Global Scientific JOURNALS

GSJ: Volume 8, Issue 2, February 2020, Online: ISSN 2320-9186
www.globalscientificjournal.com

Expansive Soils Modification using Bagasse Fibre Ash and Cement

Essien Udo[1], Apeh Ocholi Adejoh Samuel[2], Charles Kennedy[3]

[1]Department of Civil Engineering, University of Uyo, Nigeria.
[2]Department of Civil Engineering, Federal Polytechnic, Idah, Kogi State, Nigeria.
[3]Department of Civil Engineering, Faculty of Engineering, Rivers State University, Port Harcourt - Rivers State, Nigeria
Authors E-mail: [1]essienau2006@yahoo.com, [2]engrsamapeh@gmail.com, [3]ken_charl@yahoo.co.uk,.

ABSTRACT

The study appraised the employment of bagasse fibre ash of Costaceae Lacerus and cement unification in the stabilization of expansive clay soils of Ogoda, Bodo, Ogbogu, Ula-Ikata, and Kaani roads in Rivers State, Niger Delta of Nigeria with unique attributes that fell below the minimum requirement for such application and needs stabilization to improve its properties. The soils are classified as A – 7 – 6 on the AASHTO Classification System, dark grey (from wet to dry states), plasticity index properties of 20.33%, 20.35%, 21.85%, 26.30%, and 21.35% respectively. Compaction results exemplified increased values of MDD and OMC with percentage ratio inclusion of 2.5% + 2.5% (costaceae lacerus bagasse fibre ash (CLBFA) + cement to soil ratio. Results obtained showed an increase in UCS with an increase in fibre percentages to soil corresponding ratio. Proportional results showed an increased in CBR values with an increase in bagasse fibre percentages to a peak ratio of 7.5% + 7.5% to soil ratio for both unsoaked and soaked. Failure was noticed beyond peak ratio inclusion with presence of cracks and value reductions. Results obtained showed a decrease in plastic index properties with an increase in percentage ratio inclusions. The entire results showed the potential of using CLBFA + cement as admixtures in the treatment of clay soils of expansive nature.

Key Words: Clay soils,* costaceae lacerus bagasse fibre ash, cement, *CBR, UCS, Consistency, Compaction

1.0 INTRODUCTION

A variety of stabilizers have been used as soil additives to improve its engineering properties. Many stabilizers, such as lime, cement and fly ash, depend on their chemical reactions with soil elements in the presence of water (Azadegan et al. 2012; Mallella et al. 2004). Other additives, such as geofiber and geogrid, rely on their physical effects to improve soil properties (Alawaji, 2001; Viswanadham et al. 2009). Additionally, it can be combined with both chemical and physical stabilization, for example, by using lime and geofiber or geotextile together (Yang et al.

2012; Chong and Qasim, 2014). Lime is the oldest traditional chemical stabilizer used for soil stabilization (Mallela et al. 2004). However, soil stabilization using lime has advantages and disadvantages. Cement Stabilization refers to stabilizing soils with Portland cement. Cement stabilization is an important method for stabilization. It has proven very effective in sandy soil due to the ease of pulverization and mixing and the low amount of cement. The initial reaction leads to the formation of cementitious material with water in the soil. Soil stabilization is the modification of geotechnical properties to meet engineering requirements (Atoh-Okin, 1995). Soil stabilization has proven to be very economical as it provides cheaper materials for building low-cost roads. Local materials can be used effectively. There are several methods of soil stabilization.

Charles *et al.* (2018) investigated and evaluated the engineering properties of an expansive lateritic soil with the inclusion of cement/lime and costus afer bagasse fibre ash (locally known as bush sugarcane fibre ash (BSBFA) with ratios of laterite to cement, lime, and BSBFA of 2.5% 2.5%, 5.0% 5.0%, 7.5% 7.5% and 10% 10% to improve the values of CBR. At 8% in both cement and lime, the CBR reached the optimum value, beyond this range, there were cracks, and 7.5% cement and lime reached 7.5% BSBFA, and 7.25% cement and lime 0.7.5% BSBF, respectively. Overall the results showed the potential of using Bagasse, BSBFA as a composite in cement and lime treated lateritic soil.

Sabat (2012) studied the effects of polypropylene fiber on the engineering properties of RHA-lime stabilized expansive soils. The added polypropylene fiber ranges from 0.5% to 2% for a 0.5% increase. Determined characteristics Compaction, UCS, soaked CBR, hydraulic conductivity and P effect of 0 days, 7 days and 28-day curing luggage were also studied in UCS, soaked CBR, hydraulic conductivity and swelling pressure. Soil: RHA: Lime: The optimum ratio of fiber was found to be 84.5: 10: 4: 1.5.

Charles et al. (2018) evaluated the geotechnical characteristics of measureless/ expandable clay soils along the Odioku-Odiereke road in Ahoada-West in the Rivers State of the Niger Deltaic Region. Utilization of two cementitious binders of cement and lime hybridized with castor costus afer bagasse fiber to stabilize the failing part of the road. Previous research has confirmed that the soils are particularly plastic. The use of Bagasse, BSBF in mixed soils in cement and lime modified soils of clay and laterite with maximum ratio values of 8% cement and lime and 7.5% + 7.5% cement/lime + BSBF was confirmed.

Barisua et al. (2018) evaluated the achievable strength of clay soils spreading with swelling - shrinkage characteristic on the addition of two cementitious stabilized binding agents of cement and lime in a mix with Bagasse fiber of agricultural products of costaceae lacerus. The results validated incremental percentage CBR values for both un-soaked and soaked, with a top to the bottom mixed ratio of 0.75% + 7.5% for the soil corresponding to the soil. Unconfined compressive test holds incremental percentage values with composite ratios extending with cement/lime + CLBFA.

Terence et al. (2018) examined and evaluated the use of costaceae lacerus bagasse fibre ash in combination with cement and lime in various composite ratio percentages and confirmed the differences in strength. The results show that additives can work as soil stabilizers with cement in limestone at dominant higher values. The California bearing ratio of unsoaked and soaked stabilized soils with cement, lime and CLBFA composites yielded tremendously increasing percentage values to include percentage ratio variations with an appropriate mixing ratio of 85 + 7.5 + 7.5%. Unspecified compressive strength test results for un-stabilized and stabilized soils with cement/lime + CLBFA showed increasing percentage values as the ratio of parts to soil increases.

Charles et al. (2018) evaluate the utility of cementitious stabilizing binding agents of cement/lime and banana rachis fiber ash in composite operations and comparatively determine their productivity difference for soil change. Constant limitations check effects confirmed a decrease in the percentage of plastic index properties. Stabilized clay soils unconfined compressive strength test results confirmed the incorporation of composite materials into the soil greater than lime with the composition of cement, which confirms the incredible percentage values for the percentage ratio. The results show that the incorporation of composite materials into clay soils enhances the compressive properties of clay soils. The California Bearing Ratio (CBR) showed increasing percentage values of PRFA addition to the soaked cementitious binder from soaked and clay soils, leading to higher percentage values on cement with mix ratio 85 + 7.5 + 7.5%.

Charles et al. (2018) examined the effect of hybridization on Irvinga gabonensis fiber ash and cement composite materials in the modification of abundant clay soils found in the Iwofe, Chokocho, Ndoni, and Ogbele urban roads in the Niger Delta neighborhood of the South-South of Nigeria. Experimental effects confirmed the high values in the compressive testing parameters of the analyzed MDD and OMC, with the percentage ratio to soil soils with the increase of additives. The results of the immobilized and immobilized CBR results show that by adding the multiplied values for the respective percentages to the soil ratio of 7.5% + 7.5%. Comparative effects are enhanced in the unconfined compressive strength of stabilized clay soils concerning percentages. Overall results confirm the use of Irvinga gabonensis fiber (bush mango) ash and cement as soil stabilizer products.

Letam et al. (2018) Estimated the failure trend of susceptibility associated with sampling roads of Ebiriba, Ochigba, Eneka, and Isiokpo in Niger Delta, Nigeria, with the use of banana rachis fiber ash + lime as a soil stabilizer to strengthen failed sections. Comparatively, the results of compressive inspection parameters indicate the fastest values of maximum dry density and optimum humidity with respect to the ratio accumulation increase. Contrary to the results, the stabilized clay soils were found to be composite materials of the Banana Rockies Fiber + Lime Percentage ratio with an optimal ratio of 0.75% + 7.5% of the unsoaked and soaked values of the California bearing ratio. Comparative effects showed decreased values of the plastic index with admire to components inclusion percentages. The whole outcomes showed the true workable of using plantain rachis fibre ash + lime as the soil stabilize

Ramakrishna and Pradeep (2006) 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.

Sharma et al., (2008) investigated the behavior of abundant clays stabilized with lime, calcium chloride and RHA. The optimum percentage of lime and calcium chloride in the stabilization of abundant soil without the inclusion of RHA was found to be 4% and 1%, respectively. From the UCS and CBR perspective, when soil is mixed with lime or calcium chloride, the 12% RHA content is found to be optimum. In abundant soil - RHA compounds, 4% lime and 1% calcium chloride are also found to be the optimum.

2.0 MATERIALS AND METHODS

2.1 Materials

2.1.1 Soil

The soils used for the study were collected from Ogoda Town Road, Ubie, Districts of Ekpeye, Ahoada-East and Ahoada-West Local Government Area, Bodo Town Road, Gokana Local Government Area, Ogbogu Town Road, Egbema/Ndoni/Egbema Local Government Area, Ula-

Ikata Town Road, Ahoada-East Local Government area, and Kaani Town Road, Khana Local Government Area, all of Rivers State, Niger Delta, Nigeria.

2.1.2 Costaceae Lacerus Bagasse Fibre Ash

The Costaceae Lacerus bagasse fibre is widely used in localized areas, rich in Rivers State agricultural lands/shrubs, covering large areas, collected from the Oyigba Town Farmland / Bush, Ubie Clan, Ahoda-West, Rivers State, Nigeria.

2.1.3 Cement

The used cement was purchased from the open market, Port Harcourt, Rivers State.

2.2 METHOD

2.2.1 Sample Area

The soil sample used in this study was Ogoda Town, (latitude 5.04 ° 59'S and longitude 6.38 ° 42'E), Bodo Town, (latitude 4.65 ° 05'S and longitude 7.27 ° 15'E), Ogbogu Town, latitude 5.13 ° 08'S and longitude 6.33 ° 25'E), U [a-Ikata Town, (Latitude 5.95 ° 45'S and Longitude 6.66 ° 13'E) and Kani Town, Latitude 4.67 ° 13'S and Longitude 6.81 ° 55'E) All in Rivers State, Nigeria.

2.2.2 Test Conducted

Conducted 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;

2.2.3 Moisture Content Determination

The natural moisture content of the soil obtained from the site was determined per 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.

2.2.4 Grain Size Analysis (Sieve Analysis)

Mechanical or sieve analysis is performed to determine the distribution of coarse, large-sized particles. This test is done to determine the percentage of different grain sizes present in the soil

2.2.5 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.

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 compaction effort.

2.2.7 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 unspecified compressive strength, which is then used to calculate the unified untreated shear strength of the soil under non-compressible conditions

2.2.8 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.

3.0 RESULTS AND DISCUSSIONS

The soils classified as A – 7 – 6 on the AASHTO 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 1974; Allam and Sridharan 1981; Omotosho and Akinmusuru 1992; Omotosho 1993). Preliminary results on clay 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 need stabilization to improve its properties. The soils are reddish-brown and dark grey in color (from wet to dry states) plasticity index of 20.33%, 20.35%, 21.85%, 26.30%, and 21.35% respectively for Ogoda, Bodo, Ogbogu, Ula-Ikata, Kaani Town Roads. The soil has unsoaked CBR values of 8.58%,8.83%, 8.05%, 7.38%, and 9.05% and soaked CBR values of 6.33%, 7.15%, 7.35%, 5.9% and 8.23 %, unconfined compressive strength (UCS) values of 58.85kPa , 63.35kPa, 57.75kPa , 53.75kPa and 63.85kPa when compacted with British Standard light (BSL), respectively.

3.1 Compaction Test Results

The results of clay soils at 100% of maximum dry density (MDD) at preliminary test are 1.875KN/m3, 1.923KN/m3, 1.823KN/m3, 1.795KN/m3, 1.985KN/m3 representing percentile values of 96.92%, 98.82%, 98.75%, 98.36%, 99.35% and Optimum moisture content (OMC) as 15.68%, 14.93%, 16.30%, 17.45% and 15.35% with percentile values of 98.18%, 97.90%, 98.25%, 97.92%, 97.77%. For treated clay soils with costaceae lacerus bagasse fibre ash (CLBFA) + cement, obtained maximum values are 1.938KN/m3, 2.105KN/m3, 1.935KN/m3, 1.910KN/m3, 2.555KN/m3 representing percentile peak values rise of 106.19%, 109.46%, 106.14%, 106.47%, 128.72% of MDD. Stabilized soils OMC values are 16.87%, 16.15%, 17.38%, 18.83%, 16.47% with percentile values rise 107.59%, 108.17%, 106.63%, 107.91%, 107.30%. Results exemplified increased values of MDD and OMC with percentage ratio inclusion of 2.5% + 2.5% (costaceae lacerus bagasse fibre ash (CLBFA) + cement to soil ratio.

3.2 California Bearing Ratio (CBR) Test

Results of CBR at preliminary investigation of sampled roads are 8.58%, 8.83%, 8.05%, 7.38% and 9.05% (unsoaked) with percentile values of 36.11%, 31.15%, 30.17%, 31.54%, 32.04% and 6.33%, 7.15%, 7.35%, 5.9% and 8.23 % (soaked) with percentile values of 33.58%, 27.21%, 30.12%, 30.97%, 31.00% at 100% natural state. Stabilized clay soils values of 2.5% + 2.5% (costaceae lacerus bagasse fibre ash (CLBFA) + cement to soil ratio treated samples peak values before failure are 16.55%, 53.30%, 49.75%, 45.80%, and 57.30% (Unsoaked) with peak percentile values of 498.83%, 603.62%, 603.03%, 620.60%, 633.15% while soaked are 42.80%, 49.71%, 47.25%, 40.60%, and 56.35% with percentile values of 598.26%, 695.25%, 642.86%, 688.14%, 684.69%. Obtained test results confirmed increased CBR values with increase in additives percentages to soil with peak ratio of 7.7% +7.5% to soil for both unsoake and soaked. Failure was noticed beyond peak ratio inclusion with presence of cracks and value reductions.

3.3 Unconfined Compressive Strength Test

Results obtained of clay soils at preliminary engineering soil properties for the sampled roads are 58.85kPa, 63.35kPa, 57.75kPa, 53.75kPa, and 63.85kPa at 100% soils with percentile values of 56.05%, 56.56%, 42.78%, 46.74%, and 47.65%. Reinforced clay soils unconfined compressive strength test (UCS) obtained represented in figure 3.5 are 374kPa, 308kPa, 368kPa, 335kPa and 388kPa with incremental percentile peak values of 635.51%, 486.19%, 637.23%, 623.26%, 607.67%. Results showed an increased in UCS values with corresponding percentage inclusions.

3.4 Consistency Limits Test

Results of consistency limits (plastic index) properties at 100% soils are 20.33%, 20.35%, 21.85%, 26.30% and 21.35%. Reinforced clay soils plastic index properties are 18.26%, 19.30%, 19.82%, 17.05% and 18.97%. obtained percentile values of 100% natural and reinforced states are

102.52%, 102.52%, 105.30%, 101.39%, 101.50% and 89.82%, 92.78%, 90.71%, 93.17%, 93.22%. Results obtained showed decreased in plastic index properties with increase in percentage ratio inclusions.

Table 3.1: Engineering Properties of Soil Samples

LOCATION DESCRIPTION	OGODA TOWN ROAD, AHOADA-WEST L.G.A RIVERS STATE	BODO TOWN ROAD ,GOKANA L.G.A RIVERS STATE	OGBOGU TOWN-ROAD, OGBA/EGBEMA NDONI L.G.A RIVERS STATE	ULA-IKATA TOWN ROAD, AHOADA-BEMA EAST L.G.A RIVERS STATE	KAANI TOWN ROAD, KHANNA L.G.A RIVERS STATE
Depth of sampling (m)	1.5	1.5	1.5	1.5	1.5
Percentage(%) passing BS sieve #200	73.85	67.38	76.35	82.35	71.55
Colour	Grey	Grey	Grey	Grey	Grey
Specific gravity	2.71	2.68	**2.63**	2.63	2.71
Natural moisture content (%)	46.25	45.38	45.86	49.30	46.85
Consistency Limits					
Liquid limit (%)	58.85	59.45	58.35	56.67	48.25
Plastic limit (%)	38.52	39.10	37.50	30.37	24.90
Plasticity Index	20.33	20.35	21.85	26.30	21.35
AASHTO soil classification Unified Soil Classification System	A – 7 – 6	A – 7 – 6	A – 7 – 6	A – 7 – 6	A – 7 – 6
Optimum moisture content (%)	15.68	14.93	16.30	17.45	15.35
Maximum dry density (kN/m$^{3)}$	1.875	1.923	1.823	1.795	1.9.85
Gravel (%)	1.85	0.85	2.45	0.53	1.95
Sand (%)	12.35	11.08	9.75	7.34	13.25
Silt (%)	52.35	47.35	47.85	53.68	48.25
Clay (%)	33.45	40.72	39.95	38.45	36.55
Unconfined compressive strength (kPa)	58.85	63.35	57.75	53.75	63.85
California Bearing Capacity (CBR)					
Unsoaked (%) CBR	8.58	8.83	8.05	7.38	9.05
Soaked (%) CBR	6.33	7.15	7.35	5.9	8.23

Table 3.2: Properties of Coataceae Lacerus bagasse fibre. (University of Uyo, Chemical Engineering Department, Material Lab.1)

PROPERTY	VALUE
Fibre form	Single
Average length (mm)	400
Average diameter (mm)	0.86
Tensile strength (MPa)	68 - 33
Modulus of elasticity (GPa)	1.5 – 0.54
Specific weight (g/cm^3)	0.69
Natural moisture content (%)	6.3
Water absorption (%)	178 - 256

Source, 2018

Table 3.3: Composition of Bagasse. (University of Uyo, Chemical Engineering Department, Material Lab.1)

ITEM	%
Moisture	49.0
Soluble Solids	2.3
Fiber	48.7
Cellulose	41.8
Hemicelluloses	28
Lignin	21.8

Source, 2018	

Table 3.4: Results of Subgrade Soil (Clay) Test Stabilization with Binding Cementitious Products at Different percentages and Combination

SAMPLE LOCATION	SOIL + FIBRE BAGASE ASH + CEMENT	MDD (kN/m^3)	OMC (%)	UNSOAKED CBR (%)	SOAKED CBR (%)	UCS(KPa)	LL(%)	PL(%)	PI(%)	SIEVE #200	AASHTO (Classification)	NOTES
	SOFT CLAY +COSTACEAE LACERUS BAGASSE FIBRE ASH(CLBFA) + CEMENT											
OGODA TOWN ROAD, AHODA WEST.L.G.A	100%	1.825	15.68	8.58	6.33	58.85	58.85	38.52	20.33	75.85	A-7-6	POOR
	95 + 2.5 + 2.5%	1.883	15.97	23.76	18.85	105	60.45	40.62	19.83	73.85	A-7-6	GOOD
	90 + 5.5 + 5.5%	1.897	16.15	31.35	28.31	215	60.86	41.42	19.44	73.85	A-7-6	GOOD
	85 + 7.5 + 7.5%	1.916	16.55	42.80	37.87	296	61.25	42.60	18.65	73.85	A-7-6	GOOD
	80 + 10 + 10%	1.938	16.87	36.85	32.55	374	62.87	44.61	18.26	73.85	A-7-6	GOOD
BODO TOWN ROAD GOKANA. L.G.A	100%	1.923	14.93	8.83	7.15	63.35	59.45	39.10	20.35	67.35	A-7-6	POOR
	95 + 2.5 + 2.5%	1.946	15.25	28.35	26.28	112	61.35	41.50	19.85	67.35	A-7-6	GOOD
	90 + 5.5 + 5.5%	1.975	15.69	46.23	41.35	187	61.86	42.03	19.38	67.38	A-7-6	GOOD
	85 + 7.5 + 7.5%	1.997	15.93	53.30	49.71	235	62.20	43.87	19.30	67.38	A-7-6	GOOD
	80 + 10 + 10%	2.105	16.15	48.36	39.30	308	62.65	43.77	18.88	67.38	A-7-6	GOOD
OGBOGU TOWN ROAD OGBA/EGBEM A/NDONI L.G.A	100%	1.823	16.30	8.25	7.35	57.75	58.35	37.50	21.85	76.35	A-7-6	POOR
	95 + 2.5 + 2.5%	1.846	16.59	27.35	24.40	135	59.85	39.10	20.75	76.35	A-7-6	GOOD
	90 + 5.5 + 5.5%	1.875	16.83	34.30	29.88	224	60.18	39.82	20.36	76.35	A-7-6	GOOD
	85 + 7.5 + 7.5%	1.897	17.05	49.75	47.25	298	60.66	40.63	20.03	76.35	A-7-6	GOOD
	80 + 10 + 10%	1.935	17.38	37.37	32.35	368	60.97	41.15	19.82	76.35	A-7-6	GOOD
ULA-IKATA TOWN ROAD AHODA EAST L.G.A	100%	1.794	17.45	7.38	5.90	53.75	56.67	38.37	18.30	82.35	A-7-6	POOR
	95 + 2.5 + 2.5%	1.824	17.82	23.40	19.05	115	57.15	34.10	18.05	82.35	A-7-6	GOOD
	90 + 5.5 + 5.5%	1.865	18.15	31.45	27.35	234	57.65	39.83	17.82	82.35	A-7-6	GOOD
	85 + 7.5 + 7.5%	1.885	18.52	45.80	40.60	268	58.15	40.72	17.43	82.35	A-7-6	GOOD
	80 + 10 + 10%	1.910	18.83	36.35	31.78	335	58.65	41.60	17.05	82.35	A-7-6	GOOD
KAANI TOWN ROAD KHANA L.G.A	100%	1.985	15.35	9.05	8.23	63.85	48.25	27.90	20.35	71.55	A-7-6	POOR
	95 + 2.5 + 2.5%	1.998	15.70	28.25	26.55	134	48.53	28.48	20.05	71.55	A-7-6	GOOD
	90 + 5.5 + 5.5%	2.120	15.96	48.35	46.85	225	48.96	29.14	19.82	71.55	A-7-6	GOOD
	85 + 7.5 + 7.5%	2.408	16.12	57.30	56.35	285	49.23	29.88	19.35	71.55	A-7-6	GOOD
	80 + 10 + 10%	2.555	16.47	53.45	49.75	388	49.75	30.98	18.97	71.55	A-7-6	GOOD

Table 3.5: Percentile Combination of Soft Clay + Costaceae Lacerus Bagasse Fibre Ash(CLBFA) **+ Cement**

RATIO %	100%	97.25+ 0.25+2.5	94.5+0.5 + 5.0%	91.75+ 0.75+7.5	89+1.0 +10%
MAXIMUM DRY DENSITY (MDD(kN/m3)					
OGODA TOWN ROAD, AHOADA-WEST L.G.A MDD(kN/m3)	1.83	1.88	1.90	1.92	1.94
BODO TOWN ROAD GOKANA L.G.A MDD(kN/m3)	1.92	1.95	1.98	2.00	2.11
OGBOGU TOWN-ROAD, OGBA/EGBEMA NDONI L.G.A MDD(kN/m3	1.82	1.85	1.88	1.90	1.94
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A MDD(kN/m3)	1.79	1.82	1.87	1.89	1.91
KAANI TOWN ROAD, KHANA L.G.A MDD(kN/m3)	1.99	2.00	2.12	2.41	2.56
OPTIMUM MOISTURE CONTENT (%)					
OGODA TOWN ROAD, AHOADA-WEST L.G.A OMC (%)	15.68	15.97	16.15	16.55	16.87
BODO TOWN ROAD GOKANA L.G.A OMC (%)	14.93	15.25	15.69	15.93	16.15
OGBOGU TOWN-ROAD, OGBA/EGBEMA NDONI L.G.A OMC (%)	16.30	16.59	16.83	17.05	17.38
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A OMC (%)	17.45	17.82	18.15	18.52	18.83
KAANI TOWN ROAD, KHANA L.G.A OMC (%)	15.35	15.70	15.96	16.12	16.47
CONSISTENCY LIMITS (%)					
OGODA TOWN ROAD, AHOADA-WEST L.G.A LL(%)	58.85	60.45	60.86	61.25	62.87
OGODA TOWN ROAD, AHOADA-WEST L.G.A PL(%)	38.52	40.62	41.42	42.60	44.61
OGODA TOWN ROAD, AHOADA-WEST L.G.A IP(%)	20.33	19.83	19.44	18.65	18.26
BODO TOWN ROAD GOKANA L.G.A LL(%)	59.45	61.35	61.86	62.20	62.65
BODO TOWN ROAD GOKANA L.G.A PL(%)	39.10	41.50	42.03	43.87	43.77
BODO TOWN ROAD GOKANA L.G.A IP(%)	20.35	19.85	19.38	19.30	18.88
OGBOGU TOWN-ROAD, OGBA/EGBEMA NDONI L.G.A LL(%)	58.35	59.85	60.18	60.66	60.97
OGBOGU TOWN-ROAD, OGBA/EGBEMA NDONI L.G.A PL(%)	37.50	39.10	39.82	40.63	41.15
OGBOGU TOWN-ROAD, OGBA/EGBEMA NDONI L.G.A IP(%)	21.85	20.75	20.36	20.03	19.82
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A LL(%)	56.67	57.15	57.65	58.15	58.65
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A PL(%)	38.37	34.10	39.83	40.72	41.60
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A IP(%)	18.30	18.05	17.82	17.43	17.05
KAANI TOWN ROAD, KHANA L.G.A LL(%)	48.25	48.53	48.96	49.23	49.75
KAANI TOWN ROAD, KHANA L.G.A PL(%)	27.90	28.48	29.14	29.88	30.98
KAANI TOWN ROAD, KHANA L.G.A IP(%)	20.35	20.05	19.82	19.35	18.97
CALIFORNIA BEARING RATIO (%)					
OGODA TOWN ROAD, AHOADA-WEST L.G.A UNSOAKED CBR(%)	8.58	23.76	31.35	42.80	36.85
OGODA TOWN ROAD, AHOADA-WEST L.G.A SOAKED CBR(%)	6.33	18.85	28.31	37.87	32.55
BODO TOWN ROAD GOKANA L.G.A UNSOAKED CBR(%)	8.83	28.35	46.23	53.30	48.36
BODO TOWN ROAD GOKANA L.G.A SOAKED CBR(%)	7.15	26.28	41.35	49.71	39.30
OGBOGU TOWN-ROAD, OGBA/EGBEMA NDONI L.G.A UNSOAKED CBR(%)	8.25	27.35	34.30	49.75	37.37
OGBOGU TOWN-ROAD, OGBA/EGBEMA NDONI L.G.A SOAKED CBR(%)	7.35	24.40	29.88	47.25	32.35
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A UNSOAKED CBR(%)	7.38	23.40	31.45	45.80	36.35
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A SOAKED CBR(%)	5.90	19.05	27.35	40.60	31.78
KAANI TOWN ROAD, KHANA L.G.A UNSOAKED CBR(%)	9.05	28.25	48.35	57.30	53.45
KAANI TOWN ROAD, KHANA L.G.A SOAKED CBR (%)	8.23	26.55	46.85	56.35	49.75

UNCONFINED COMPRESSIVE STRENGTH (KPa)					
OGODA TOWN ROAD, AHOADA-WEST L.G.A UCS (Kpa)	58.85	105.00	215.00	296.00	374.00
BODO TOWN ROAD GOKANA L.G.A UCS (Kpa)	63.35	112.00	187.00	235.00	308.00
OGBOGU TOWN-ROAD, OGBA/EGBEMA NDONI L.G.A UCS (Kpa)	57.75	135.00	224.00	298.00	368.00
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A UCS (Kpa)	53.75	115.00	234.00	268.00	335.00
KAANI TOWN ROAD, KHANA L.G.A UCS (Kpa)	63.85	134.00	225.00	285.00	388.00

Table 3.6: Percentile Decrease / Increase of Clay + Costaceae Lacerus Bagasse Fibre Ash(CLBFA) + Cement

RATIO %	100%	97.25+0.25 +2.5	94.5+0.5+ 5.0%	91.75+ 0.75+7.5	89+1.0 +10%
MAXIMUM DRY DENSITY (MDD(kN/m3)					
OGODA TOWN ROAD, AHOADA-WEST L.G.A MDD(kN/m3)	96.920	103.178	103.945	104.986	106.192
BODO TOWN ROAD GOKANA L.G.A MDD(kN/m3)	98.818	101.196	102.704	103.848	109.464
OGBOGU TOWN-ROAD, OGBA/EGBEMA NDONI L.G.A MDD(kN/m3)	98.754	101.262	102.852	104.059	106.144
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A MDD(kN/m3)	98.355	101.672	103.958	105.072	106.466
KAANI TOWN ROAD, KHANA L.G.A MDD(kN/m3)	99.349	100.655	106.801	121.310	128.715
OPTIMUM MOISTURE CONTENT (%)					
OGODA TOWN ROAD, AHOADA-WEST L.G.A OMC (%)	98.184	101.849	102.997	105.548	107.589
BODO TOWN ROAD GOKANA L.G.A OMC (%)	97.902	102.143	105.090	106.698	108.171
OGBOGU TOWN-ROAD, OGBA/EGBEMA NDONI L.G.A OMC (%)	98.252	101.779	103.252	104.601	106.626
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A OMC (%)	97.924	102.120	104.011	106.132	107.908
KAANI TOWN ROAD, KHANA L.G.A OMC (%)	97.771	102.280	103.974	105.016	107.296
CONSISTENCY LIMITS (%)					
OGODA TOWN ROAD, AHOADA-WEST L.G.A LL(%)	97.353	102.719	103.415	104.078	106.831
OGODA TOWN ROAD, AHOADA-WEST L.G.A PL(%)	94.830	105.452	107.529	110.592	115.810
OGODA TOWN ROAD, AHOADA-WEST L.G.A IP(%)	102.521	97.541	95.622	91.736	89.818
BODO TOWN ROAD GOKANA L.G.A LL(%)	96.903	103.196	104.054	104.626	105.383
BODO TOWN ROAD GOKANA L.G.A PL(%)	94.217	106.138	107.494	112.199	111.944
BODO TOWN ROAD GOKANA L.G.A IP(%)	102.519	97.543	95.233	94.840	92.776
OGBOGU TOWN-ROAD, OGBA/EGBEMA NDONI L.G.A LL(%)	97.494	102.571	103.136	103.959	104.490
OGBOGU TOWN-ROAD, OGBA/EGBEMA NDONI L.G.A PL(%)	95.908	104.267	106.187	108.347	109.733
OGBOGU TOWN-ROAD, OGBA/EGBEMA NDONI L.G.A IP(%)	105.301	94.966	93.181	91.670	90.709
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A LL(%)	99.160	100.847	101.729	102.612	103.494
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A PL(%)	112.522	88.872	103.805	106.125	108.418
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A IP(%)	101.385	98.634	97.377	95.246	93.169
KAANI TOWN ROAD, KHANA L.G.A LL(%)	99.423	100.580	101.472	102.031	103.109
KAANI TOWN ROAD, KHANA L.G.A PL(%)	97.963	102.079	104.444	107.097	111.039
KAANI TOWN ROAD, KHANA L.G.A IP(%)	101.496	98.526	97.396	95.086	93.219
CALIFORNIA BEARING RATIO (%)					
OGODA TOWN ROAD, AHOADA-WEST L.G.A UNSOAKED CBR(%)	36.111	276.923	365.385	498.834	429.487
OGODA TOWN ROAD, AHOADA-WEST L.G.A SOAKED CBR(%)	33.581	297.788	447.235	598.262	514.218
BODO TOWN ROAD GOKANA L.G.A UNSOAKED CBR(%)	31.146	321.065	523.556	603.624	547.678
BODO TOWN ROAD GOKANA L.G.A SOAKED CBR(%)	27.207	367.552	578.322	695.245	549.650
OGBOGU TOWN-ROAD, OGBA/EGBEMA NDONI L.G.A UNSOAKED CBR(%)	30.165	331.515	415.758	603.030	452.970
OGBOGU TOWN-ROAD, OGBA/EGBEMA NDONI L.G.A SOAKED CBR(%)	30.123	331.973	406.531	642.857	440.136
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A UNSOAKED CBR(%)	31.538	317.073	426.152	620.596	492.547
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A SOAKED CBR(%)	30.971	322.881	463.559	688.136	538.644
KAANI TOWN ROAD, KHANA L.G.A UNSOAKED CBR (%)	32.035	312.155	534.254	633.149	590.608
KAANI TOWN ROAD, KHANA L.G.A SOAKED CBR(%)	30.998	322.600	569.259	684.690	604.496

UNCONFINED COMPRESSIVE STRENGTH (KPa)					
OGODA TOWN ROAD, AHOADA-WEST L.G.A UCS (Kpa)	56.048	178.420	365.336	502.974	635.514
BODO TOWN ROAD GOKANA L.G.A UCS (Kpa)	56.563	176.796	295.185	370.955	486.188
OGBOGU TOWN-ROAD, OGBA/EGBEMA NDONI L.G.A UCS (Kpa)	42.778	233.766	387.879	516.017	637.229
ULA-IKATA TOWN ROAD, AHOADA-EAST L.G.A UCS (Kpa)	46.739	213.953	435.349	498.605	623.256
KAANI TOWN ROAD, KHANA L.G.A UCS (Kpa)	47.649	209.867	352.388	446.359	607.674

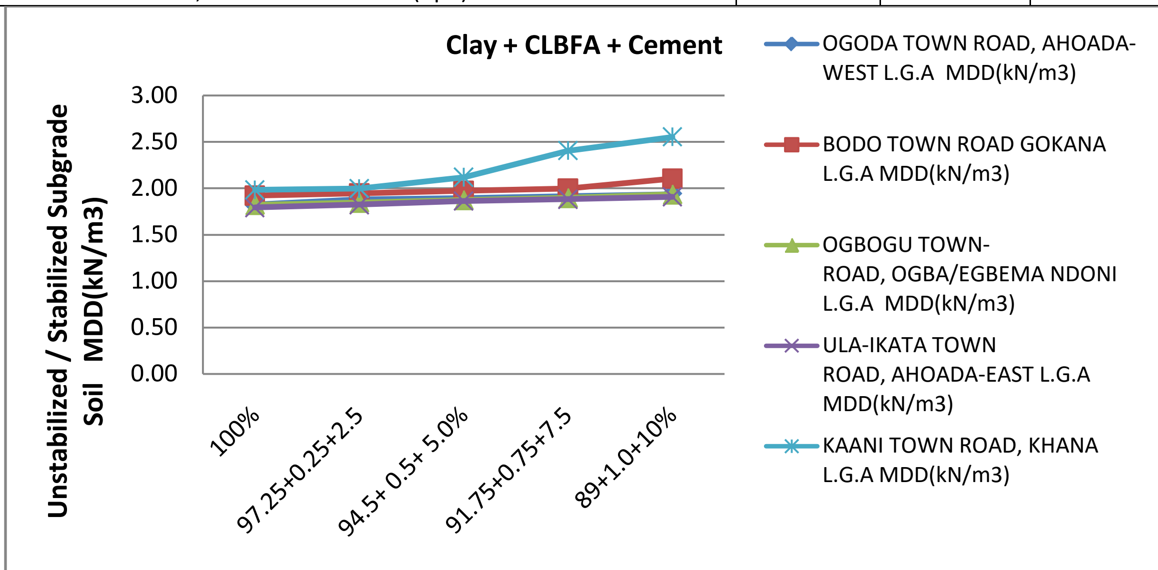

Figure 3.1: **Maximum Dry Density of Subgrade Stabilization Test of Clay Soil from Ogoda, Bodo, Ogbogu, Ula-Ikata, Kaani Towns), Rivers State with CLBFA+ Cement at Different Percentages and Combinations**

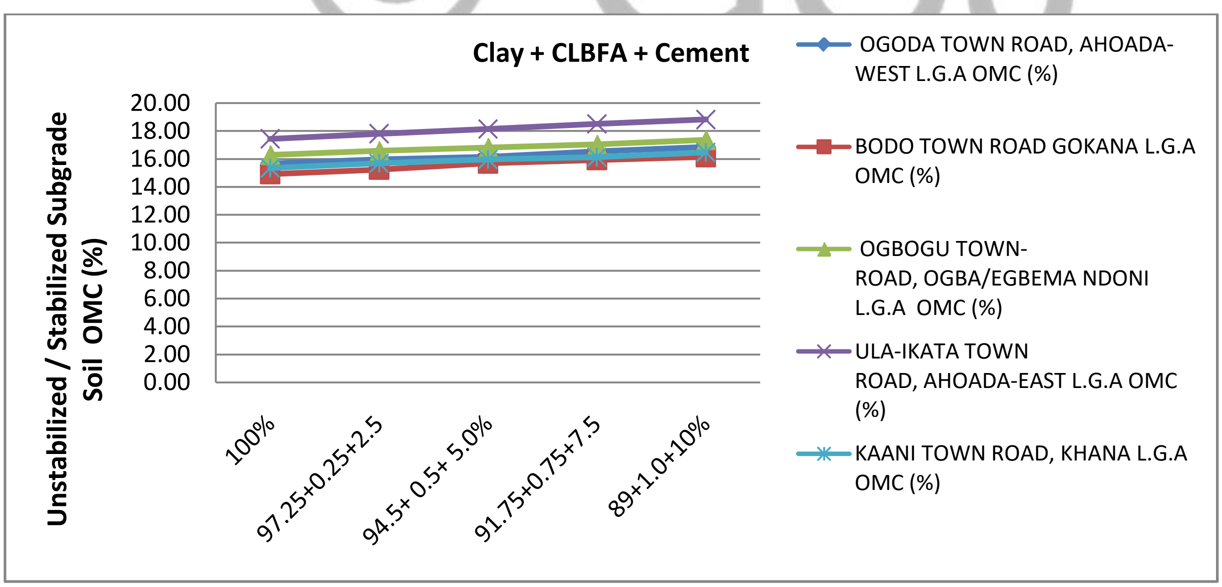

Figure 3.2: **Optimum Moisture Content of Subgrade Stabilization Test of Clay Soil Ogoda, Bodo, Ogbogu, Ula-Ikata, Kaani Towns), Rivers State with CLBFA + Cement at Different Percentages and Combination**

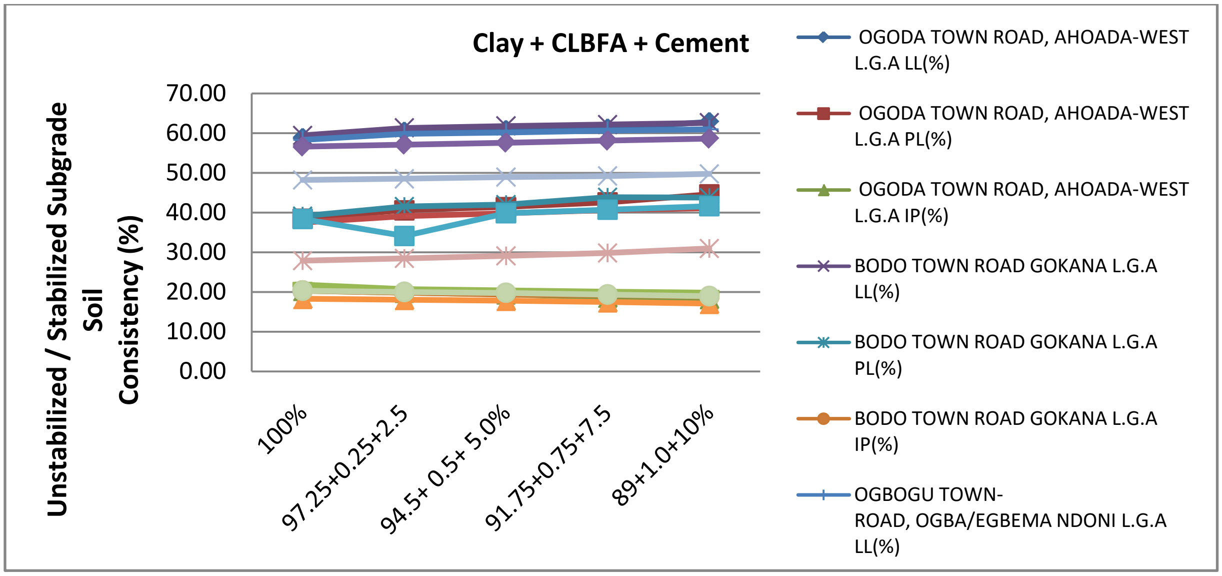

Figure 3.3: **Consistency Limits of Subgrade Stabilization Test of Clay Soil from Ogoda, Bodo, Ogbogu, Ula-Ikata, Kaani Towns), Rivers State with CLBFA + Cement at Different Percentages and Combinations**

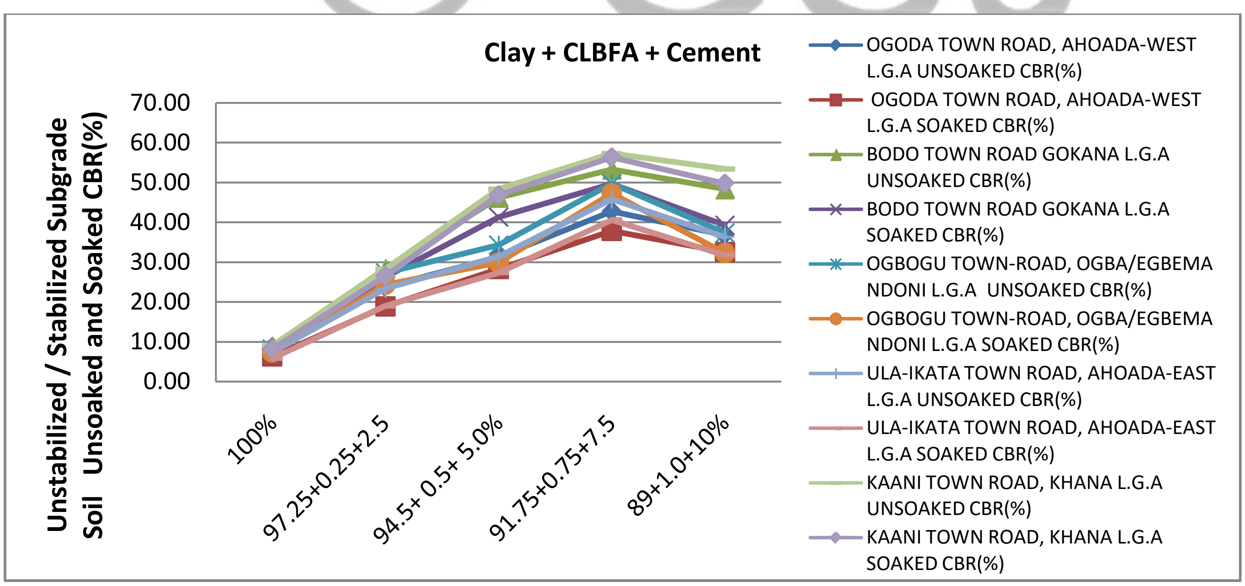

Figure 3.4: **California Bearing Ratio of Subgrade Stabilization Test of Clay Soil from Ogoda, Bodo, Ogbogu, Ula-Ikata, Kaani Towns), Rivers State with CLBFA + Cement at Different Percentages and Combinations**

GSJ: Volume 8, Issue 2, February 2020
ISSN 2320-9186

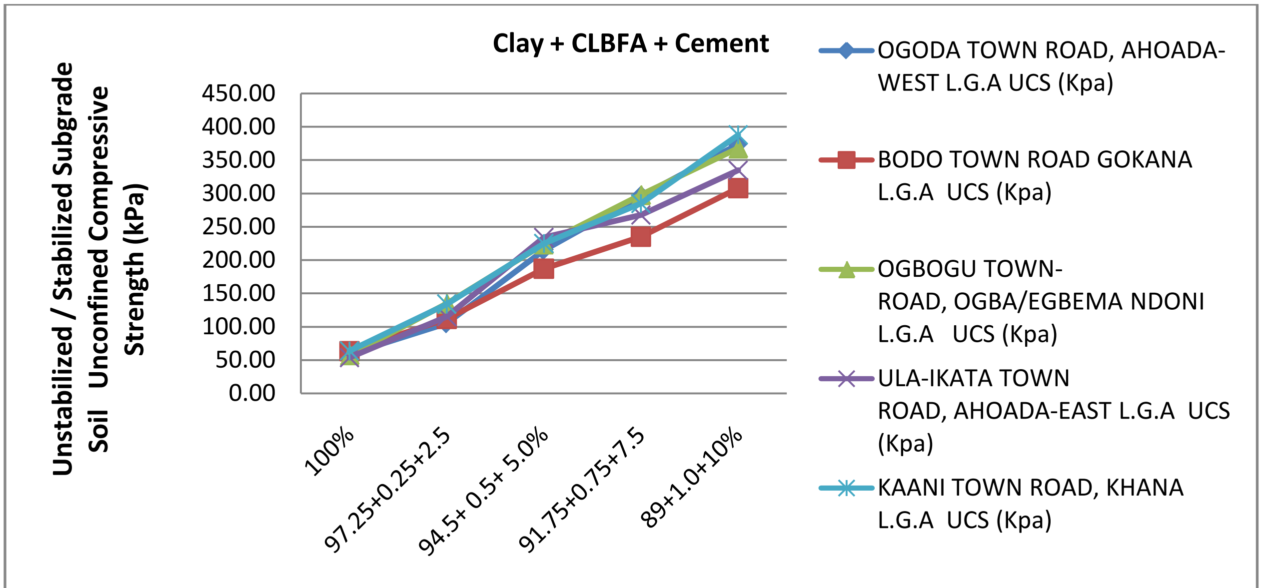

Figure 3.5: Unconfined Compressive Strength (UCS) of Subgrade Soil from Ogoda, Bodo, Ogbogu, Ula-Ikata, Kaani Towns), Rivers State with CLBFA + Cement at Different Percentages and Combinations

4.0 Conclusions

The following conclusions were made from the experimental research results.

1. The soils classified as A – 7 – 6 on the AASHTO Classification System
2. Clay Soils are dark grey (from wet to dry states) plasticity index of 20.33%, 20.35%, 21.85%, 26.30%, and 21.35% respectively for Ogoda, Bodo, Ogbogu, Ula-Ikata, and Kaani.
3. The entire results showed the potential of using CLBFA + cement as admixtures in the treatment of clay soils
4. Costaceae Lacerus Bagasse Fibre Ash(CLBFA) acts as pozzolana
5. Results obtained showed increased in UCS with an increase in fibre percentages to soil the corresponding ratio

6. Proportional results showed an increased in CBR values with increase in bagasse fibre percentages to a peak ratio of 7.5% + 7.5% to soil ratio

REFERENCES

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

Awaji, H.A., (2001). Settlement and Bearing Capacity of Geogrid-Reinforced Sand over Collapsible Soil. Geotext. Geomembranes, 19(2): 75-88

Attoh-Okine, N.O. (1995). Lime Treatment of Laterite Soils and Gravels-Revisited. Construction and Building Material, 9(5): 283-287

Azadegan, O., S.H. Jafari and J. Li, (2012). Compaction Characteristics and Mechanical Properties of Lime/Cement Treated Granular Soils. *Electron. J. Geotech. Eng., 17: 2275-2284*

Barisua, E. N., Charles, K., Ode, T., (2018). Comparative Strength Evaluation of Cementitious Stabilizing Agents Blended with Pulverized Bagasse Fibre for Stabilization of Expansive Lateritic Soils. *Global Scientific Journal,* 6(12):220-238

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

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

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

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

Mallela, J., Harold, P. V. Q., Smith, K. L. and E. Consultants., (2004). Consideration of Lime-Stabilized Layers in Mechanistic-empirical Pavement Design. The National Lime Association, Arlington, Virginia, USA

Ola, S. A. (1974). Need for Estimated Cement Requirements for Stabilizing Lateritic Soils. *Journal of Transportation Engineering, ASCE*, 100(2):379–388.

Omotosho, P. O. (1993). Multi-Cyclic Influence on Standard Laboratory Compaction of Residual Soils. *Engineering Geology. 36, 109–115.*

Omotosho, P .O. and Akinmusuru, J .O. (1992). The behavior of Soils (Lateritic) Subjected to Multi-Cyclic Compaction. *Engineering Geology*, 32, 53–58

Sabat, A. K. (2012). Effect of Polypropylene Fiber on Engineering Properties of Rice Husk Ash – Lime Stabilized Expansive Soil, *Electronic Journal of Geotechnical Engineering, 17(E), 651-660*

Sharma, R.S., Phanikumar, B. R. and Rao, B.V. (2008). Engineering Behaviour of a Remolded Expansive Clay Blended with Lime, Calcium Chloride and Rice-Husk Ash, *Journal of Materials in Civil Engineering, 20(8): 509-515*

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.

Viswanadham, B.V.S., Phanikumar, B. R and Mukherjee, R.V. (2009). Swelling Behavior of a Geofiber-Reinforced Expansive Soil. Geotech. Geomembranes, 27(1): 73-76.

Yang, G., Liu, H., P. L. and Zhang, B. (2012). Geogrid-Reinforced Lime-Treated Cohesive Soil Retaining Wall: Case study and implications. Geotext. Geomembranes, 35(0): 112-118.