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EVALUATION OF PLANTAIN RACHIS FIBRE AND LIME STABILIZED SOFT CLAY SOILS AS HIGHWAY PAVEMENT MATERIAL.

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ABSTRACT

The research work investigated the complementation of Deltaic problematic soft clay soils with stabilizer from waste agricultural products of plantain rachis fibre + lime in combined action to improve their strength for the purpose of road embankment materials. Preliminary investigations as shown in table 3.1 confirmed soils as poor and unfit for such purpose except stabilized. Comparatively, results shown in table 3.1 and 3.2 on compaction test parameters indicated increased values of maximum dry density (MDD) and optimum moisture content (OMC) relatively with percentage inclusion increase. In contrast to results of tables 3.1 and 3.2, stabilized clay soils California bearing ratio of unsoaked and soaked values increased with respect to composite materials of plantain rachis fibre + lime percentile ratio with optimum percentage of 0.75% + 7.5%. Cracks and values reduction were confirmed outside optimum percentile. Final comparative results as shown in tables 3.1 and 3.2 indicated that stabilized clay soils unconfined compressive strength test increased relatively to additives inclusion percentile ratio increase. Results as shown in table 3.1 and figure 3.1 - 3.4 showed decreased values of plastic index relatively to percentile ratio increase. The entire results showed good potential of using plantain rachis fibre ash + lime as soil stabilizer.

Key Words: Clay, Plantain Rachis Fibre, Lime, CBR, UCS, Consistency, Compaction

1.0 Introduction

Niger Delta clay soils do not conform to the widely reported parent-rock-related gradation trend common to other lateritic soils (Ola 1[1]; Lohnes, Fish, and Daniel [2]; Tuncer and Lohnes [3]; Akpokodje [4]; Omotosho [5]; Leton and Omotosho [6]). They are, however, the most suitable and most widely used soil materials for road earthworks in the entire Niger Delta (Arumala and Akpokodje, [7]). Except in very rare and exceptional cases, soils (including deltaic lateritic soils) in their natural states hardly possess characteristics suitable for desired engineering applications, particularly for road works. The minimum requirements for soils or soil-based materials usable in road pavement structures have been indicated by the FMW Specifications [8].

Charles *et al.*[9] 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 strength the failed section of the road. Results obtained of compaction test of Optimum moisture content (OMC) and maximum dry density (MDD) of clay soils cement bush sugarcane bagasse fibre (BSBF) reinforced soils at combined actions to soil ratios of 3.75% 0.25%, 5.5% 0.5%, 7.25% 0.75% and 9% 1.0% of cement and BSBF combined percentages.

Charles *et al.* [10] investigated the susceptible to pavement degradation resulted in very many failures, potholes and cracks along the stretches of Odioku road, Ahoada West, Rivers State. Stabilizers were used in single and combined actions to determine the suitability of the composite material that will solve these problems. Treated soils with Lime decreased in liquid limits and increased in plastic limits. At 8% of lime, CBR values reached optimum, beyond this range, cracks exist and 7.5% lime + 0. 75% BSBF, optimum value are reached.

Mesbah *et al.* [11] carried out tensile tests on soil specimens reinforced with sisal fibres and concluded that the fibres, length and their tensile strength are the most important factors affecting the tensile strength of the soil composite.

2.0 Materials and Methods

2.1 Materials

2.1.1 Soil

The soils used for the study were collected from Ebiriba Town Road, in Ahoada-West Local Government, Ochigba Town Road, in Ahoada-East Local Government Area, Eneka Town Road, in Obio/Akpor Local Government Area and IsiokpoTown Road, in Ikwerre 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 Lime

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

2.2 Method

2.2.1 Sampling Locality

The soil sample used in this study were collected along Ebiriba Town, (latitude 5.10° 31'N and longitude 6.38° 8'E), Ochigba a Town, (latitude 5.1° 30'N and longitude 6.35° 55'E), Eneka Town, latitude 4.90° 28'N and

longitude 7.03° 15'E), and Isiokpo Town, latitude 5.05° 41'N and longitude 6.92° 33'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 [12]; Allam and Sridharan [13]; Omotosho and Akinmusuru [14]; Omotosho [15]. The soils are reddish brown and dark grey in colour (from wet to dry states) plasticity index of 28.55%, 25.97%, 33.50%, and 28.40% respectively for Ebiriba, Ochigba, Eneka and Isiokpo Town Roads. The soil has unsoaked CBR values of 6.38%, 7.75%, 8.24% and 7.85%, and soaked CBR values of 5.25%, 6.03%, 6.35% and 6.30%, unconfined compressive strength (UCS) values of 68.85kPa, 77.35kPa, 79.85kPa and 65.57kPa when compacted with British Standard light (BSL), respectively.

3.1 Compaction Test Results

Preliminary test evaluation on the sampled roads test at zero percentage clay soils compaction test parameters of maximum dry density (MDD) values are 1.685 KN/m³, 1.705 KN/m³, 1.663 KN/m³, 1.605 KN/m³ and optimum moisture content (OMC) 16.38%, 17.45%, 16.75% and 15.87%. Stabilized clay soils with plantain rachis fibre + lime at 0.25% + 2.5%, 0.5% + 5.0%, 0.75% + 7.5% and 1.0% + 10% produced crest values of maximum dry density (MDD) values are 1.782KN/m³, 1.792KN/m³, 1.746KN/m³, 1.693KN/m³ and optimum moisture content (OMC) 18.33%, 19.32%, 18.23% and 17.42%. Comparatively, results shown in table 3.1 and 3.2 on compaction test parameters indicated increased values of maximum dry density (MDD) and optimum moisture content (OMC) relative to percentage inclusion increase.

3.2 California Bearing Ratio (CBR) Test

Results shown in table 3.1 of California bearing ration (CBR) of clay soils at zero percentage additives are unsoaked 6.38%, 7.75%, 8.24% and 7.85%, and soaked 5.25%, 6.03%, 6.35% and 6.30%. Modified clay soils with additives of plantain rachis fibre + lime as shown in table 3.1 yielded peak values of California bearing ratio (CBR) unsoaked values of 53.15%, 55.15%, 58.25%, 57.85%, and soaked 49.40%, 49.58%, 56.15% and 55.42%. In contrast to results of tables 3.1 and 3.2, stabilized clay soils California bearing ratio of unsoaked and soaked values increased with respect to composite materials of plantain rachis fibre + lime percentile ratio with optimum percentage of 0.75% + 7.5%. Cracks and values reduction were confirmed outside optimum percentile.

3.3 Unconfined Compressive Strength Test

Preliminary test conducted on clay soils of sampled roads at 100% natural soils of unconfined compressive strength test are 68.85kPa, 77.35kPa, 79.85kPa and 65.57kPa. Stabilized clay soils with stabilizer shown in table 3.1 yielded crest values 4655kPa, 471kPa, 509kPa and 423kPa.Final comparative results as shown in

tables 3.1 and 3.2 indicated that stabilized clay soils unconfined compressive strength test increased relatively to additives inclusion percentile ratio increase.

3.4 Consistency Limits Test

Results shown in table 3.1 of clay soils consistency limits test (Plastic index) value at zero percentage additives are 28.55%, 25.97%, 33.50%, and 28.40%. Stabilized clay soils yielded values as 27.75%, 28.45%, 37.53%b and 27.27%. Results as shown in table 3.1 and figure 3.1 - 3.4 showed decreased values of plastic index relatively to percentile ratio increase.

Lessier Description	Ebiriba Dood	Oshigha Boad	- Enaka Doad	Isiokno Bood Ikusarra						
Location Description	Aboodo West	Aboodo Foot	Obio/Almon							
		Anoada East		L.G.A						
	L.G.A	L.G.A	L.G.A	1.0						
Depth of sampling (m)	1.0	1.0	1.0	1.0						
Percentage(%) passing BS sieve	75.55	75.05	82.85	69.55						
#200										
Colour	Greyish /black	Grey	Greyish	Greyish						
Specific gravity	2.45	2.68	2.62	2.48						
Natural moisture content (%)	47.36	43.85	47.80	48.15						
Consistency limits										
Liquid limit (%)	57.30	56.35	63.30	57.75						
Plastic limit (%)	28.75	30.38	29.80	29.35						
Plasticity Index	28.55	25.97	33.50	28.40						
AASHTO soil classification	A-7-6/CH	A-7-6/CH	A-7-6/CH	A-7-6/CH						
Unified Soil Classification System										
Compaction characteristics										
	16.20	17.45	1675	15.07						
Optimum moisture content (%)	16.38	17.45	16.75	15.87						
Maximum dry density (kN/m ³⁾	1.685	1.705	1.663							
Grain size distribution										
Gravel (%)	0	0	0	0						
Sand (%)	16.25	12.35	12.80 14.35							
Silt (%)	43.83	39.85	41.85	42.35						
Clay (%)	39.92	46.80	45.35	56.70						
Unconfined compressive strength (kPa)	68.85	68.85 77.35 79.85								
California Bearing Capacity (CBR)										
Unsoaked (%) CBR	6.38	7.75	8.24	7.85						
Soaked (%) CBR	5.25	6.03	6.35	6.30						

Table 3.1: Engineering Properties of Soil Samples

SAMPLE	SOIL + FIBRE				- 1							
LOCATION	PLANTAIN	m ³⁾		Q	CBR					0	(uoi)	
	RACHIS + LIME	kN/	(%) KE	ğ	Pa)				#20	O/	
		Ō	C ()	40%) %)	KE	Σ.	(%	(%	()	ΛE	SHT SSif	IES
		ΠD	MC	CBR	SO^ %)	CC	TT(JL(9	%)Ic	SIE	AA.S USC Cla	LON VO
CLAY SOIL + PLATAIN RACHIS FIBRE ASH (PRF)+ LIME												
EBIRIBA	100%	1.685	16.38	6.38	5.25	68.85	57.30	28.75	28.55	79.55	A – 7 – 6/CH	POOR
ROAD	97.25+0.25+2.5%	1.691	16.78	28.45	24.30	98	57.30	28.75	28.55	59.55	A – 7 – 6/CH	GOOD
AHOADA	94.5+0.5+5.0%	1.715	17.43	39.80	37.78	235	58.28	30.16	28.12	59.55	A – 7 – 6/CH	GOOD
WEST L.G.A	91.75+0.75+7.5%	1.756	17.90	53.15	49.40	378	58.56	30.62	27.94	59.55	A – 7 – 6/CH	GOOD
	89+1.0+10%	1.782	18.33	46.18	42.85	465	58.74	30.99	27.75	59.55	A – 7 – 6/CH	GOOD
OCHIGBA	100%	1.705	17.45	7.75	6.03	77.35	56.35	30.38	25.97	75.05	A – 7 – 6/CH	POOR
ROAD	97.25+0.25+2.5%	1.725	17.86	28.95	26.05	115	56.78	27.44	29.34	75.05	A – 7 – 6/CH	GOOD
AHOADA	94.5+0.5+5.0%	1.744	18.40	42.35	39.53	248	56.99	27.95	29.04	75.05	A – 7 – 6/CH	GOOD
EAST L.G.A	91.75+0.75+7.5%	1.761	18.93	55.15	49.58	383	57.28	28.43	28.85	75.05	A – 7 – 6/CH	GOOD
	89+1.0+10%	1.792	19.32	47.45	44.85	471	57.57	29.12	28.45	75.05	A – 7 – 6/CH	GOOD
ENEKA	100%	1.663	16.75	8.24	6.35	79.85	63.30	29.80	38.50	82.85	A – 7 – 6/CH	POOR
ROAD	97.25+0.25+2.5%	1.678	17.28	34.60	31.48	128	63.65	25.34	38.31	82.85	A – 7 – 6/CH	GOOD
OBIO/AKPO	94.5+0.5+5.0%	1.693	17.56	41.45	38.65	267	63.92	25.84	38.08	82.85	A – 7 – 6/CH	GOOD
R L.G.A	91.75+0.75+7.5%	1.715	17.89	58.25	56.15	415	64.25	26.39	37.86	82.85	A – 7 – 6/CH	GOOD
	89+1.0+10%	1.746	18.23	47.38	45.55	509	64.65	27.12	37.53	82.85	A – 7 – 6/CH	GOOD
ISIOKPO	100%	1.605	15.87	7.85	6.30	65.75	57.75	29.35	28.40	69.55	A – 7 – 6/CH	POOR
ROAD	97.25+0.25+2.5%	1.635	16.24	25.45	23.63	195	57.85	29.69	28.16	69.55	A – 7 – 6/CH	GOOD
IKWERRE	94.5+0.5+5.0%	1.658	16.73	39.65	37.26	218	58.18	30.25	27.93	69.55	A – 7 – 6/CH	GOOD
L.G.A	91.75+0.75+7.5%	1.671	17.15	55.42	53.16	338	58.45	30.80	27.65	69.55	A – 7 – 6/CH	GOOD
	89+1.0+10%	1.693	17.42	49.15	44.35	423	58.81	31.54	27.27	69.55	A – 7 – 6/CH	GOOD

 Table 3.2: Results of Subgrade Soil (Clay) Test Stabilization with Binding Cementitious Products at Different

 Percentages and Combination



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



Figure 3.2: Subgrade Stabilization Test of Clay Soil from Ochigba in Ahoada - East L.G.A of Rivers State with PRF + Lime at Different Percentages and Combination



Figure 3.3: Subgrade Stabilization Test of Clay Soil from Eneka in Obio/Akpor L.G.A of Rivers State with PRF + Lime at Different Percentages and Combination



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



Figure 3.5: Unconfined Compressive Strength (UCS) of Niger Deltaic Clay Soils Subgrade with PRF + Lime of (Ebiriba, Ochigba, Eneka and Isiokpo Towns) all in Rivers State

4.0 Conclusions

The following conclusions were made from the experimental research results.

- i. Soils are classified as A-7-6/CH on the AASHTO classification schemes / Unified Soil Classification System.
- Comparatively, results shown in table 3.1 and 3.2 on compaction test parameters indicated increased values of maximum dry density (MDD) and optimum moisture content (OMC) relatively to percentage inclusion increase.
- iii. In contrast to results of tables 3.1 and 3.2, stabilized clay soils California bearing ratio of unsoaked and soaked values increased with respect to composite materials of plantain rachis fibre + lime percentile ratio with optimum percentage of 0.75% + 7.5%. Cracks and values reduction were confirmed outside optimum percentile.
- iv. Final comparative results as shown in tables 3.1 and 3.2 indicated that stabilized clay soils unconfined compressive strength test increased relatively to additives inclusion percentile ratio increase.
- v. Results as shown in table 3.1 and figure 3.1 3.4 showed decreased values of plastic index relatively to percentile ratio increase.

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