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COMPOSITE MATERIALS HYBRID AS STABILIZER OF DELTAIC LATERITIC SOILS

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ABSTRACT

The study evaluated the modification of geotechnical properties of Niger deltaic lateritic soils of fragile and manipulative characteristics that are prone to severe cracks and differential settlement with the composite materials hybrid of plantain rachis fibre + cement with 0.25% + 2.5%, 0.5% + 5.0%, 0.75% + 7.5% and 1.0% + 10% to soils percentage ratio inclusion to improve their strength. Preliminary investigations computed the percentage (%) passing BS sieves #200 as 38.46%, 39.40%, 36.85%, and 36.42%, reddish brown color, plasticity index are 17.11%, 22.5%, 14.10%, and 18.51%, California bearing ratio (CBR) values unsoaked are 9.25%, 9.48%, 7.85%, 8.65%, and soaked 7.40%, 8.05%, 6.65% and 6.65 % and unconfined compressive strength (UCS) values of 168kPa, 178kPa, 163kPa and 175kPa. Soils are classified as A-2-6 SC and A-2-4 SM on the AASHTO classification schemes / Unified Soil Classification System and are less for use as embankment materials for road constructional materials. Stabilized lateritic soils comparative results showed decreased values of maximum dry density (MDD) and increased values of optimum moisture content (OMC) with relating values to percentages ratio fibre + cement inclusion demonstrated graphically in figures. Computed results illustrated increased values of both unsoaked and soaked California bearing ratio to percentages inclusion increase, with 0.75% + 7.5% optimum mix ratio to soils. Cracks and reductions in values were noticed beyond optimum. Results showed that fibre percentages ratio increase hoisted the values of unconfined compressive strength. Results of fibre + cement stabilized lateritic soils showed decreased in plastic index as against un-stabilized. Entire results showed the potential use of plantain rachis fibre + cement as soil stabilizers.

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

1.0 INTRODUCTION

Soil strengthening is an obvious method required to improve soils of weak properties and could be mechanical (if simply compacted with or without the addition of sand addition), chemical (if compacted with controlled proportions of stabilizing agents, including bitumen, lime and cement), thermal (which could produce dehydrated hard-pans) and even electrical (through, for example, electro-osmosis). For a temperate soil to be suitable for cement stabilization as single and combined state as and useful in the construction of road pavement structure, the HRB specify that the percentage fines, liquid limit and plasticity index must not exceed 50 %, 40 % and 18 % respectively, while Millard and O'Reilly [1] specify that the product of the plasticity index and the percentage passing through a 42 µm sieve (no 40) must not exceed 1 000.

Charles *et al.* [2] evaluated the effectiveness in the used of lime and costus afer fibre (Bush sugarcane bagasse fiber ash (BSBFA) in single and combined actions as soil stabilizer to improve its properties. Considering the fact that Niger Deltaic soils fall short of the minimum requirements for such applications on Specifications for road pavement structural materials (after FMW 1997). Entire results showed tremendous strength increased in soil properties with the inclusion of additives. The entire results showed the potential of using bagasse BSBFA as admixture in lime treated soils of clay and laterite with 8 % lime + 7.5% lime + BSBFA. Treated soils with Lime decreased in liquid limits and increased in plastic limits. Soils with Lime and fibre products in combinations increased CBR values appreciably both at soaked and unsoaked conditions respectively At 8% of both cement and lime, CBR values reached optimum, beyond this range, cracks exist and 7.5% lime + 7.5% BSBFA, optimum value are reached.

Manikandan and Moganraj [3] had found that the combined effect of bagasse ash and lime were more effective than the effect of bagasse ash alone in controlling the consolidation characteristics of expansive soil along with the improvement in other properties.

Charles *et al.* [4] 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.

Sabat [5] 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 [6] 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.* [7] 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.

Charles *et al.* [8] 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.

2.0 MATERIALS AND METHODS

2.1 Materials

2.1.1 Soil

The soils used for the study were collected from Ogbogoro Town Road, in Obio/Akpor Local Government, Egbeda Town Road, in Emuoha Local Government Area, Igwuruta Town Road, in Ikwerre Local Government Area and Aleto Town Road, in Eleme Local Government area, all in Rivers State, Niger Delta region, Nigeria. It lies on the recent coastal plain of the North-Western of Rivers state of Niger Delta.

2.1.2 Plantain Rachis Fibre

The Plantain Rachis fibres are obtained from Iwofe markets, in Obio/Akpor Local Area of Rivers State, they are abundantly disposed as waste products both on land and in the river.

2.1.3 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 Ogbogoro Town, (latitude 4.81° 33'S and longitude 6.92° 18'E), Egbeda a Town, (latitude 5.14° 15'N and longitude 6.45° 23'E), Igwuruta Town, latitude 4.97° 93'N and longitude 6.99° 80'E), and Aleto Town, latitude 4.81° 32'S and longitude 7.09° 28'E) all in Rivers State, Nigeria.

2.2.2 Test Conducted

Test conducted were (1) Moisture Content Determination (2) Consistency limits test (3) Particle size distribution (sieve analysis) and (4) Standard Proctor Compaction test, California Bearing Ratio test (CBR) and Unconfined compressive strength (UCS) tests;

2.2.3 Moisture Content Determination

The natural moisture content of the soil as obtained from the site was determined in accordance with BS 1377 (1990) Part 2. The sample as freshly collected was crumbled and placed loosely in the containers and the containers with the samples were weighed together to the nearest 0.01g.

2.2.4 Grain Size Analysis (Sieve Analysis)

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

2.2.5 Consistency Limits

The liquid limit (LL) is arbitrarily defined as the water content, in percent, at which a part of soil in a standard cup and cut by a groove of standard dimensions will flow together at the base of the groove for a distance of 13 mm (1/2in.) when subjected to 25 shocks from the cup being dropped 10 mm in a standard liquid limit apparatus operated at a rate of two shocks per second.

2.2.6 Moisture – Density (Compaction) Test

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

2.2.7 Unconfined Compression (UC) Test

The unconfined compressive strength is taken as the maximum load attained per unit area, or the load per unit area at 15% axial strain, whichever occurs first during the performance of a test. The primary purpose of this test is to determine the unconfined compressive strength, which is then used to calculate the unconsolidated undrained shear strength of the clay under unconfined conditions

2.2.8 California Bearing Ratio (CBR) Test

The California Bearing Ratio (CBR) test was developed by the California Division of Highways as a method of relegating and evaluating soil- subgrade and base course materials for flexible pavements.

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 color (from wet to dry states) plasticity index of 17.11%, 22.5%, 14.10%, and 18.51% respectively for Ogbogoro, Egbeda, Igwuruta and Aleto Town Roads. The soil has unsoaked CBR values of 9.25%, 9.48%, 7.85% and 8.65%, and soaked CBR values of 7.40%, 8.05%, 6.65% and 6.65%, unconfined compressive strength (UCS) values of 168kPa, 178 kPa, 163kPa and 175kPa when compacted with British Standard light (BSL), respectively.

3.1 Compaction Test Results

Table 3.1 presented the compaction test of lateritic soils sampled results at 100% natural state of maximum dry density (MDD), 1.755 KN/m³, 1.838KN/m³, 1.924 KN/m³, 1.865 KN/m³, and Optimum moisture content (OMC), 14.85%, 14.40%, 15.03% and 16.05%. Plantain rachis fibre + cement stabilized soils with 0.25% + 2.5%, 0.5% + 5.0%, 0.75% + 7.5% and 1.0% + 10% to soils percentage ratio inclusion maximum values of MDD are 2.215KN/m³, 2.335KN/m³, 2.505KN/m³, 2.486KN/m³ and OMC, 16.15%, 17.36%, 15.70% and 16.47%. Computed comparative results of un-stabilized and stabilized soils showed increased compaction parameters of maximum and optimum moisture content with increase to corresponding percentages inclusion as demonstrated graphically in figures 3.1 - 3.4.

3.2 California Bearing Ratio (CBR) Test

From preliminary investigation computed test results shown in table 3.1 at 100% lateritic soils, California bearing ratio test results values of unsoaked are 9.25%, 9.48%, 7.85% 8.65% and soaked are 7.40%, 8.05%, 6.65% and 6.65%. Fibre + cement stabilized results of the percentages inclusion in table 3.2, CBR maximum value of unsoaked are 78.35%, 69.85%, 83.20%, 62.80% and soaked 69.85%, 62.87%, 75.36% and 57.25%. Computed results illustrated increased values of both unsoaked and soaked California bearing ratio to

percentages ratio inclusion increase, with 0.75% + 7.5% optimum mix ratio to soils. Cracks and reductions in values were noticed beyond optimum.

3.3 Unconfined Compressive Strength Test

Investigated and computed results of unconfined compressive strength test at 100% lateritic soils of sampled roads are 168kPa, 178kPa, 163kPa and 175kPa. Results of fibre + cement stabilized lateritic soils are 505kPa, 488kPa, 528kPa and 436kPa. Results showed that fibre percentages ratio increase hoisted the values of unconfined compressive strength.

3.4 Consistency Limits Test

Table 3.1 presented computed results of consistency limits (Plastic index) properties of sampled soils at 100% natural state with the results as 17.11 %, 22.50%, 14.1 0% and 18.51%. Fibre stabilized samples plastic index properties maximum values are 15.45%, 16.94%, 20.90% and 12.88%. Results of fibre + cement stabilized lateritic soils showed decreased in plastic index as against un-stabilized.



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Location Description	OGOBOGOR	EGBEDA	IGWURUTA	ALETO ROAD						
	O ROAD	ROAD	ROAD	ELEME						
	OBIO/AKPOR	EMUOHA	IKWERE	L.G.A						
	L.G.A	L.G.A	L.G.A							
Depth of sampling (m)	1.5	1.5	1.5	1.5						
Percentage(%) passing BS	38.35	42.15	36.35	39.40						
sieve #200										
Colour	Reddish	Reddish Reddish		Reddish						
Specific gravity	2.59	2.78	2.77	15.35						
Natural moisture content (%)	22.6	19.48	10.95	15.35						
Consistency										
Liquid limit (%)	38.46	42.35	35.15	38.65						
Plastic limit (%)	21.35	19.85	21.05	20.14						
Plasticity Index	17.11	22.50	14.1 0	18.51						
AASHTO soil classification	A-2-4/SM	A-2-4/SM	A-2-4/SC	A-2-4/SC						
Unified Soil Classification										
System										
Optimum moisture content (%)	14.85	14.40	15.08	16.05						
Maximum dry density (kN/m ³⁾	1.755	1.883	1.924	1.865						
Gravel (%)	3.25	2.85	3.83	2.35						
Sand (%)	38.65	36.50	32.58	39.45						
Silt (%)	23.85	38.75	33.45	37.85						
Clay (%)	34.25	22.90	30.14	20.35						
Unconfined compressive	168	178	163	175						
strength (kPa)										
California Bearing Capacity (CBR)										
Unsoaked (%) CBR	9.25	9.48	7.85	8.65						
Soaked (%) CBR	7.40	8.05	6.65	6.93						

Table 3.1: Engineering Properties of Soil Samples

TABLE 3.2: RESULTS OF SUBGRADE SOIL (LATERITE) TEST STABILIZATION WITH BINDING CEMENTITIOUS PRODUCTS AT DIFFERENT PERCENTAGES AND COMBINATION

												_
SAMPLE	SOIL + FIBRE			R	(%						70	
LOCATION	PLANTAIN	3)		CB	R (°						I)	
	RACHIS	N/m	_	ED	CB					00	o / U ation	
	+	(kl	(%)	DAK	Œ	KPa			_	Е #2	HTC	S S
	CEMENT	DD	MC	NSC ()	AAC	CS(L(%	L(%	(%)]	ΙEV	ASH	110
		Σ	0	$\square $	Š	Ŋ	L	Ы	Ы	\mathbf{S}	A ()	Z
LATERITE + PLANTAIN RACHIS FIBRE (PRF) + CEMENT												
OGOBOGORO	100%	1.755	14.85	9.25	7.40	168	38.46	21.35	17.11	38.46	A-2-4/SM	POOR
ROAD	97.25+0.25+2.5%	1.808	15.15	46.35	39.75	265	38.96	22.11	16.85	38.46	A-2-4/SM	GOOD
OBIO/AKPOR	94.5+0.5+5.0%	1.925	15.45	56.35	49.38	335	39.75	23.40	16.35	38.46	A-2-4/SM	GOOD
L.G.A	91.75+0.75+7.5%	1.973	15.85	78.35	69.85	415	40.65	24.75	15.90	38.64	A -2-4/SM	GOOD
	89.9+1.0+10%	2.215	16.15	63.80	58.37	505	41.82	26.37	15.45	38.64	A -2-4/SM	GOOD
ALETO ROAD	100%	1.865	16.05	8.65	6.93	175	38.65	20.14	18.51	39.40	A -2- 4/SC	POOR
ELEME	97.25+0.25+2.5%	1.925	16.58	36.25	31.45	258	39.85	21.72	18.13	39.40	A -2- 4/SC	GOOD
L.G.A	94.5+0.5+5.0%	1.976	16.83	48.85	42.30	307	40.40	22.55	17.85	39.40	A-2-4 /SC	GOOD
	91.75+0.75+7.5%	2.118	17.08	69.85	62.87	375	40.85	23.50	17.32	39.40	A-2- 4/SC	GOOD
	89.9+1.0+10%	2.335	17.36	56.37	51.40	488	41.62	24.68	16.94	39.40	A-2- 4/SC	GOOD
EGBEDA	100%	1.883	14.40	9.48	8.05	178	42.35	19.85	22.50	42.15	A-2-4/SM	POOR
ROAD	97.25+0.25+2.5%	1.931	14.72	46.85	43.08	287	43.75	21.65	22.10	42.15	A-2-4/SM	GOOD
EMUOHA	94.5+0.5+5.0%	1.986	14.98	58.85	53.85	328	44.37	22.55	21.82	42.15	A-2-4/SM	GOOD
L.G.A	91.75+0.75+7.5%	2.205	15.37	83.20	75.36	418	44.93	23.58	21.35	42.15	A-2-4/SM	GOOD
	89.9+1.0+10%	2.505	15.70	77.75	68.33	528	45.35	24.45	20.90	42.15	A-2-4/SM	GOOD
IGWURUTA	100%	1.924	15.08	7.85	6.65	168	35.15	21.05	14.10	36.35	A -2- 4/SC	POOR
ROAD	97.25+0.25+2.5%	2.083	15.47	30.85	28.38	225	35.62	21.81	13.81	36.35	A -2- 4/SC	GOOD
IKWERE	94.5+0.5+5.0%	2.226	15.93	43.45	39.60	301	36.08	22.51	13.57	36.35	A -2- 4/SC	GOOD
L.G.A	91.75+0.75+7.5%	2.450	16.18	62.80	57.25	395	36.75	23.52	13.23	36.35	A-2-4/SC	GOOD
	89.9+1.0+10%	2.486	16.47	55.80	52.30	436	37.18	24.30	12.88	36.35	A-2-4/SC	GOOD



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



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



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



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





of (Ogbogoro, Aleto, Egbeda and Igwuruta Towns) all in Rivers State

4.0 Conclusions

The following conclusions were made from the experimental research results.

- i. Soils are classified as A-2-6 SC and A-2-4 SM on the AASHTO classification schemes / Unified Soil Classification System.
- ii. Comparatively, results showed decreased values of MDD and increased values of OMC with relating values to percentages ratio fibre inclusion.
- iii. Computed comparative results of un-stabilized and stabilized soils showed increased compaction parameters of maximum and optimum moisture content with increase to corresponding percentages inclusion as demonstrated graphically in figures 3.1 3.4.
- iv. Computed results illustrated increased values of both unsoaked and soaked California bearing ratio to percentages ratio inclusion increase, with 0.75% + 7.5% optimum mix ratio to soils. Cracks and reductions in values were noticed beyond optimum.
- v. Results showed that fibre percentages ratio increase hoisted the values of unconfined compressive strength.
- vi. Results of fibre + cement stabilized lateritic soils showed decreased in plastic index as against unstabilized.

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