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POTENTIAL OF CEMENT, LIME - COSTACEAE LACERUS BAGASSE FIBRE IN LATERITIC SOILS SWELL – SHRINK CONTROL AND STRENGTH VARIANCE DETERMINATIONS

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ABSTRACT

The investigative work examined the contributive improvement on expansive lateritic soils with less matured characteristics, sensitive to manipulations by many forms with hybridized composite materials of cement + costaceae lacerus bagasse fibre and lime + costaceae lacerus bagasse fibre, their varying strengths and the behavioral attributes for soil modifications. The soils classified as A-2-6 SC and A-2-4 SM on the AASHTO classification schemes / Unified Soil Classification System, reddish in color, with plasticity index of 17.30%, 14.23%, 15.20%, 15.50%, and 16.10%. The soil has CBR values unsoaked of 8.7%,8.5%, 7.8%, 9.4%, and 10.6% and soaked of 8.3%, 7.8%, 7.2%, 8.5% and 9.8 %, unconfined compressive strength values of 178kPa, 145kPa, 165kPa, 158kPa and 149kPa respectively of Odiokwu, Oyigba, Anakpo, Upatabo and Ihubuluko Town sampled Roads. Descriptive statistical percentile varying preliminary compaction test results at 100% natural clay conditions of maximum dry density (MDD) and optimum moisture content (OMC) from sampled roads are Odioku, 1.015% and 1.021%, Oyigba 1.027%%, and 1.056%, Anakpo 1.024% and 1.043%, Upatabo 1.101% and 1.016%, Ihubuluko 1.038% and 11.037%, respectively of MDD and OMC. Results of California bearing ratio (CBR) test results of unsoaked are 2.626%, 3.724%, 3.635%, 3.048%, 3.014%, and soaked, 3.410%, 3.199%, 3.215%, 2.782%, 2.842%, for Odioku, Oyigba, Anakpo, Upatabo and Ihubuluko respectively at 100% clay matural conditions. Unconfined compressive strength test of sampled roads are Odioku 1.275%, Oyigba 1.414%, Anakpo 1.303%, Upatabo 1.316% and Ihubuluko 1.483% respectively at 100% natural state. Consistency limits (Plastic index) test results at 100% natural condition from sampled roads are Odioku 0.936%, Oyigba 1.019%, Anakpo 1.069%, Upatabo 0.947% and Ihubuluko 1.038%. Stabilized soils maximum dry density (MDD) and optimum moisture content (OMC) demonstrated incremental percentile values with increase in composite stabilizers inclusion percentages ratio to soils. Incremental percentile values of California bearing ratio (CBR) stabilized soils with cement, lime and CLBF showed optimum percentile ratio at 91.75+0.75 +7.5% were obtained. Results confirmed that both cementitious agents showed good combination with CLBF. Figure 3.7 illustrated the strength variations of composite stabilizers with respect to percale ratio inclusion with cement at higher values. Unconfined compressive strength test of stabilized soils with cement / lime + CLBF showed incremental percentile relatively to the percentage ratios to stabilizers and soils. Results of consistency limits (Plastic Index) test showed percentile decreased values with increased in composite materials to soil. Summarized stabilized soils result

demonstrated incremental percentile value of cement and lime + costaceae lacerus bagasse fibre. Results showed the potentials of both cementitious agents as good composite materials suitable for soil modifications with cement composition in higher dominant values.

Key Words: Clay soils, Costaceae Lacerus Bagasse Fibre, *Cement, Lime, CBR, UCS, Consistency, Compaction*

1.0 Introduction

Expansive soils are characterized by its shrinkage ability when it comes in contact with water; it expands in rainy season as a result of water and shrinks during summer/dry season. Expansive Soil (clay) formations, especially those with high in situ water contents, are susceptible to large settlements and possess low shear strength unless they are naturally cemented. Pre-compression of such deposits with geodrains can prevent this large settlement and thus enhance shear strength. Soil stabilization has taken a new shape in recent times due to increase of demand for infrastructure, raw material and fuel; it's emerging as a popular and cost effective method. Expansive Soil (clay), when mixed with cement or lime will be stabilized because cement, lime and water react to form cementitious calcium silicate and aluminate hydrates, which bind the soil particles together (Gueddouda *et al*. [1] The study of the treatment of clays using several methods of stabilization (addition of NaCl salt, lime, cement, and association lime+ cement, and association lime + salt) show that for certain combinations the reduction rate in swelling potential more than 90% (Gueddouda *et al*., [1]).

Kumar and Prasanna [2] studied the effect of silica and calcium extracted from rice husk ash on geotechnical properties of expansive soils. They concluded that the characteristics of such soils are improved remarkably.

Goyal *et al*., [3] reported that SCBA with high specific surface area, high contents of amorphous silica and calcium oxide fulfilled the principal requirements of a pozzolanic material.

Ganesan *et al*., [4] studied on the use of bagasse ash (BA) as partial cement replacement material in respect of cement mortars. Up to 20 % of ordinary Portland cement can be optimally replaced with well-burnt bagasse ash without any adverse effect on the desirable properties of concrete. Several studies have been carried out on the effectiveness of clay stabilization by RHA admixing.

Charles *et al.* [5] 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 CBR and un Soaked CBR CBR 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.

Charles *et al.* [6] evaluated the geotechnical properties of an expansive clay soil found along Odioku – Odiereke Rd 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 Rd. 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.

Charles *et al.* [7] 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 of less than 10%. At 8% of both cement and lime, CBR values reached optimum, beyond this range, cracks exist and 7.5% cement and lime 7.5% BSBFA, and 7.25% cement and lime 0. 7.5% BSBF, optimum value are reached. The entire results showed the potential of using bagasse, BSBFA as admixtures in cement and lime treated soils of laterite.

Kalantari *et al.*, [8] experimented the use of cement, polypropylene fibers and optimum moisture content values to strengthen peat. From their laboratory study it was observed that peat with cement and fibers can be used as the base course in the pavement construction. It appears that the fibers prevent the formation and the development of the cracks upon loading and thus increasing the strength of the samples.

2.0 Materials and Methods

2.1 Materials

2.1.1 Soil

The soils used for the study were collected from Ubie, Upata and Igbuduya Districts of Ekpeye, Ahoada- East and Ahoada-West Local Government of Rivers State, beside the at failed sections of the Unity linked Rds at 1.5 m depth, at Odiokwu Town Rd(CH 0+950), Oyigba Town Rd(CH 4+225), Anakpo Town Rd(CH6+950) , Upatabo Town Rd (CH8+650), Ihubuluko Town Rd, all of Rivers State, Niger Delta, Nigeria. It lies on the recent coastal plain of the North-Western of Rivers state of Niger Delta.

2.1.2 Costaceae Lacerus Bagasse Fibre

The Costaceae Lacerus bagasse fibre are wide plants, medicinally used in the local areas, abundant in Rivers State farmlands / bushes, they covers larger areas, collected from at Oyigba Town Farmland / Bush, Ubie Clan, Ahoada-West, Rivers State, Nigeria.

2.1.3 Lime

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

2.1.4 Cement

The cement used was Portland Cemenet, 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 Odioku Town, (latitude 5.07° 14‘S and longitude 6.65° 80‘E), Oyigba Town, (latitude 7.33° 24‘S and longitude 3.95° 48‘E), Oshika Town, latitude 4.05° 03‘S and longitude 5.02° 50‘E), Upatabo Town, (latitude 5.35° 34‘S and longitude 6.59° 80‘E) and Ihubujuko Town, latitude 5.37° 18‘S and longitude 7.91° 20‘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

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. The soils are reddish brown and dark grey in color plasticity index of 17.30%, 14.23%, 15.20%, 15.50%, and 16.10% respectively for Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Town Rds. The soil has un Soaked CBR values of 8.7%,8.5%, 7.8%, 9.4%, and 10.6% and Soaked CBR values of 8.3%, 7.8%, 7.2%, 8.5% and

9.8 %, unconfined compressive strength values of 178kPa, 145kPa, 165kPa ,158kPa and 149kPa when compacted with British Standard light, respectively..

3.1 Compaction Test Results

Preliminary Compaction test results at 100% natural clay condition percentile values of maximum dry density (MDD) and optimum moisture content (OMC) derived from tables 3.2 and 3.3 to 3.2A and 3.3A of sampled roads are Odioku, 1.015% and 1.021%, Oyigba 1.027%%, and 1.056%, Anakpo 1.024% and 1.043%, Upatabo 1.101% and 1.016%, Ihubuluko 1.038% and 11.037%, respectively of MDD and OMC. Obtained percentile results of stabilized clay soil with composites materials are Odioku laterite + Cement + CLBF MDD, 3.047%, 5.6%, 10.263%, 12.57822%, laterite + lime + CLBF, 1.935%, 2.191%, 5.876%, 9.714%, OMC are Laterite + Cement + CLBF, 4.154%, 6.172%, 9.561%, 13.920%, laterite + lime + CLBF, 1.448%,1.770%, 4.434%, 9.276%. Oyigba MDD are laterite + cement + CLBF + CLBF 10.855%, 15.037%, 16.639%, 19.218%. Anakpo MDD are laterite + cement + CLBF, 4.680%, 7.562%, 10.702%, 12.194%, laterite + lime + CLBF 2.557%, 3.947%, 10.123%, 14.755%, OMC are laterite + cement + CLBF, 8.484%, 11.445%, 15.055%, 18.737%, Ihubuluko are MDD laterite + cement + CLBF, 7.462%, 8.412%, 14.398%, 16.013%, laterite + lime + CLBF, 1.891%, 4.789%, 6.642%, 8.542%, OMC are laterite + cement + CLBF 7.177%, 11.743%, 13.396%, 15.876%, laterite + lime + CLBF, 5.867%, 9.456%, 11359%, 14.812%. Figures 3.1 and 3.2 demonstrated graphically strength variance of percentages ratio of composites inclusion with cement at peak over lime. Maximum dry density (MDD) and optimum moisture content (OMC) demonstrated incremental percentile values with increase in composite stabilizers inclusion percentages ratio to soils.

3.2 California Bearing Ratio (CBR) Test

Results of California bearing ratio (CBR) test percentile results of unsoaked are 2.626%, 3.724%, 3.635%, 3.048%, 3.014%, and soaked, 3.410%, 3.199%, 3.215%, 2.782%, 2.842%, for Odioku, Oyigba, Anakpo, Upatabo and Ihubuluko respectively at 100% clay matural conditions. Stabilized unsoaked laterite + cement + CLBF are 224.569%, 519.397%, 684.339%, 596.983%, laterite + lime + CLBF; 257.060%, 409.359%, 640.968%, 513.382%, soaked laterite + cement + CLBFA 311.635%, 484.527%, 665.250%, 541.274%, laterite + lime + CLBF, 225.267%, 360.207%, 631.652%, 474.664%. Oyigba stabilized unsoaked laterite + cement + CLBF are 345.497%, 572.556%, 758.438%, 498.438%, laterite + lime + CLBF, 211.364%, 355.129%, 540.187%, 484.305%, soaked laterite + cement + CLBF, 288.609%, 464.250%, 640.148%, 498.225%, laterite + lime + CLBF, 197.280%, 330.613%, 435.741%, 392.664%. Anakpo unsoaked laterite + cement + CLBF are 335.948%, 521.846%, 733.384%, 632.102%, laterite + lime + CLBF, 296.054%, 473.875%, 655.926%, 594.388%, soaked laterite + cement + CLBF, 290.426%, 505.704%, 658.482%, 572.371%, laterite + lime + CLBF, 287.377%, 480.433%, 657.100%, 589.461%. Upatabo unsoaked laterite + cement + CLBF are 271.977%, %, 689.212470.914%, 539.850%, laterite + lime + CLBF are 236.828%, 378.850%, 524.594%, 485.233%, soaked laterite + cement + CLBF, 242.294%, 468.177%, 665.706%, 568.177%, laterite + lime + CLBF 239.635%, 394.929%, 544.341%, 476.694%, Ihubuluko unsoaked laterite + cement + CLBF are 268.238%, 422.484%, 663.521%, 512.578%, laterite + lime + CLBF 236.498%, 336.027%, 506.593%, 451.593%, soaked laterite + cement + CLBF 248.995%, 410.220%, 666.138%, 512.260%, laterite + lime + CLBF 2.559%, 216.843%, 336.945%, 504.803%, 441.333%. Figure 3.3 graphically presented the variance in strength of composite stabilizers with cement at maximum values to lime. Incremental percentile values of California bearing ratio (CBR) stabilized soils with cement, lime and

CLBF showed optimum percentile ratio at 91.75+0.75 +7.5% were obtained. Results confirmed that both cementitious agents showed good combination with CLBF with cement composition in dominant rise of values.

3.3 Unconfined Compressive Strength Test

Derived percentile values generated from table 3.8 to 3.8A of unconfined compressive strength test of sampled roads are Odioku 1.275%, Oyigba 1.414%, Anakpo 1.303%, Upatabo 1.316% and Ihubuluko 1.483% respectively at 100% natural state. Stabilized composite materials cnconfined compressive strength of Odioku laterite + cement + CLBF are 49.114%, 81.136%, 114.283%,154.170%, laterite + lime + CLBF 35.139%, 53.678%, 82.892%,109.858%, Oyigba laterite + cement + CLBF are 70.648%, 112.027%, 146.510%, 189.958%, laterite + lime + CLBF 36.667%, 71.149%, 101.494%, 133.908%. Anakpo laterite + cement + CLBF are 53.559%, 91.741%, 126.286%, 162.650%, laterite + lime + CLBF 33.566%, 69.930%, 88.112%, 112.354%. Upatabo laterite + cement + CLBF are 55.684%, 87.330%,131.633%, 165.178%, laterite + lime + CLBF 32.775%, 51.130%, 91.003%,116.320%, Ihubuluko laterite + cement + CLBF 80.834%, 101.524%, 138.075%, 170.489%, laterite + lime + CLBF 44.717%, 71.614%, 104.027%, 133.683%. Figure 3.7 illustrated the strength variations of composite stabilizers with respect to percale ratio inclusion with cement at higher values. Unconfined compressive strength test of stabilized soils with cement / lime + CLBF showed incremental percentile relatively to the percentage ratios to stabilizers and soils.

3.4 Consistency Limits Test

Percentile values generated from tables 3.5, 3.6, 3.6, 3.7 to 3.5A, 3.6A and summarized into 3.7A of consistency limits (Plastic index) test results at 100% natural condition from sampled roads are Odioku 0.936%, Oyigba 1.019%, Anakpo 1.069%, Upatabo 0.947% and Ihubuluko 1.038%. Stabilized Odioku laterite + cement + CLBF are -13.149%, -14.883%, -16.039%, -17.773%, laterite + lime + CLBF -2.911%, -4.645%, -7.536%, -10.426% , Oyigba laterite + cement + CLBF -3.759%, -8.187%, -15.215%, -8.187%, laterite + lime + CLBF -3.259%, -4.805%, -8.178%, -11.341%. Anakpo laterite + cement + CLBF laterite + cement + CLBF -2.158%, -3.534%,-5.355%, -9.954% laterite + lime + CLBF -1.575%, -4.385%, -7.980%, -9.157%. Upatabo laterite + cement + CLBF -2.953%, -6.333%, -8.882%, -9.372%, laterite + lime + CLBF -4.605%, -6.225%, -6.948% -8.288%, -10.230%. laterite + lime + CLBF. Results of consistency limits (Plastic Index) test showed percentile decreased values with increased in composite materials to soil ratio of both cementitious stabilizing agents.

Table 3.1: Engineering Properties of Soil Samples of (Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Towns), Rivers State

Location Description	Odiokwu Town Rd (CH 0+950)	Oyigba Town Rd (CH 4+225)	Anakpo Town Rd (CH6+950)	Upatabo Town Rd (CH8+650)	Ihubuluko Town Rd (CH10+150)
	(Laterite)	(Laterite)	(Laterite)	(Laterite)	(Laterite)
Depth of sampling (m)	1.5	1.5	1.5	1.5	
(%) 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 /UCS Classifications	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
Lateritic (%)	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 Maximum Dry Density (MDD) of Niger Deltaic Lateritic Soils Subgrade with CLBF + Cement / Lime of (Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Towns), Rivers State

RATIO %	100%	97.25+0.25 +2.5%	94.5+ 0.5 + 5.0%	91.75+0.7 5+7.5%	89+1.0 +10%
MDD (Laterite + Cement + CLBF) ODIOKWU TOWN ROAD	1.95	1.98	2.04	2.13	2.18
MDD (kN/m3) (Laterite + Lime + CLBF)ODIOKWU TOWN ROAD	1.95	1.97	1.98	2.05	2.13
MDD (Laterite + Cement + CLBF) OYIGBA TOWN ROAD	1.86	1.91	1.96	2.02	2.09
MDD (kN/m3) (Laterite + Lime + CLBF)OYIGBA TOWN ROAD	1.86	1.88	1.90	1.94	2.01
MDD (Laterite + Cement + CLBF) ANAKPO TOWN ROAD	1.94	1.99	2.05	2.11	2.14
MDD (kN/m3) (Laterite + Lime + CLBF)ANAKPO TOWN ROAD	1.94	1.97	2.00	2.10	2.12
MDD (Laterite + Cement + CLBF) UPATABO TOWN ROAD	1.76	1.91	1.93	1.96	1.95
MDD (kN/m3) (Laterite + Lime + CLBF) UPATABO TOWN ROAD	1.76	1.86	1.91	1.93	1.95
MDD (Laterite + Cement + CLBF) IHUBULUKO TOWN ROAD	2.11	2.19	2.21	2.33	2.37
MDD (kN/m3) (Laterite + Lime + CLBF)IHUBULUKO TOWN ROAD	2.11	2.13	2.19	2.23	2.27

Table 3.2A: Results of Maximum Dry Density (MDD) Percentile Increase / Decrease of Niger Deltaic Lateritic Soils Subgrade with CLBF + Cement / Lime of (Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Towns), Rivers State

RATIO %	100%	97.25+0.25 +2.5%	94.5+ 0.5 + 5.0%	91.75+0.75 +7.5%	89+1.0 +10%
MDD (Laterite + Cement + CLBF) ODIOKWU TOWN ROAD	1.015%	3.047%	5.657%	10.263%	12.822%
MDD (kN/m3) (Laterite + Lime + CLBF)ODIOKWU TOWN ROAD	1.010%	1.935%	2.191%	5.876%	9.714%
MDD (Laterite + Cement + CLBF) OYIGBA TOWN ROAD	1.03%	5.42%	7.95%	11.24%	14.95%
MDD (kN/m3) (Laterite + Lime + CLBF)OYIGBA TOWN ROAD	1.01%	3.93%	5.06%	9.16%	11.93%
MDD (Laterite + Cement + CLBF) ANAKPO TOWN ROAD	1.02%	4.68%	7.56%	10.70%	12.19%
MDD (kN/m3) (Laterite + Lime + CLBF)ANAKPO TOWN ROAD	1.01%	2.56%	3.95%	9.40%	10.12%
MDD (Laterite + Cement + CLBF) UPATABO TOWN ROAD	1.08%	16.08%	17.33%	19.26%	18.35%
MDD (kN/m3) (Laterite + Lime + CLBF) UPATABO TOWN ROAD	1.06%	10.85%	13.64%	14.78%	16.09%
MDD (Laterite + Cement + CLBF) IHUBULUKO TOWN ROAD	1.04%	7.46%	8.41%	14.40%	16.01%
MDD (kN/m3) (Laterite + Lime + CLBF)IHUBULUKO TOWN ROAD	1.01%	3.89%	6.79%	9.64%	12.54%

Table 3.3: Results of Optimum Moisture Content (OMC) of Niger Deltaic Lateritic Soils Subgrade with CLBF + Cement / Lime of (Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Towns), Rivers State

RATIO %	100%	97.25+0.25 +2.5%	94.5+ 0.5 + 5.0%	91.75+0.75 +7.5%	89+1.0 +10%
OMC%(Laterite + Cement + CLBF) ODIOKWU TOWN ROAD	12.39	12.65	12.90	13.32	13.86
OMC%(Laterite + Lime + CLBF) ODIOKWU TOWN ROAD	12.39	12.48	12.52	12.85	13.45
OMC%(Laterite + Cement + CLBF) OYIGBA TOWN ROAD	14.35	15.15	15.75	15.98	16.35
OMC%(Laterite + Lime + CLBF) OYIGBA TOWN ROAD	14.35	15.39	15.42	15.58	15.78
OMC%(Laterite + Cement + CLBF) ANAKPO TOWN ROAD	13.85	14.45	14.86	15.36	15.87
OMC%(Laterite + Lime + CLBF) ANAKPO TOWN ROAD	14.85	14.95	15.33	15.77	15.95
OMC%(Laterite + Cement + CLBF) UPATABO TOWN ROAD	11.79	11.98	12.25	12.65	13.05
OMC%(Laterite + Lime + CLBF) UPATABO TOWN ROAD	15.25	15.85	15.92	16.15	16.38
OMC%(Laterite + Cement + CLBF) IHUBULUKO TOWN ROAD	10.95	11.35	11.55	11.85	12.15
OMC%(Laterite + Lime + CLBF) IHUBULUKO TOWN ROAD	14.76	14.99	15.42	15.77	15.88

Table 3.3A: Results of Optimum Moisture Content (OMC) Percentile Increase / Decrease of Niger Deltaic Lateritic Soils Subgrade with CLBF + Cement / Lime of (Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Towns), Rivers State

RATIO %	100%	97.25+0.25 +2.5%	94.5+ 0.5 + 5.0%	91.75+0.75 +7.5%	89+1.0 +10%
OMC%(Laterite + Cement + CLBF) ODIOKWU TOWN ROAD	1.021%	4.154%	6.172%	9.561%	13.920%
OMC%(Laterite + Lime + CLBF) ODIOKWU TOWN ROAD	1.007%	1.448%	1.770%	4.434%	9.276%
OMC%(Laterite + Cement + CLBF) OYIGBA TOWN ROAD	1.06%	10.86%	15.04%	16.64%	19.22%
OMC%(Laterite + Lime + CLBF) OYIGBA TOWN ROAD	1.07%	14.01%	14.21%	15.33%	16.72%
OMC%(Laterite + Cement + CLBF) ANAKPO TOWN ROAD	1.04%	8.48%	11.44%	15.05%	18.74%
OMC%(Laterite + Lime + CLBF) ANAKPO TOWN ROAD	1.01%	1.34%	3.90%	6.86%	8.08%
OMC%(Laterite + Cement + CLBF) UPATABO TOWN ROAD	1.02%	3.20%	5.49%	8.88%	12.27%
OMC%(Laterite + Lime + CLBF) UPATABO TOWN ROAD	1.04%	7.72%	8.18%	9.69%	11.20%
OMC%(Laterite + Cement + CLBF) IHUBULUKO TOWN ROAD	1.04%	7.18%	9.00%	11.74%	14.48%
OMC%(Laterite + Lime + CLBF) IHUBULUKO TOWN ROAD	1.02%	3.09%	6.01%	8.38%	9.12%

Table 3.4: Results of California Bearing Ratio (CBR) of Niger Deltaic Lateritic Soils Subgrade with CLBF + Cement / Lime of (Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Towns), Rivers State

RATIO %	100%	97.25+0.25 +2.5%	94.5+ 0.5 + 5.0%	91.75+0.75 +7.5%	89+1.0 +10%
UNSOAKED (Laterite + Cement + CLBF) ODIOKWU TOWN ROAD	8.70	22.85	48.50	62.85	55.25
UNSOAKED (Laterite + Lime + CLBF) ODIOKWU TOWN ROAD	8.70	25.35	38.60	58.75	47.65
SOAKED(Laterite + Cement + CLBF) ODIOKWU TOWN ROAD	8.30	28.30	42.65	57.65	47.36
SOAKED (Laterite + Lime + CLBF) ODIOKWU TOWN ROAD	8.30	21.85	33.05	55.58	42.55
UNSOAKED (Laterite + Cement + CLBF) OYIGBA TOWN ROAD	8.50	31.65	50.95	66.75	44.65
UNSOAKED (Laterite + Lime + CLBF) OYIGBA TOWN ROAD	8.50	21.35	33.57	49.30	44.55
SOAKED(Laterite + Cement + CLBF) OYIGBA TOWN ROAD	7.80	24.95	38.65	52.37	41.30
SOAKED (Laterite + Lime + CLBF) OYIGBA TOWN ROAD	7.80	18.65	29.05	37.25	33.89
UNSOAKED (Laterite + Cement + CLBF) ANAKPO TOWN ROAD	7.80	28.35	42.85	59.35	51.45
UNSOAKED (Laterite + Lime + CLBF) ANAKPO TOWN ROAD	7.80	25.48	39.35	53.55	48.75

SOAKED(Laterite + Cement + CLBF) ANAKPO TOWN ROAD	7.20	23.15	38.65	49.65	43.45
SOAKED (Laterite + Lime + CLBF) ANAKPO TOWN ROAD	7.20	22.95	36.85	49.57	44.70
UNSOAKED (Laterite + Cement + CLBF) UPATABO TOWN ROAD	9.40	28.65	47.35	67.87	53.83
UNSOAKED (Laterite + Lime + CLBF) UPATABO TOWN ROAD	9.40	25.70	39.05	52.75	49.05
SOAKED(Laterite + Cement + CLBF) UPATABO TOWN ROAD	8.50	23.65	42.85	59.64	51.35
SOAKED (Laterite + Lime + CLBF) UPATABO TOWN ROAD	8.50	23.45	36.65	49.35	43.60
UNSOAKED (Laterite + Cement + CLBF) IHUBULUKO TOWN ROAD	10.60	31.95	48.30	73.85	57.85
UNSOAKED (Laterite + Lime + CLBF) IHUBULUKO TOWN ROAD	10.60	28.95	39.50	57.58	51.75
SOAKED(Laterite + Cement + CLBF) IHUBULUKO TOWN ROAD	9.80	27.85	43.65	68.73	53.65
SOAKED (Laterite + Lime + CLBF) IHUBULUKO TOWN ROAD	9.80	25.08	36.85	53.30	47.08

Table 3.4A: Results of California Bearing Ratio (CBR) Percentile Increase / Decrease of Niger Deltaic Lateritic Soils Subgrade with CLBF + Cement / Lime of (Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Towns), Rivers State

RATIO %	100%	97.25+0.25 +2.5%	94.5+ 0.5 + 5.0%	91.75+0.75 +7.5%	89+1.0 +10%
UNSOAKED (Laterite + Cement + CLBF) ODIOKWU TOWN ROAD	2.626%	224.57%	519.40%	684.34%	596.98%
UNSOAKED (Laterite + Lime + CLBF) ODIOKWU TOWN ROAD	2.914%	257.06%	409.36%	640.97%	513.38%
SOAKED(Laterite + Cement + CLBF) ODIOKWU TOWN ROAD	3.410%	311.64%	484.53%	665.25%	541.27%
SOAKED (Laterite + Lime + CLBF) ODIOKWU TOWN ROAD	2.633%	225.27%	360.21%	631.65%	474.66%
UNSOAKED (Laterite + Cement + CLBF) OYIGBA TOWN ROAD	3.72%	345.50%	572.56%	758.44%	498.44%
UNSOAKED (Laterite + Lime + CLBF) OYIGBA TOWN ROAD	2.51%	211.36%	355.13%	540.19%	484.31%
SOAKED(Laterite + Cement + CLBF) OYIGBA TOWN ROAD	3.20%	288.61%	464.25%	640.15%	498.22%
SOAKED (Laterite + Lime + CLBF) OYIGBA TOWN ROAD	2.39%	197.28%	330.61%	435.74%	392.66%
UNSOAKED (Laterite + Cement + CLBF) ANAKPO TOWN ROAD	3.63%	335.95%	521.85%	733.38%	632.10%
UNSOAKED (Laterite + Lime + CLBF) ANAKPO TOWN ROAD	3.27%	296.05%	473.87%	655.93%	594.39%
SOAKED(Laterite + Cement + CLBF) ANAKPO TOWN ROAD	3.22%	290.43%	505.70%	658.48%	572.37%
SOAKED (Laterite + Lime + CLBF) ANAKPO TOWN ROAD	3.19%	287.38%	480.43%	657.10%	589.46%
UNSOAKED (Laterite + Cement + CLBF) UPATABO TOWN ROAD	3.05%	271.98%	470.91%	689.21%	539.85%
UNSOAKED (Laterite + Lime + CLBF) UPATABO TOWN ROAD	2.73%	236.83%	378.85%	524.59%	485.23%
SOAKED(Laterite + Cement + CLBF) UPATABO TOWN ROAD	2.78%	242.29%	468.18%	665.71%	568.18%
SOAKED (Laterite + Lime + CLBF) UPATABO TOWN ROAD	2.76%	239.64%	394.93%	544.34%	476.69%
UNSOAKED (Laterite + Cement + CLBF) IHUBULUKO TOWN ROAD	3.01%	268.24%	422.48%	663.52%	512.58%
UNSOAKED (Laterite + Lime + CLBF) IHUBULUKO TOWN ROAD	2.73%	236.50%	336.03%	506.59%	451.59%
SOAKED(Laterite + Cement + CLBF) IHUBULUKO TOWN ROAD	2.84%	249.00%	410.22%	666.14%	512.26%
SOAKED (Laterite + Lime + CLBF) IHUBULUKO TOWN ROAD	2.56%	216.84%	336.95%	504.80%	441.33%

Table 3.5: Results of Liquid Limit (LL) of Niger Deltaic Lateritic Soils Subgrade with CLBF + Cement / Lime of (Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Towns), Rivers State

RATIO %	100%	97.25+0.25 +2.5%	94.5+ 0.5 + 5.0%	91.75+0.75 +7.5%	89+1.0 +10%
LL(Laterite + Cement + CLBF) ODIOKWU TOWN ROAD	39.75	40.35	42.45	43.67	45.15
LL (Laterite + Lime + CLBF)ODIOKWU TOWN ROAD	39.75	39.15	38.45	38.05	36.75
LL(Laterite + Cement + CLBF) OYIGBA TOWN ROAD	36.90	38.75	38.95	40.15	42.10
LL (Laterite + Lime + CLBF)OYIGBA TOWN ROAD	36.90	36.45	35.67	35.05	34.25
PL(Laterite + Cement + CLBF) ANAKPO TOWN ROAD	21.45	27.08	22.70	25.18	36.00
PL (Laterite + Lime + CLBF) ANAKPO TOWN ROAD	21.68	21.65	22.67	22.45	21.89
LL(Laterite + Cement + CLBF) UPATABO TOWN ROAD	36.85	37.93	39.15	41.35	42.35
LL (Laterite + Lime + CLBF) UPATABO TOWN ROAD	36.85	36.28	35.85	35.25	34.65
LL(Laterite + Cement + CLBF) IHUBULUKO TOWN ROAD	37.65	39.86	40.85	42.30	44.35
LL (Laterite + Lime + CLBF)IHUBULUKO TOWN ROAD	37.65	37.18	36.75	36.25	35.78

Table 3.5A: Results of Liquid Limit (LL) Percentile Increase / Decrease of Niger Deltaic Lateritic Soils Subgrade with CLBF + Cement / Lime of (Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Towns), Rivers State

RATIO %	100%	97.25+0.25 +2.5%	94.5+ 0.5 + 5.0%	91.75+0.75 +7.5%	89+1.0 +10%
LL(Laterite + Cement + CLBF) ODIOKWU TOWN ROAD	1.015%	2.996%	8.279%	11.349%	15.072%
LL (Laterite + Lime + CLBF)ODIOKWU TOWN ROAD	0.985%	-3.042%	-4.803%	-5.809%	-9.080%
LL(Laterite + Cement + CLBF) OYIGBA TOWN ROAD	1.05%	9.79%	10.33%	13.58%	18.87%
LL (Laterite + Lime + CLBF)OYIGBA TOWN ROAD	0.99%	-2.45%	-4.57%	-6.25%	-8.42%
PL(Laterite + Cement + CLBF) ANAKPO TOWN ROAD	1.26%	47.04%	26.62%	38.18%	88.62%
PL (Laterite + Lime + CLBF) ANAKPO TOWN ROAD	1.00%	-0.28%	4.43%	3.41%	0.83%
LL(Laterite + Cement + CLBF) UPATABO TOWN ROAD	1.03%	5.78%	9.09%	15.06%	17.77%
LL (Laterite + Lime + CLBF) UPATABO TOWN ROAD	0.98%	-3.12%	-4.28%	-5.91%	-7.54%
LL(Laterite + Cement + CLBF) IHUBULUKO TOWN ROAD	1.06%	11.41%	14.04%	17.90%	23.34%
LL (Laterite + Lime + CLBF)IHUBULUKO TOWN ROAD	0.99%	-2.51%	-3.65%	-4.98%	-6.23%

Table 3.6: Results of Plastic Limit (PL) of Niger Deltaic Lateritic Soils Subgrade with CLBF + Cement / Lime of (Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Towns), Rivers State

RATIO %	100%	97.25+0.25 +2.5%	94.5+ 0.5 + 5.0%	91.75+0.75 +7.5%	89+1.0 +10%
PL(Laterite + Cement + CLBF) ODIOKWU TOWN ROAD	22.45	24.65	25.85	26.98	27.85
PL (Laterite + Lime + CLBF) ODIOKWU TOWN ROAD	22.45	22.10	21.70	21.68	21.65
PL(Laterite + Cement + CLBF) ODIOKWU TOWN ROAD	22.67	23.85	24.45	26.10	27.13
PL (Laterite + Lime + CLBF) OYIGBA TOWN ROAD	22.67	22.45	22.45	22.10	21.70
PL(Laterite + Cement + CLBF) ANAKPO TOWN ROAD	21.45	27.08	22.70	25.18	36.00
PL (Laterite + Lime + CLBF) ANAKPO TOWN ROAD	21.68	21.65	22.67	22.45	21.89
PL(Laterite + Cement + CLBF) UPATABO TOWN ROAD	19.35	20.48	21.37	22.55	23.50
PL (Laterite + Lime + CLBF) UPATABO TOWN ROAD	21.75	21.40	21.45	20.72	20.50
PL(Laterite + Cement + CLBF) IHUBULUKO TOWN ROAD	21.55	22.15	22.90	23.75	25.12
PL (Laterite + Lime + CLBF) IHUBULUKO TOWN ROAD	20.45	20.83	19.35	18.90	18.81

Table 3.6A: Results of Plastic Limit (PL) Percentile Increase / Decrease of Niger Deltaic Lateritic Soils Subgrade with CLBF + Cement / Lime of (Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Towns), Rivers

RATIO %	100.00%	97.25+0.25 +2.5%	94.5+ 0.5 + 5.0%	91.75+0.75 +7.5%	89+1.0 +10%
PL(Laterite + Cement + CLBF) ODIOKWU TOWN ROAD	1.10%	18.72%	24.07%	29.10%	32.98%
PL (Laterite + Lime + CLBF) ODIOKWU TOWN ROAD	0.98%	-3.14%	-4.92%	-5.01%	-5.15%
PL(Laterite + Cement + CLBF) ODIOKWU TOWN ROAD	1.05%	10.15%	12.80%	20.08%	24.62%
PL (Laterite + Lime + CLBF) OYIGBA TOWN ROAD	0.99%	-1.95%	-1.95%	-3.49%	-5.26%
PL(Laterite + Cement + CLBF) ANAKPO TOWN ROAD	1.26%	47.04%	26.62%	38.18%	88.62%
PL (Laterite + Lime + CLBF) ANAKPO TOWN ROAD	1.00%	-0.28%	4.43%	3.41%	0.83%
PL(Laterite + Cement + CLBF) UPATABO TOWN ROAD	1.06%	11.36%	15.96%	22.06%	26.96%
PL (Laterite + Lime + CLBF) UPATABO TOWN ROAD	0.98%	-3.24%	-3.01%	-6.37%	-7.38%
PL(Laterite + Cement + CLBF) IHUBULUKO TOWN ROAD	1.03%	5.49%	8.97%	12.92%	19.27%
PL (Laterite + Lime + CLBF) IHUBULUKO TOWN ROAD	1.02%	3.68%	-3.55%	-5.76%	-6.20%

Table 3.7: Results of Plastic Index (PI) of Niger Deltaic Lateritic Soils Subgrade with CLBF + Cement / Lime of (Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Towns), Rivers State

RATIO %	100%	97.25+0.25 +2.5%	94.5+ 0.5 + 5.0%	91.75+0.75 +7.5%	89+1.0 +10%
PI (Laterite + Cement + CLBF) ODIOKWU TOWN ROAD	17.30	16.20	15.90	15.70	15.40
PI (Laterite + Lime + CLBF) ODIOKWU TOWN ROAD	17.30	17.05	16.75	16.25	15.75
PI (Laterite + Cement + CLBF) OYIGBA TOWN ROAD	14.23	14.50	12.80	11.80	12.80
PI (Laterite + Lime + CLBF) OYIGBA TOWN ROAD	14.23	14.00	13.78	13.30	12.85
PI (Laterite + Cement + CLBF) ANAKPO TOWN ROAD	15.30	15.15	14.87	14.75	14.47
PI (Laterite + Lime + CLBF) ANAKPO TOWN ROAD	15.30	15.18	14.75	14.20	14.02
PI (Laterite + Cement + CLBF) UPATABO TOWN ROAD	17.50	16.58	16.20	17.00	15.50
PI (Laterite + Lime + CLBF) UPATABO TOWN ROAD	17.50	17.38	17.04	16.78	16.23
PI (Laterite + Cement + CLBF) IHUBULUKO TOWN ROAD	16.10	16.71	15.47	15.25	15.20
PI (Laterite + Lime + CLBF) IHUBULUKO TOWN ROAD	16.10	15.85	15.50	15.18	14.85

Table 3.7A: Results of Plastic Limit (PL) Percentile Increase / Decrease of Niger Deltaic Lateritic Soils Subgrade with CLBF + Cement / Lime of (Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Towns), Rivers State

RATIO %	100%	97.25+0.25 +2.5 %	94.5+ 0.5 + 5.0%	91.75+0.75 +7.5%	89+1.0 +10%
PI (Laterite + Cement + CLBF) ODIOKWU TOWN ROAD	0.94%	-13.15%	-14.88%	-16.04%	-17.77%
PI (Laterite + Lime + CLBF) ODIOKWU TOWN ROAD	0.99%	-2.91%	-4.65%	-7.54%	-10.43%
PI (Laterite + Cement + CLBF) OYIGBA TOWN ROAD	1.02%	3.76%	-8.19%	-15.21%	-8.19%
PI (Laterite + Lime + CLBF) OYIGBA TOWN ROAD	0.98%	-3.26%	-4.81%	-8.18%	-11.34%
PI (Laterite + Cement + CLBF) ANAKPO TOWN ROAD	0.99%	-1.97%	-3.80%	-4.58%	-6.41%
PI (Laterite + Lime + CLBF) ANAKPO TOWN ROAD	0.99%	-1.57%	-4.39%	-7.98%	-9.16%
PI (Laterite + Cement + CLBF) UPATABO TOWN ROAD	0.95%	-10.81%	-12.98%	-8.41%	-16.98%
PI (Laterite + Lime + CLBF) UPATABO TOWN ROAD	0.99%	-1.38%	-3.32%	-4.80%	-7.95%
PI (Laterite + Cement + CLBF) IHUBULUKO TOWN ROAD	1.04%	7.44%	-0.26%	-1.63%	-1.94%
PI (Laterite + Lime + CLBF) IHUBULUKO TOWN ROAD	0.98%	-3.13%	-5.30%	-7.29%	-9.34%

Table 3.8: Results of Unconfined Compressive Strength (UCS) of Niger Deltaic Lateritic Soils Subgrade with CLBF + Cement / Lime of (Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Towns), Rivers State

RATIO %	100%	97.25+0.25 +2.5%	94.5+ 0.5 + 5.0%	91.75+0.75 +7.5%	89+1.0 +10%
UCS (Laterite + Cement + CLBF) ODIOKWU TOWN ROAD	178.00	227.00	284.00	343.00	414.00
UCS(Laterite + Lime + CLBF) ODIOKWU TOWN ROAD	178.00	212.00	245.00	297.00	345.00
UCS (Laterite + Cement + CLBF)OYIGBA TOWN ROAD	145.00	205.00	265.00	315.00	378.00
UCS(Laterite + Lime + CLBF)BODO TOWN ROAD	145.00	174.00	224.00	268.00	315.00
UCS(Laterite + Cement + CLBF) ANAKPO TOWN ROAD	165.00	215.00	278.00	335.00	395.00
UCS (Laterite + Lime + CLBF) ANAKPO TOWN ROAD	165.00	195.00	255.00	285.00	325.00
UCS (Laterite + Cement + CLBF) UPATABO TOWN ROAD	158.00	208.00	258.00	328.00	381.00
UCS(Laterite + Lime + CLBF) UPATABO TOWN ROAD	158.00	186.00	215.00	278.00	318.00
UCS (Laterite + Cement + CLBF) IHUBULUKOTOWN ROAD,	145.00	215.00	245.00	298.00	345.00
UCS(Laterite + Lime + CLBF) IHUBULUKO TOWN ROAD,	145.00	181.00	220.00	267.00	310.00

Table 3.8A: Results of Unconfined Compressive Strength (UCS) Percentile Increase / Decrease of Niger Deltaic Lateritic Soils Subgrade with CLBF + Cement / Lime of (Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Towns), Rivers State

RATIO %	100%	97.25+0.25 +2.5%	94.5+ 0.5+ 5.0%	91.75+0.75 +7.5%	89+1.0 +10%
UCS (Laterite + Cement + CLBF) ODIOKWU TOWN ROAD	1.28%	49.11%	81.14%	114.28%	154.17%
UCS(Laterite + Lime + CLBF) ODIOKWU TOWN ROAD	1.19%	35.14%	53.68%	82.89%	109.86%
UCS (Laterite + Cement + CLBF)OYIGBA TOWN ROAD	1.41%	70.65%	112.03%	146.51%	189.96%
UCS(Laterite + Lime + CLBF)BODO TOWN ROAD	1.20%	36.67%	71.15%	101.49%	133.91%
UCS(Laterite + Cement + CLBF) ANAKPO TOWN ROAD	1.30%	53.56%	91.74%	126.29%	162.65%
UCS (Laterite + Lime + CLBF) ANAKPO TOWN ROAD	1.18%	33.57%	69.93%	88.11%	112.35%
UCS (Laterite + Cement + CLBF) UPATABO TOWN ROAD	1.32%	55.68%	87.33%	131.63%	165.18%
UCS(Laterite + Lime + CLBF) UPATABO TOWN ROAD	1.18%	32.78%	51.13%	91.00%	116.32%
UCS (Laterite + Cement + CLBF) IHUBULUKO TOWN ROAD	1.48%	80.83%	101.52%	138.08%	170.49%
UCS(Laterite + Lime + CLBF) IHUBULUKO TOWN ROAD	1.25%	44.72%	71.61%	104.03%	133.68%

Table 3.8A: Results of Unconfined Compressive Strength (UCS) Percentile Increase / Decrease of Niger Deltaic Lateritic Soils Subgrade with CLBF + Cement / Lime of (Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Towns), Rivers State

RATIO %	100%	97.25+0.25 +2.5%	94.5+ 0.5+ 5.0%	91.75+0.75 +7.5%	89+1.0 +10%
UCS (LATERITE + CEMENT + CLBF) ODIOKWU TOWN ROAD	1.275281	49.11399	81.13646	114.2825	154.1702
UCS(LATERITE + LIME + CLBF) ODIOKWU TOWN ROAD	1.191011	35.13886	53.67819	82.89167	109.858
UCS (LATERITE + CEMENT + CLBF) OYIGBA TOWN ROAD	1.413793	70.6476	112.0269	146.5097	189.9579
UCS(LATERITE + LIME + CLBF) OYIGBA TOWN ROAD	1.234	36.66667	71.14943	101.4943	133.908
UCS(LATERITE + CEMENT + CLBF) ANAKPO TOWN ROAD	1.30303	53.55884	91.74066	126.2861	162.6498
UCS (LATERITE + LIME + CLBF) ANAKPO TOWN ROAD	1.181818	33.56643	69.93007	88.11189	112.3543
UCS (LATERITE + CEMENT + CLBF) UPATABO TOWN ROAD	1.316456	55.68403	87.3296	131.6334	165.1777
UCS(LATERITE + LIME + CLBF) UPATABO TOWN ROAD	1.177215	32.77528	51.12971	91.00313	116.3196
UCS (LATERITE + CEMENT + CLBF) IHUBULUKOTOWN ROAD,	1.482759	80.834	101.5237	138.0754	170.4892
UCS(LATERITE + LIME + CLBF) IHUBULUKO TOWN ROAD,	1.248276	44.71709	71.61364	104.0274	133.6826

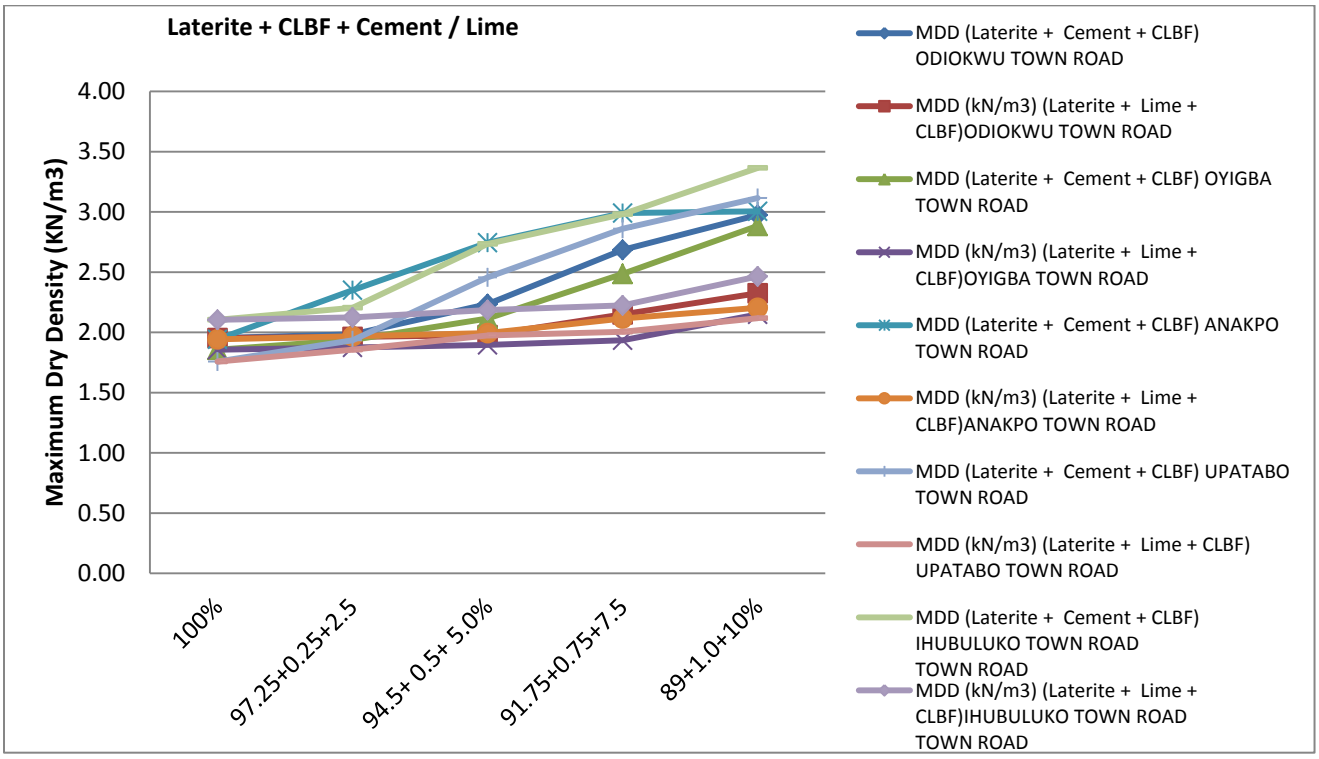

Figure 3.1: Maximum Dry Density (MDD) of Niger Deltaic Lateritic Soils Subgrade with CLBF + Cement / Lime of (Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Towns), Rivers State

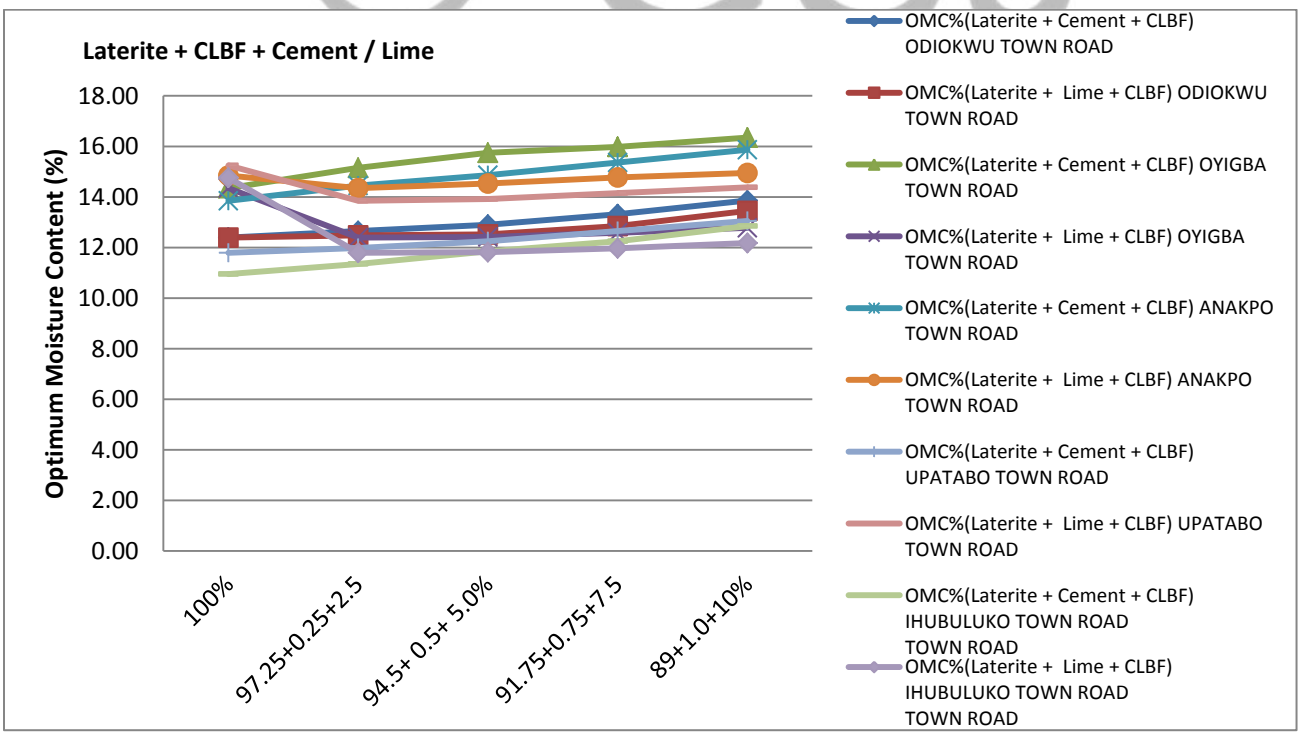

Figure 3.2: Optimum Moisture Content (OMC) of Niger Deltaic Lateritic Soils Subgrade with CLBF + Cement / Lime of (Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Towns), Rivers State

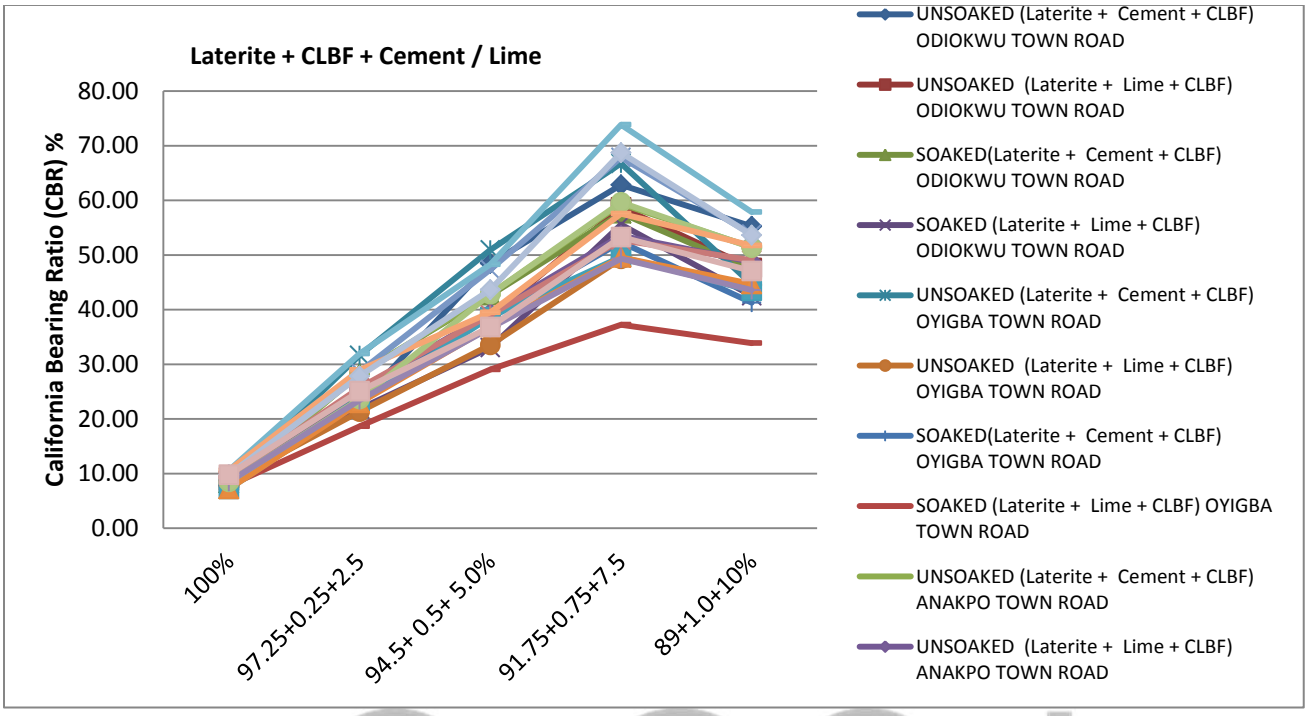

Figure 3.3: California Bearing Ratio (CBR) of Niger Deltaic Lateritic Soils Subgrade with CLBF + Cement / Lime of (Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Towns), Rivers State

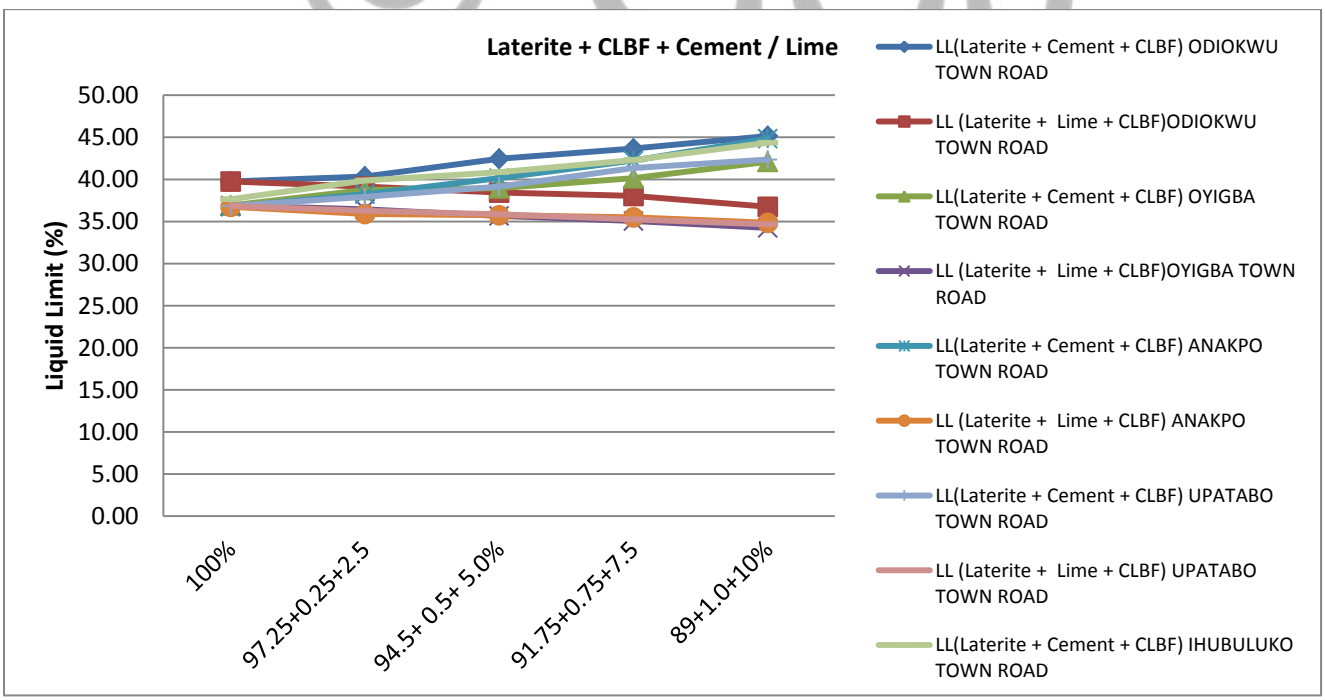

Figure 3.4: Liquid Limit (LL) of Niger Deltaic Lateritic Soils Subgrade with CLBF + Cement / Lime of (Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Towns), Rivers State

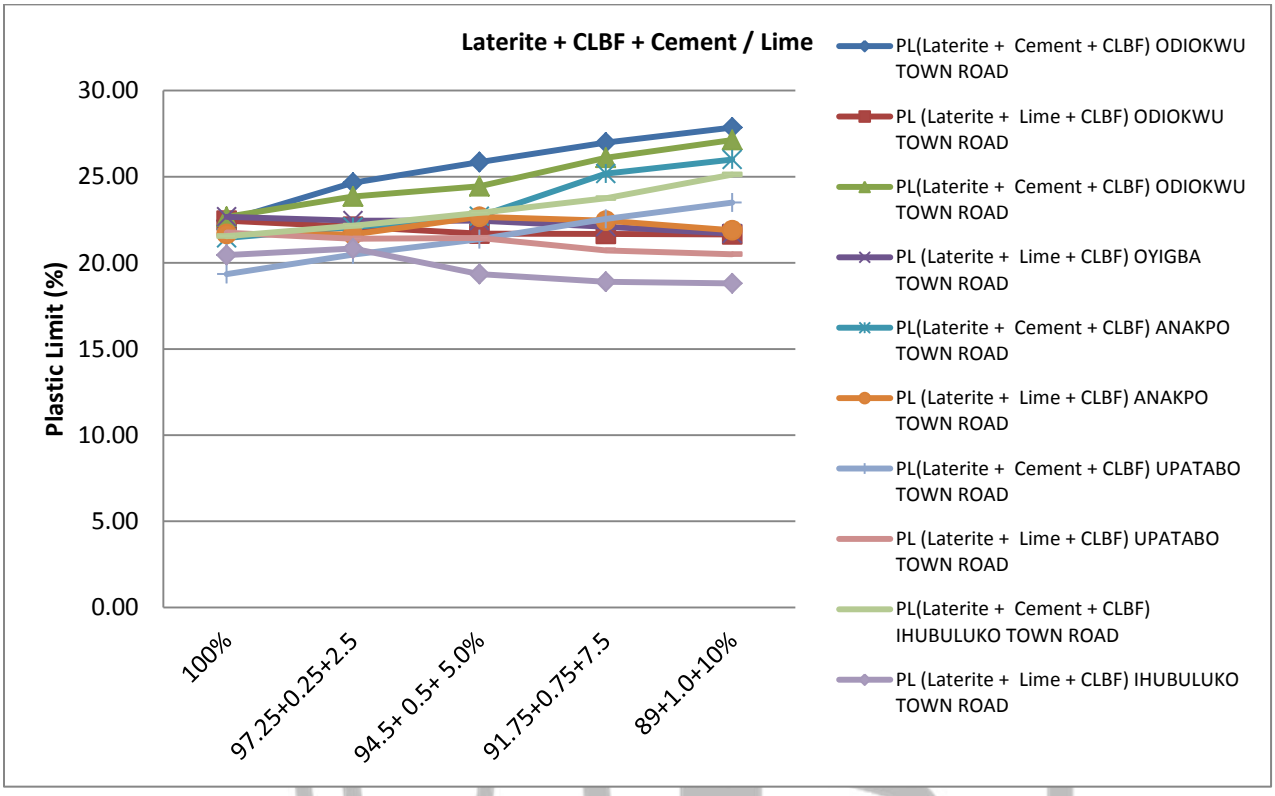

Figure 3.5: Plastic Limit (PL) of Niger Deltaic Lateritic Soils Subgrade with CLBF + Cement / Lime of (Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Towns), Rivers State

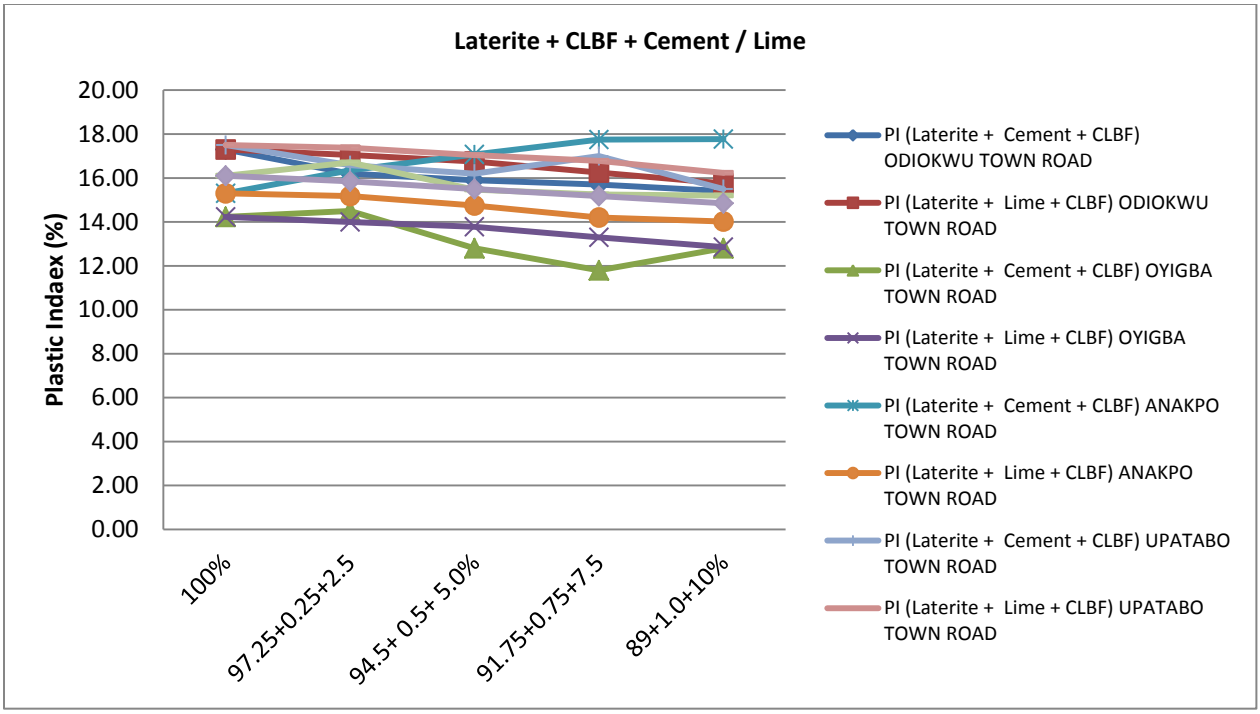

Figure 3.6: Plastic Index (PI) of Niger Deltaic Lateritic Soils Subgrade with CLBF + Cement / Lime of (Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Towns), Rivers State

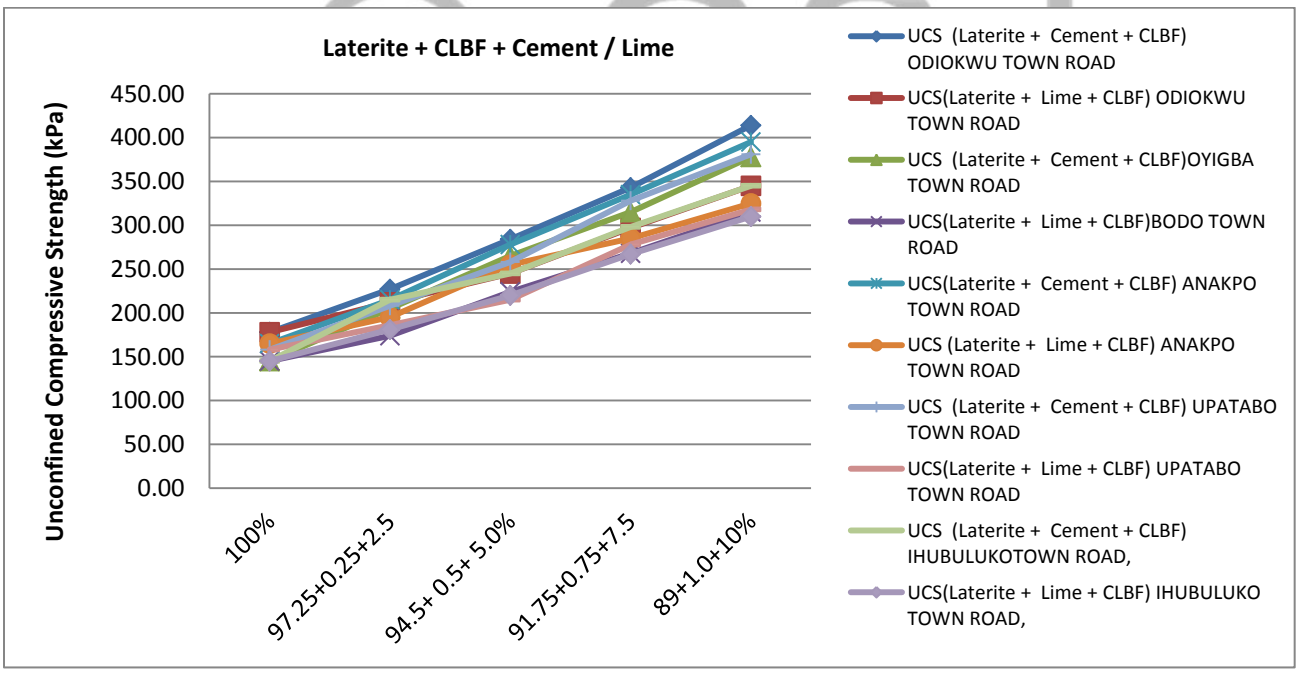

Figure 3.7: Unconfined Compressive Strength (UCS) of Niger Deltaic Laterite Soils Subgrade with CLBF + Cement / Lime of (Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Towns), Rivers State

4.0 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. The soils are reddish brown and dark grey in color plasticity index of 17.30%, 14.23%, 15.20%, 15.50%, and 16.10% respectively for Odiokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Town Roads

iii. The soil has un Soaked CBR values of 8.7%,8.5%, 7.8%, 9.4%, and 10.6% and Soaked CBR values of 8.3%, 7.8%, 7.2%, 8.5% and 9.8 %, unconfined compressive strength values of 178kPa, 145kPa, 165kPa ,158kPa and 149kPa when compacted with British Standard light, respectively.

iv. Maximum dry density (MDD) and optimum moisture content (OMC) demonstrated incremental percentile values with incease in composite stabilizers inclusion percentages ratio to soils.

v. Incremental percentile values of California bearing ratio (CBR) stabilized soils with cement, lime and CLBF showed optimum percentile ratio at 91.75+0.75 +7.5% were obtained.

vi. Results confirmed that both cementitious agents showed good combination with CLBF.

vii. Unconfined compressive strength test of stabilized soils with cement / lime + CLBF showed incremental percentile relatively to the percentage ratios to stabilizers and soils.

viii. Results of consistency limits (Plastic Index) test showed percentile decreased values with increased in composite materials to soil

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