.266	100.739	101.422	102.673	104.039
Ihubuluko Town Road MDD(kN/m3)	96.915	103.183	104.893	105.843	108.551
OPTIMUM MOISTURE CONTENT (%)					
Odioku Town Road OMC(kN/m3)	97.253	102.825	104.278	107.103	110.169
Oyigba Town Road OMC(kN/m3)	97.686	102.369	104.321	106.341	109.686
Anakpo Town Road OMC(kN/m3)	97.193	102.888	104.477	108.881	109.386
Upatabo Twon Road OMC(kN/m3)	98.005	102.036	105.513	108.482	110.941
Ihubuluko Town Road OMC(kN/m3)	96.817	103.288	105.479	108.584	110.959
CONSISTENCY LIMITS (%)					
Odioku Town Road LL(%)	100.176	99.824	99.119	98.566	97.308
Odioku Town Road PL(%)	100.134	99.866	99.599	99.465	98.976
Odioku Town Road IP(%)	100.232	99.769	98.497	97.399	95.145
Oyigba Town Road LL(%)	100.600	99.404	99.133	97.642	96.883
Oyigba Town Road PL(%)	100.177	99.824	100.706	100.529	103.529
Oyigba Town Road IP(%)	101.281	98.735	96.627	93.043	91.778
Anakpo Town Road LL(%)	100.602	99.401	98.367	97.551	96.544
Anakpo Town Road PL(%)	100.140	99.860	99.394	99.394	99.953
Anakpo Town Road IP(%)	101.459	98.562	96.928	94.967	91.765
Upatabo Twon Road LL(%)	100.766	99.240	98.562	97.503	96.798
Upatabo Twon Road PL(%)	98.423	101.602	98.605	97.519	97.261
Upatabo Twon Road IP(%)	99.943	100.057	98.514	97.486	96.286
Ihubuluko Town Road LL(%)	100.722	99.283	98.486	97.477	96.627
Ihubuluko Town Road PL(%)	101.843	98.190	99.629	99.258	99.397
Ihubuluko Town Road IP(%)	102.028	98.012	96.957	94.720	92.919
CALIFORNIA BEARING RATIO (%)					
Odioku Town Road UNSOAKED CBR(%)	77.333	129.310	158.621	204.023	175.287
Odioku Town Road SOAKED CBR(%)	76.217	131.205	148.193	186.145	178.795
Oyigba Town Road UNSOAKED CBR(%)	81.340	122.941	151.176	183.294	168.235
Oyigba Town Road SOAKED CBR(%)	76.621	130.513	149.487	179.103	159.615
Anakpo Town Road UNSOAKED CBR(%)	85.060	117.564	163.462	190.769	180.513
Anakpo Town Road SOAKED CBR(%)	80.268	124.583	167.778	194.167	172.917
Upatabo Town Road UNSOAKED CBR(%)	71.865	139.149	178.191	205.851	182.553
Upatabo Twon Road SOAKED CBR(%)	67.194	148.824	179.412	207.647	195.882
Ihubuluko Town Road UNSOAKED CBR(%)	76.923	130.000	167.925	200.943	181.226
Ihubuluko Town Road SOAKED CBR(%)	76.265	131.122	155.612	185.510	166.837
UNCONFINED COMPRESSIVE STRENGTH (KPa)					
Odioku Town Road UCS(kN/m3)	93.194	107.303	116.854	133.708	156.180
Oyigba Town Road UCS(kN/m3)	89.506	111.724	128.966	148.276	178.621
Anakpo Town Road UCS(kN/m3)	88.235	113.333	122.424	140.000	162.424
Upatabo Twon Road UCS(kN/m3)	84.946	117.722	137.342	144.304	160.127
Ihubuluko Town Road UCS(kN/m3)	85.799	116.552	140.000	155.862	160.690

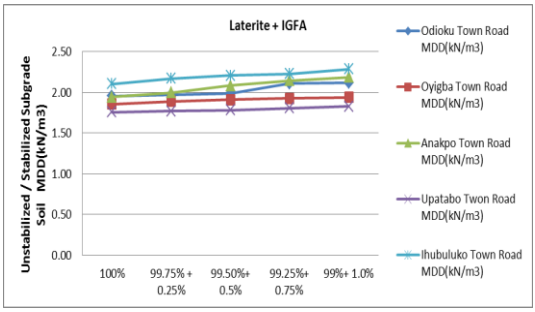

Figure 3.1: Maximum Dry Density of Subgrade Stabilization Test of Lateritic Soil from Odioku, Oyigba, Anakpo, Upatabo and Ihubuluko Towns), Ahoad-West L.G.A, Rivers State with IGFA at Different Percentages and Combination

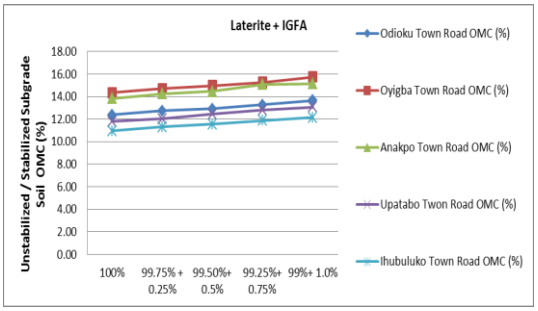

Figure 3.2: Optimum Moisture Content of Subgrade Stabilization Test of Lateritic Soil from Odioku, Oyigba, Anakpo, Upatabo and Ihubuluko Towns), Ahoad-West L.G.A, Rivers State with IGFA at Different Percentages and Combination

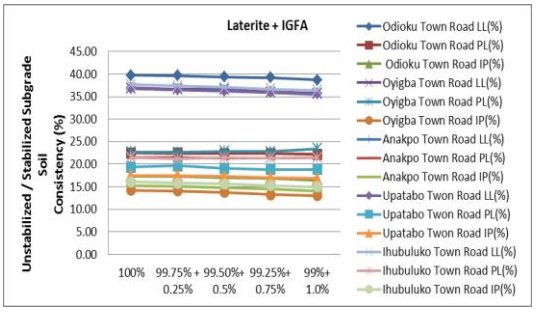

Figure 3.3: Consistency Limits of Subgrade Stabilization Test of Lateritic Soil from Odioku, Oyigba, Anakpo, Upatabo and Ihubuluko Towns), Ahoad-West L.G.A, Rivers State with IGFA at Different Percentages and Combination

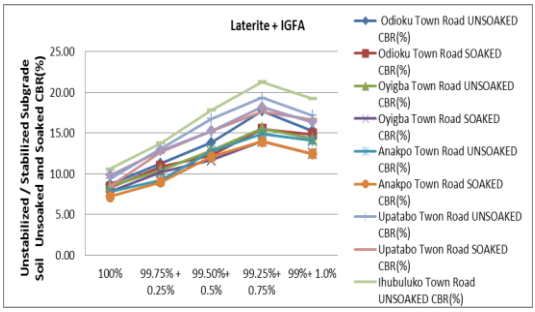

Figure 3.4: Subgrade California Bearing Ratio of Subgrade Stabilization Test of Lateritic Soil from Odioku, Oyigba, Anakpo, Upatabo and Ihubuluko Towns), Ahoad-West L.G.A, Rivers State with IGFA at Different Percentages and Combination

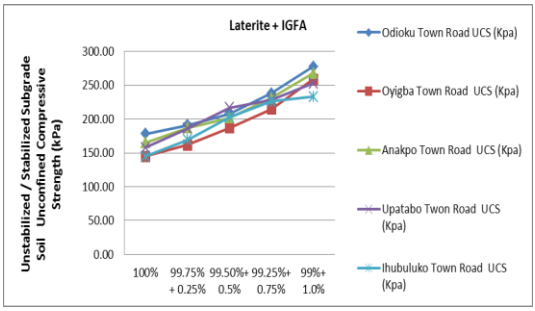

Figure 3.6: Unconfined Compressive Strength (UCS) of Subgrade Stabilization Test of Lateritic Soil from Odioku, Oyigba, Anakpo, Upatabo and Ihubuluko Towns), Ahoad-West L.G.A, Rivers State with IGFA at Different Percentages and Combination

CONCLUSIONS

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 ash as admixtures in treated soils

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

REFERENCES

1. Allam, M. M. and Sridharan, A. (1981). Effect of Repeated Wetting and Drying on Shear Strength. *Journal of Geotechnical Engineering, ASCE,*107(4):421–438.
2. Barisua, E. N., Charles, K., Ode, T., (2018). Comparative Strength Evaluation of Cementious Stabilizing Agents Blended with Pulverized Bagasse Fibre for Stabilization of Expansive Lateritic Soils. *Global Scientific Journal,* 6(12):220-238
3. Charles, K., Isaac, O. A., Terence, T.T. W. (2018). Stabilization of Deltaic Soils Using Costus Afer Bagasse Fibre Ash as Pozzolana . *International Journal of Civil and Structural Engineering Research.* 6(1):133-141
4. Charles, K., Essien, U., Gbinu, S. K. (2018). Stabilization of Deltaic Soils using Costus Afer Bagasse Fiber . International Journal of Civil and Structural Engineering Research. 6(1): 148-156
5. Charles, K.`, Amakiri – Whyte, B., Terence, T. T. W. (2018). Stabilization of Black Cotton Clayey Soils with Cementitious Stabilizing Agents Blended with Waste Agricultural Products. Journal of Scientific and Engineering Research, 5(12):227-238
6. Charles, K., Terence, T. T. W., and Gbinu, S. K., (2018). Stabilization of Niger Deltaic Expansive Clay Soils Using Composite Materials, International Journal of Advances in Scientific Research and Engineering, 4(11): 21 - 28
7. Ghavami, K., h., Toledo Filho, R.D., and Barbosa, N.P., (1999). Behavior of Composite Soil Reinforced with Natural Fibres.Cement and Concrete Composites, 21, 39–48
8. Khedari, J., Suttidonk, B., Pratinhong, N., Hirunlabh, J. (2001). New Light Weight Composite Construction Materials with Low Thermal Conductivity. Cement and Concrete Composites, 23, 65–70.

9. Letam, L. P., Charles, K., and Terence, T. T. W., (2018). Influence of Waste Agricultural Fibre Products Material and Lime on Geotechnical Characteristics of Expansive Soils, International Journal of Advances in Scientific Research and Engineering, 4(11): 49 - 57
10. Mesbah, A., Morel, J. C., Walker, P., Ghavami, K. H. (2004). Development of a Direct Tensile Test for Compacted Earth Blocks Reinforced with Natural Fibers. *Journal of materials in Civil Engineering,* 16(1): 95–98.
11. Ola, S. A. (1974). Need for Estimated Cement Requirements for Stabilizing Lateritic Soils. *Journal of Transportation Engineering, ASCE*, 100(2):379–388
12. Omotosho, P. O. (1993). Multi-Cyclic Influence on Standard Laboratory Compaction of Residual Soils, *Engineering Geology. 36, 109–115.*
13. Omotosho, P .O. and Akinmusuru, J .O. (1992). Behavior of Soils (Lateritic) Subjected to Multi-Cyclic Compaction. *Engineering Geology,* 32, 53–58
14. Prabakar, J. and Sridhar, R.S. (2002). Effect of Random Inclusion of Sisal Fibre on Strength Behavior of Soil. Construction and Building Materials, 16, 123–131
15. Ramakrishna, G. and Sundararajan, T. (2005). Studies on the Durability of Natural Fibres and the Effect of Corroded Fibres on the Strength of Mortar. Cement and Concrete Composites, 27(5): 575-582
16. Terence, T. T. W., Charles, K,. Amakiri – Whyte, B., (2018). Performance Characteristics of Cement, Lime - Pozzolanic Bagasse Fibre Ash Stabilized Expansive Lateritic Soils for Highway Pavement Materials. International Journal of Scientific & Engineering Research, 9(12): 1092 – 1109.