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COMPARATIVE EVALUATION OF EFFECTIVENESS OF CEMENT / LIME AND COSTUS AFER BAGASSE FIBER STABILIZATION OF EXPANSIVE SOIL

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ABSTRACT

The study 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. The preliminary results obtained classified the soil as A-2 -7 on the AASHTO classification scheme and soils at natural state are percentage (%) passing BS sieves #200 are 80.5%. The soils from wet to dry states are dark grey in color with consistency limit properties of liquid limit of 56.1 %, plastic limit of 22.4 %, plasticity index of 33.7%. The specific gravity properties are 2.65 % and natural moisture content 45.5 %. The compaction characteristic properties were optimum moisture content 12.39 %, Maximum dry density 1.64kN/m^3. The preliminary investigation values indicated that the soils are highly plastic. 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. OMC of soil + cement + BSBF treated soils increased from 12.93% to 13.10% (clay) and soil + lime + bagasse fibre treated soils, OMC increased from 12.93% to 24.61% (clay) with 90.332% higher of lime compared to that of cement. MDD of (clay), soil + cement + BSBF of ratio above increased from 1.640kN/m^3 and 1.79kN/m^3 and soil + lime + bagasse fibre treated soils increased from 1.640KN/m^3 to 1.864KN/m^3 (clay), with 3.91% higher in cement treated. CBR test results of (clay) soil + cement + bagasse fibre (BSBF) increased from 7.6% to 24.7% and lime + soil treated, increased from 7.6% to 16.4% with 50.6% higher in cement treated soil, both cement / lime + BSBF having an optimum inclusion percentage ratio of soils 92% + cement 7.25 + BSBF 0.75%. UCS test results of soil + cement + BSBF increased from 78.6kPa to 678kPa while soil + lime + BSBF increased from 78.6kPa to 308kPa, with 120.1% higher in cemented to lime treated. Consistency limits test results showed decreased values from 56.1% to 47.9% (clay) soil + cement + BSBF treated soils and soil + lime + BSBF treated soil, LL decreased from 56.1% to 47.7%. Entire results showed strength increased in clay soil with the composite materials, with higher values in cement to lime treated soil.

Key Words: Clay and lateritic soils, Costus Afer Fibre , CBR, UCS, Consistency, Compaction

1.0 INTRODUCTION

Bagasse is a fibrous residue that remains after crushing the stalks of Bush Sugarcane, and contains short fibers. It consists of water, fibers, and small amounts of soluble solids. Percentage contribution of each of these components varies according to the variety, maturity, method of harvesting, and the efficiency of the crushing plant. When juice is extracted from the cane sugar, the solid waste material is known as bagasse. When this waste is burned it gives ash called as bagasse ash. When this bagasse is burnt the resultant ash is bagasse ash. Western Maharashtra is having maximum number of sugar factories, these factories faces a disposal problem of large quantity bagasse.

Sabat [1] , investigated the effects of bagasse ash and lime sludge on OMC, MDD, UCS, soaked CBR and Swelling pressure of an expansive soil in order to study its cost effectiveness in strengthening the sub-grade of a flexible pavement in expansive soil areas. The best stabilization effects were obtained when the optimum percentage of bagasse ash was 8% and lime sludge was 16%.

Manikandan and Moganraj [2], found that the combined effect of bagasse ash and lime were more effective than the effect of bagasse ash alone in controlling the consolidation characteristics of expansive soil along with the improvement in other properties.

Gandhi [3] successfully worked on improving the existing poor and expansive sub grade soil using bagasse ash. Bagasse ash effectively dries wet soils and provides an initial rapid strength gain, which is useful during construction in wet, unstable ground conditions. The swell potential of expansive soils decreases by replacing some of the volume previously held by order to evaluate the possibility of their use in the industry. He conducted tests like Liquid Limit, Plastic Limit, Plasticity Index, Shrinkage Limit, Free Swell Index and Swelling Pressure with the increasing percentage of Bagasse ash at 0 %, 3 %, 5 %, 7 % and 10 % respectively .He found out that as the percentage of bagasse ash increases in the soil sample, all the properties decrease.

Rao *et al*., [4] studied the effects of RHA, lime and gypsum on engineering properties of expansive soil and found that UCS increased by 548 % at 28 days of curing and CBR increased by 1350 % at 14 days curing at RHA- 20%, lime -5 % and gypsum -3%.

Sabat [5] studied the effect of lime sludge (from paper manufacturing industry) on compaction, CBR, shear strength parameters, coefficient of compression, Ps and durability of an expansive soil stabilized with optimum percentage of RHA after 7days of curing. The optimum proportion soil: RHA: lime sludge was found to be 75:10:15.

Amu *et al*., [6] used (Class- F) fly ash and cement for stabilization of expansive soil. It was found that stabilizing effect of 9% cement and 3% fly ash was better than the stabilizing effect 12 % cement.

Cokca [7], Nalbantoglu [8] ,Pandian and Krishna [9] and Misra *et al*., [10] studied effect of class- C fly ash on different engineering properties of expansive soil and had found varied success.

Sharma and Gupta [11] investigated the effect of fly ash(class-F) on sand stabilized black cotton soil based on compaction and CBR test the optimum proportion of soil: sand :fly ash was found to be 63:27:15.

2.0 MATERIALS AND METHODS

2.1 Materials

2.1.1 Soil

The deltaic soils (laterite) are abundant in Rivers State within the dry flat country. The soils used for the study was collected from a borrow pit at 1.5 m depth, at Odioku – Odiereke Town Road, Ubie Clan, Ahoada-West, Rivers State, Nigeria, lies on the recent coastal plain of the North-Western of Rivers state of Niger Delta.

2.1.2 Lime

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

2.1.3 Costus Afer (Bush Sugarcane) Bagasse Fibre

The bush sugarcane bagasse fibre are abundant in Rivers State farmlands / bushes, they are wide plants and covers larger areas, collected from at Odioku Town Farmland / Bush, Ubie Clan, Ahoada-West, Rivers State, Nigeria.

2.1.4 Cement

The cement used was Eagle Portland Cement, purchased in the open market at Mile 3 market road, Port Harcourt, Rivers State

2.3 METHOD

2.3.1 Sampling Locality

The soil sample used in this study were collected along Odioku Community road in Ahoada West Local Government, in Rivers state, of Nigeria, (latitude 5.07° 14'S and longitude 6.65° 80'E), from trial borrow-pits the various earthworks within the entire roads. The top soil was removed to a depth of 0.5 m before the soil samples were taken, sealed in plastic bags and put in sacks to avoid loss of moisture during transportation. All samples were air dried for about two weeks to take advantage of the aggregating potentials of lateritic soils upon exposure (Allam and Sridharan [12]; Omotosho and Akinmusuru [13]) .

These tests were conducted to prove that fibre product at varying proportions to give positive effect on the stabilization of soil and with binding cementitious inclusions. A number of tests were conducted as these tests include (1) Moisture Content Determination (2) Atterberg limits test (3) Particle size distribution (sieve analysis) and (4) Standard Proctor Compaction test, Califonia Bearing Ratio test (CBR) and Unconfined compressive strength (UCS) tests;

2.3.1 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.

2.3.2 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.

2.3.3 Consistency Limits

This test is performed to determine the plastic and liquid limits of a fine grained soil. 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. The plastic limit (PL) is the water content, in percent, at which a soil can no longer be deformed by rolling into 3.2 mm (1/8 in.) diameter threads without crumbling.

2.3.4 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. The compactive effort is the amount of mechanical energy that is applied to the soil mass. Several different methods are used to compact soil in the field, and some examples include tamping, kneading, vibration, and static load compaction. This laboratory will employ the tamping or impact compaction method using the type of equipment and methodology developed by R. R. Proctor in 1933, therefore, the test is also known as the Proctor test.

2.3.5 Unconfined Compression (UC) 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. According to the ASTM standard, the unconfined compressive strength (qu) is defined as the compressive stress at which an unconfined cylindrical specimen of soil will fail in a simple compression test. In addition, in this test method, 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.

2.3.6 California Bearing Ratio (CBR) Test

The California Bearing Ratio (CBR) test was developed by the California Division of Highways as a method of classifying and evaluating soil- subgrade and base course materials for flexible pavements. CBR is a measure of resistance of a material to penetration. The CBR tests were performed in order to determine effect of fibre inclusion on CBR values of reinforced soils.

3.0 RESULTS AND DISCUSSIONS

Table 3.1 showed the preliminary laboratory analysis of the engineering properties of soil (clay) sample, results obtained classified the soil as A-2 -7 on the AASHTO classification scheme and soils at natural state are percentage (%) passing BS sieves #200 are 80.5% (clay). The soils from wet to dry states are dark grey in color with consistency limit properties of liquid limit of 56.1 %, plastic limit of 22.4 %, plasticity index of 33.7%. The specific gravity properties are 2.65 % and natural moisture content 45.5 %. The compaction characteristic properties were optimum moisture content 12.39 %, Maximum dry density 1.64kN/m^3. The preliminary investigation values indicated that the soils are highly plastic.

3.1 Compaction Test Results

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.

OMC of Soil + cement + BSBF treated soils increased from 12.93% to 13.10% (clay) and soil + lime + bagasse fibre treated soils, OMC increased from 12.93% to 24.61% (clay) with 90.332% higher of lime compared to that of cement. MDD of (Clay), soil + cement + BSBF of ratio above increased from 1.640KN/m^3 and 1.79KN/m^3 and soil + lime + bagasse fibre treated soils increased from 1.640KN/m^3 to 1.864KN/m^3 (clay), with 3.91% higher in cement treated.

3.2 California Bearing Ratio (CBR) Test

CBR test results of (clay) soil + cement + bagasse fibre (BSBF) increased from 7.6% to 24.7% and lime + soil treated, increased from 7.6% to 16.4% with 50.6% higher in cement treated soil, both cement / lime + BSBF having an optimum inclusion percentage ratio of soils 92% + cement 7.25 + BSBF 0.75%.

3.3 Unconfined Compressive Strength Test

Results of (clay) soil + cement + BSBF increased from 78.6kPa to 678kPa while soil + lime + BSBF increased from 78.6kPa to 308kPa, with 120.1% higher in cemented to lime treated.

3.4 Consistency Limits Test

Results showed decreased values from 56.1% to 47.9% (clay) soil + cement + BSBF treated soils and soil + lime + BSBF treated soil, LL decreased from 56.1% to 47.7% .

Table 3.1: Engineering Properties Soil (Clay) Samples

	(Clay)
Percentage(%) passing BS sieve #200	80.5
Colour	Grey
Specific gravity	2.65
Natural moisture content (%)	45.5
	Atterberg limits
Liquid limit (%)	56.1
Plastic limit (%)	22.4
Plasticity Index	33.7
AASHTO CLAY classification	A-7-6
	Compaction characteristics
Optimum moisture content (%)	12.39
Maximum dry density (kN/m$^{3)}$	1.64
	Grain size distribution
Gravel (%)	0
Sand (%)	10
Silt (%)	48
Clay (%)	42
Unconfined compressive strength (kPa)	78.6
	California Bearing capacity (CBR)
Unsoaked (%) CBR	7.6
Soaked (%) CBR	7.4

Table 3.2: Properties of Bush sugarcane bagasse fibre. (Rivers State University of Science and Technology, Chemical Engineering Department, Material Lab.1)

Property	Value
Fibre form	Single
Average length (mm)	150
Average diameter (mm)	0.5
Tensile strength (MPa)	60 - 23
Modulus of elasticity (GPa)	1.1 – 0.35
Specific weight (g/cm^3)	0.52
Natural moisture content (%)	8.8
Water absorption (%)	150 - 223

Source, 2018

Table 3.3: Composition of Bagasse. (Rivers State University of Science and Technology, 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

`S/no	Description of materials Bush sugarcane bagasses fibre products	MDD (kN/m^3)	OMC (%)	CBR (%)	LL(%)	PL(%)	PI(%)	SIEVE #200	AASHTO Class	Remarks
					CLAY					
1	CLAY 100%	1.64	10.37	7.6	56.1	22.4	33.7	74.4	A-7-6.	POOR
					CLAY + CEMENT + BSBF					
7	CLAY 96%+ CEMENT 3.75% +BSBF 0.25%	1.783	10.34	13.8	54	25	29	74.4	A-7-6.	GOOD
8	CLAY 94%+ CEMENT 5.5% +BSBF 0.50%	1.789	12.02	16.8	52.7	26.6	22.1	74.4	A-7-6.	GOOD
9	CLAY 92%+ CEMENT 7.25% +BSBF 0.75%	1.791	13.10	24.7	48.5	28	20.5	74.4	A-7-6.	GOOD
10	CLAY 90%+ CEMENT 9% +BSBF1.0%	1.785	14.04	17.6	47.9	24.5	23.4	74.4	A-7-6.	GOOD
					CLAY + LIME + BSBF					
7	CLAY 96%+ LIME 3.75% +BSBF 0.25%	1.727	12.70	12.6	52	22	30	74.4	A-7-6.	GOOD
8	CLAY 94%+ LIME 5.5% +BSBF 0.50%	1.734	12.79	15.2	50.3	24.8	25.5	74.4	A-7-6.	GOOD
9	CLAY 92%+ LIME 7.25% +BSBF 0.75%	1.742	14.35	18.4	48.3	26	22.3	74.4	A-7-6.	GOOD
11	CLAY 90%+ LIME 9% +BSBF1.0%	1.735	15.07	12.8	47.7	24.7	23	74.4	A-7-6.	GOOD

Table 3.5: UNCONFINED COMPRESSIVE STRENGTH (UCS) TEST SUMMARY RESULTS

S/NO	DESCRIPTION OF MATERIALS BUSH SUGARCANE BAGASSES FIBRE PRODUCTS	2 DAYS CURING PERIODS	7 DAYS CURING PERIODS	14 DAYS CURING PERIODS	21 DAYS CURING PERIODS	28 DAYS CURING PERIODS
	CLAY					
1	CLAY 100% + LIME 0%	78.6	78.6	78.6	78.6	78.6
	CLAY + LIME + BSBF					
2	CLAY 96%+ LIME 3.75% +BSBF 0.25%	165.6	171.3	184.2	191.1	203.1
3	CLAY 94%+ LIME 5.5% +BSBF 0.50%	198.1	207.4	215.6	223.1	223.6
4	CLAY 92%+ LIME 7.25% +BSBF 0.75%	258.5	264.1	277.4	291	308.1
5	CLAY 90%+ LIME 9% +BSBF1.0%	183.4	192.1	212.1	221.1	236.1
	CLAY +CEMENT + BSBF					
6	CLAYS 100% + CEMENT 0%	78.6	78.6	78.6	78.6	
7	CLAY 96%+ CEMENT 3.75% +BSBF 0.25%	290	311	328	342	365
8	CLAY 94%+ CEMENT 5.5% +BSBF 0.50%	473	495	518	532	550
9	CLAY 92%+ CEMENT 7.25% +BSBF 0.75%	650	672	689	712	738
10	CLAY 90%+ CEMENT 9% +BSBF1.0%	583	605	636	660	678

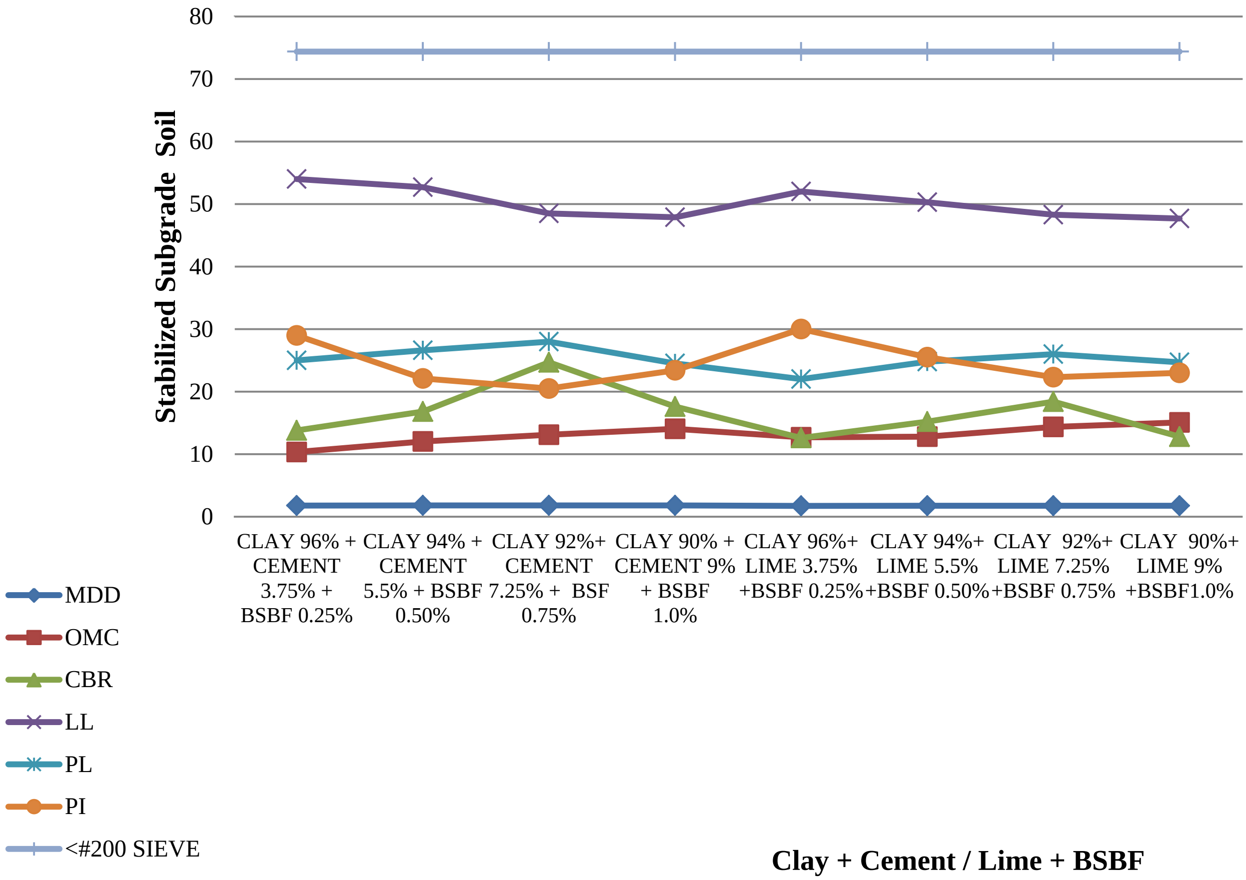

Figure 3.1: Subgrade Stabilization Test of Clay Soil from Odioku in Ahoada-West L.G.A of Rivers State with Cement / Lime + BSBF at Different Percentages and Combination

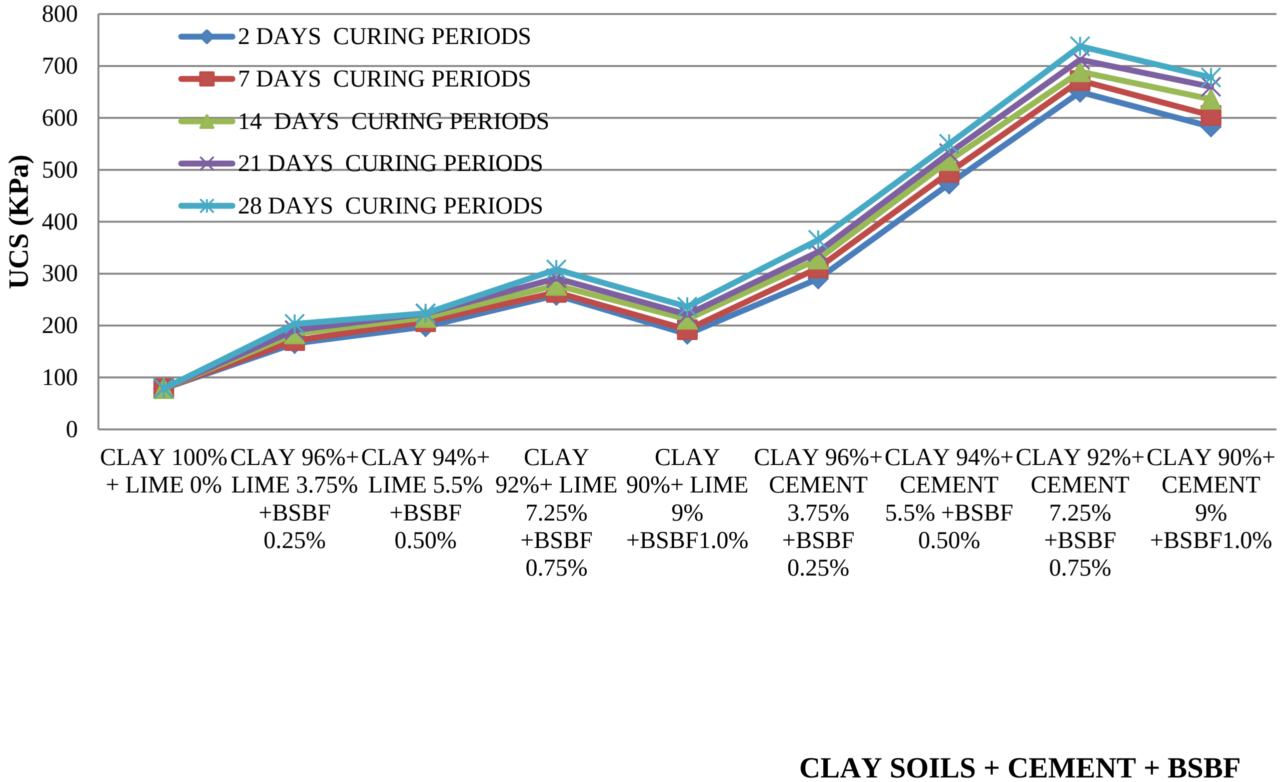

Figure 3.2: Unconfined Compressive Strength (UCS) of Clay Soil from Odioku in Ahoada-West L.G.A of Rivers State with Cement / Lime and BSBF at Different Percentages and Combinations

4.0 Conclusions

The following conclusions can be made from the final investigations:

i. Results of tests carried out show that the optimum moisture content increased with increasing cement and lime.

ii. Treated soils with Cement and Lime decreased in liquid limits and increased in plastic limits. Soils with Cement, Lime and fibre products in combinations increased CBR values appreciably both at soaked and unsoaked conditions.

iii. The entire results showed the potential of using bagasse, BSBF as admixtures in cement and lime treated soils of clay and laterite.

iv. The entire results showed the potential of using bagasse BSBF as admixture in cement and lime treated soils of clay and laterite with 8 % cement and lime and 7.5% +7.5 % of cement / lime + BSBF .

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