Effectual Use of Costaceae Lacerus Bagasse Fibre and Lime as Expansive Soil Stabilizer

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ABSTRACT

The research work investigated the effectual use of bagasse fibre of costaceae lacerus and lime in combination of 0.2+2.5%, 0.5% + 5.0%, 0.75% + 7.5% and 1.0% + 10% to soils ratio in the modification of weak soils of low properties for subgrade pavement. Soils were classified as A-2-6 SC and A-2-4 SM on the AASHTO classification schemes / Unified Soil Classification System from preliminary investigation and fell below approved standard for its application as road pavement structures. Results of consistency limits (Plastic index) properties decreased with increased in CLBF + lime inclusion to lateritic soils. The swelling potential of treated soil decreased with the inclusion of additives of 0.75% + 7.5% percentage ratio to soils. Unconfined compressive strength results showed tremendous increased with an increase in additive percentages. California bearing ratio of unsoaked and soaked reached optimum values percentage inclusion at 0.75% +7.5 %, beyond this value, crack was formed which resulted to potential failure. Entire results showed the latent use of costaceae lacerus and lime in combined actions as soil stabilizers.

Key Words: Lateritic soils, Costaceae Lacerus, Lime, CBR, UCS, Consistency, Compaction.

1. INTRODUCTION

The properties possessed by the soils determine their degree of reactivity with lime and other additives, and the ultimate strength that the stabilized layers will develop. Lime has a number of effects when added into soil which can be generally categorized as soil drying, soil modification, and soil stabilization (Bhuyan, [1]). Current trend for enhancement of engineering properties of soil is stabilization through deployment of different additives, especially industrial wastes in the projects which create scope for best utilization of abundantly available industrial waste at a substantially low cost.

Charles et al. [2] 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 cemenitious agents of cement and lime, hybridized with costus afer bagasse fibre to strength the failed section of the road. Results obtained of compaction test of Optimum moisture content (OMC) and maximum dry density (MDD) of clay soils cement bush sugarcane bagasse fibre (BSBF) reinforced soils at combined actions to soil ratios of 3.75% 0.25%, 5.5% 0.5%, 7.25% 0.75% and 9% 1.0% of cement and BSBF combined percentages.

Charles et al. [3] investigated the susceptible to pavement degradation resulted in very many failures, potholes and cracks along the stretches of Odioku road, Ahoada West, Rivers State. Stabilizers were used in single and combined actions to determine the
suitability of the composite material that will solve these problems. Treated soils with Lime decreased in liquid limits and increased in plastic limits. At 8% of lime, CBR values reached optimum, beyond this range, cracks exist and 7.5% lime + 0.75% BSBF, optimum value are reached.

Charles et al. [4] 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 Bagasse Fibre) were mixed in single and combines actions to improved their unique properties. Results showed that inclusion stabilizing material improved strength properties of the soils. Results of tests carried out show that the optimum moisture content increased with increasing cement ratios to both soils (clay) and (laterite). Treated soils with Cement decreased in liquid limits and increased in plastic limits. Soils with Cement and fibre products in combinations increased CBR values appreciably both at soaked and unsoaked conditions. At 8% of lime, CBR values reached optimum, beyond this range, cracks exist and 7.5% cement + 0.75% BSBF, optimum value are reached.

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 7 days of curing. The optimum proportion soil: RHA: lime sludge was found to be 75:10:15.

Rao et al. [6] 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%.

Otoko and Blessing [7] studied the engineering behavior of stabilized marine clay with cement and lime. The authors showed that the strength characteristics of the marine clay was improved as unconfined compressive strength and maximum dry density increased with increase in cement and lime content with of coarse, a corresponding decrease in the optimum moisture content.

2. 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 roads at 1.5 m depth, at Odiokwu Town Road (CH 0+950), Oyigba Town Road (CH 4+225), Anakpo Town Road (CH 6+950) , Upatabo Town Road (CH 8+650), Ihubuluko Town Road, 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.

2.2 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 Ihubuluko 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. RESULTS AND DISCUSSIONS
Preliminary results on lateritic soils as seen in detailed test results given in Tables: 5 showed that the physical and engineering properties fall below the minimum requirement for such application and needs stabilization to improve its properties. The soils classified as A-2-6 SC and A-2-4 SM on the AASHTO classification schemes / Unified Soil Classification System as shown in table 3.1 and are less matured in the soils vertical profile and probably much more sensitive to all forms of manipulation that other deltaic lateritic soils are known for (Ola [8]; Allam and Sridharan [9]; Omotosho and Akinmusuru [10]; Omotosho [11]). The soils are reddish brown and dark grey in colour (from wet to dry states) plasticity index of 17.30%, 14.23%, 15.20%, 15.50%, and 16.10% respectively for Odokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Town Roads. The soil has unsoaked 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 (UCS) values of 178kPa, 145kPa, 165kPa, 158kPa and 149kPa when compacted with British Standard light (BSL), respectively.

3.1 Compaction Test Results
Preliminary test results of soils at natural state of maximum dry density (MDD) and optimum moisture content (OMC) results of lateritic soils for Odokwu, Oyigba, Anakpo, Upatabo, Ihubuluko Town Roads at 100% are 1.954KN/m³, 1.857KN/m³, 1.943KN/m³, 1.758KN/m³ and 2.105KN/m³ MDD and 12.39%, 14.35%, 13.85%, 11.79 and 10.95% OMC. With 0.25+2.5%, 0.5% + 5.0%, 0.75% + 7.5% and 1.0% + 10% inclusion of costaceae lacerus bagasse fibre ash (CLBF) + lime, maximum dry density (MDD) increased to 2.325 KN/m³, 2.150 KN/m³, 2.205 KN/m³, 2.118 KN/m³, 2.465 KN/m³ and optimum moisture content (OMC) increased to 14.85%, 15.25%, 14.76%, 12.58% and 12.05%. Compaction results showed an increased on both MDD and OMC with an increase in additives inclusion as presented in table 3.4 and represented in figures 3.1 -3.5.

3.2 California Bearing Ratio (CBR) Test
Results obtained at 100% soils are unsoaked CBR values 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%. With 0.2+2.5%, 0.5% + 5.0%, 0.75% + 7.5% and 1.0% + 10% inclusion of costaceae lacerus bagasse fibre ash (CLBF) + lime, unsoaked values are 58.75%, 49.30%, 53.55%, 52.75%, 57.58% and soaked are 55.8%, 37.25%, 49.57%, 49.35% and 53.30%. Results showed corresponding increased with percentages variation as shown in table 3.4 and figures 3.1-3.5 with optimum inclusion at 99.25% + 0.75% ratio (Soil +CLBF + Lime).

3.3 Unconfined Compressive Strength Test
Results obtained of lateritic soils at preliminary engineering soil properties are unconfined compressive strength (UCS) values of 178kPa, 145kPa, 165kPa, 158kPa and 149kPa at 100% soils, increased to 345kPa, 315kPa, 325kPa, 318kPa, 310kPa respectively as shown in table 3.4 and figure 3.5. Results showed tremendous increased in UCS with additives inclusion to lateritic soils.
3.4 Consistency Limits Test
Preliminary results of consistency limits (Plastic Index) are 17.30%, 14.23%, 15.20%, 15.50%, and 16.10% at 100% lateritic soils and 15.75%, 12.85%, 14.02%, 16.23% and 14.85% as shown in table 3.1 and figures 3.1 – 3.5. Decreased in plastic index properties were recorded in stabilized soils with increased in additives inclusion percentages.

Table 3.1: Engineering Properties of Soil Samples

| Location Description | Odiokwu Town Road (CH 0+950) | Oyigba Town Road (CH 4+225) | Anakpo Town Road (CH6+950) | Upatabo Town Road (CH8+650) | Ihubuluko Town Road (CH10+150) |
|----------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
|                      | (Laterite)                  | (Laterite)                  | (Laterite)                  | (Laterite)                  | (Laterite)                  |
| Depth of sampling (m)| 1.5                         | 1.5                         | 1.5                         | 1.5                         | 1.5                         |
| Percentage(%) passing BS sieve #200 Colour | 28.35 Reddish | 40.55 Reddish | 36.85 Reddish | 33.45 Reddish | 39.25 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 soil classification | A-2-6 SC               | A-2-4 SM                   | A-2-4 SM                   | A-2-6 SC                   | A-2-4 SM                   |
| Unified Soil Classification System |                   |                             |                             |                             |                             |
| Optimun 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                       |
| Compaction Characteristics |                             |                             |                             |                             |                             |
| 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                       |
| Clay (%)              | 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. 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/cm³)         | 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 3.5: Results of Subgrade Soil (Clay) Test Stabilization with Binding Cementitious Products at Different percentages and Combination

| SAMPLE LOCATION       | SOIL + (CLBF) + LIME | MDD (kN/m³) | OMC (%) | UNSOAKED CBR (%) | SOAKED CBR (%) | UCS (KPa) | LL (%) | PI (%) | SIEVE #200 | AASHTO / USCS Classification | Notes |
|-----------------------|----------------------|-------------|---------|------------------|----------------|------------|--------|--------|------------|-------------------------------|-------|
| Odiokwu Town Road     | 100%                 | 1.954       | 12.3    | 8.70            | 8.30           | 178        | 39.7   | 22.45  | 17.3       | A-2                          | POOR  |
|                       | %                    | 9           | 22.5    | 21.8            | 212            | 39.1       | 22.10  | 17.0   | 28.3       | 1.963                        | GOOD  |
| CH (0+950)            | 97.25+0.25+2.5       | 1.963       | 12.4    | 25.3            | 21.8           | 212        | 39.1   | 22.10  | 17.0       | 28.3                         | A-2 6/SC|
|                       | %                    | 2           | 5       | 5               | 5              | 5          | 5      | 5      | 5          |                              | GOOD  |
|                       | 94.5+ 0.5+ 5.0%      | 1.978       | 12.5    | 38.6            | 33.0           | 245        | 38.4   | 21.70  | 16.7       | 28.3                         | A-2 6/SC|
|                       | %                    | 8           | 0       | 5               | 5              | 5          | 5      | 5      | 5          |                              | GOOD  |
|                       | 91.75+0.75+7.5       | 2.150       | 12.7    | 58.7            | 55.5           | 297        | 38.0   | 21.68  | 16.2       | 28.3                         | A-2 6/SC|
|                       | %                    | 8           | 5       | 8               | 5              | 5          | 5      | 5      | 5          |                              | GOOD  |
|                       | 89+1.0+10%           | 2.325       | 14.8    | 47.6            | 42.2           | 345        | 36.7   | 21.65  | 15.7       | 28.3                         | A-2 6/SC|
|                       | %                    | 5           | 5       | 5               | 5              | 5          | 5      | 5      | 5          |                              | GOOD  |
| Oyigba Town Road      | 100%                 | 1.857       | 14.3    | 8.50            | 7.80           | 145        | 36.9   | 22.67  | 14.2       | 40.5                         | A-2 4/SM|
|                       | %                    | 5           | 5       | 5               | 5              | 5          | 5      | 5      | 5          |                              | POOR  |
| CH (4+225)            | 97.25+0.25+2.5       | 1.875       | 14.5    | 21.3            | 18.6           | 174        | 36.4   | 22.45  | 14.0       | 40.5                         | A-2 4/SM|
|                       | %                    | 3           | 5       | 5               | 5              | 5          | 5      | 5      | 5          |                              | GOOD  |
|                       | 94.5+ 0.5+ 5.0%      | 1.896       | 14.7    | 33.5            | 29.0           | 224        | 35.6   | 21.89  | 13.7       | 40.5                         | A-2 4/SM|
|                       | %                    | 7           | 7       | 5               | 7              | 7          | 8      | 5      | 8          |                              | GOOD  |
|                       | 91.75+0.75+7.5       | 1.935       | 14.9    | 49.3            | 37.2           | 268        | 35.0   | 21.75  | 13.3       | 40.5                         | A-2 4/SC|
|                       | %                    | 5           | 0       | 5               | 5              | 0          | 5      | 5      | 5          |                              | GOOD  |
|                       | 89+1.0+10%           | 2.150       | 15.2    | 44.5            | 33.8           | 315        | 34.2   | 21.40  | 12.8       | 40.5                         | A-2 4/SM|
|                       | %                    | 5           | 5       | 9               | 5              | 5          | 5      | 5      | 5          |                              | GOOD  |
| Ayahnakpo             | 100%                 | 1.943       | 13.8    | 7.80            | 7.20           | 165        | 36.7   | 21.45  | 15.3       | 36.8                         | A-2 4/SM|

Notes
| Town Road (CH6+950) | %    | 5    | 13.9 | 25.4 | 22.9 | 195 | 35.9 | 20.72 | 15.1 | 36.8 | 4/SM | A-2- | POOR |
|----------------------|------|------|------|------|------|-----|------|-------|------|------|------|-----|------|
| 97.25+0.25+2.5       |      | 1.968| 2    | 8    | 5    | 0   | 8    | 5     | 4/SM |
| 94.5+ 0.5+ 5.0%      |      | 1.995| 14.1 | 39.3 | 36.8 | 255 | 35.7 | 20.50 | 14.7 | 36.8 | A-2- | GOOD |
| 91.75+0.75+7.5       |      | 2.115| 14.3 | 53.5 | 49.5 | 285 | 35.5 | 20.45 | 14.2 | 36.8 | A-2- | GOOD |
| %                    |      | 5    | 5    | 5    | 5    | 5   | 5    | 5     | 5    | 5    | 4/SM |
| 89+1.0+10%           |      | 2.205| 14.7 | 48.7 | 44.7 | 325 | 34.8 | 20.83 | 14.0 | 36.8 | A-2- | GOOD |
| %                    |      | 6    | 5    | 0    | 5    | 5   | 2    | 5     | 4/SM |
| Upatabo Town Road (CH8+650) | 100% | 1.758| 11.7 | 9.40 | 8.50 | 158 | 36.8 | 19.35 | 17.5 | 33.4 | A-2- | POOR |
| %                    |      | 9    | 5    | 0    | 5    | 6/SC|
| 97.25+0.25+2.5       |      | 1.856| 11.8 | 25.7 | 23.4 | 186 | 36.2 | 18.90 | 17.3 | 33.4 | A-2- | GOOD |
| %                    |      | 2    | 0    | 5    | 8    | 5   | 8    | 6/SM |
| 94.5+ 0.5+ 5.0%      |      | 1.975| 11.9 | 39.0 | 36.6 | 215 | 35.8 | 18.81 | 17.0 | 33.4 | A-2- | GOOD |
| %                    |      | 7    | 5    | 5    | 5    | 4   | 5    | 6/SM |
| 91.75+0.75+7.5       |      | 2.005| 12.1 | 52.7 | 49.3 | 278 | 35.2 | 18.47 | 16.7 | 33.4 | A-2- | GOOD |
| %                    |      | 8    | 5    | 5    | 5    | 8   | 5    | 6/SC |
| 89+1.0+10%           |      | 2.118| 12.5 | 49.0 | 43.6 | 318 | 34.6 | 18.42 | 16.2 | 33.4 | A-2- | GOOD |
| %                    |      | 8    | 5    | 0    | 5    | 3   | 5    | 6/SM |
| Ihubuluko Town Road (CH10+150) | 100% | 2.105| 10.9 | 10.6 | 9.80 | 145 | 37.6 | 21.55 | 16.1 | 39.2 | A-2- | GOOD |
| %                    |      | 5    | 0    | 5    | 9    | 5   | 6/SC |
| 97.25+0.25+2.5       |      | 2.125| 11.0 | 28.9 | 25.0 | 181 | 37.1 | 21.33 | 15.8 | 39.2 | A-2- | POOR |
| %                    |      | 8    | 0    | 5    | 8    | 8   | 5    | 6/SM |
| 94.5+ 0.5+ 5.0%      |      | 2.186| 11.3 | 39.5 | 36.8 | 220 | 36.7 | 21.25 | 15.5 | 39.2 | A-2- | GOOD |
| %                    |      | 2    | 0    | 5    | 5    | 8   | 0    | 6/SM |
| 91.75+0.75+7.5       |      | 2.225| 11.6 | 57.5 | 53.3 | 267 | 36.2 | 21.07 | 15.1 | 39.2 | A-2- | GOOD |
| %                    |      | 7    | 8    | 0    | 5    | 8   | 5    | 6/SC |
| 89+1.0+10%           |      | 2.465| 12.0 | 51.7 | 47.0 | 310 | 35.7 | 20.93 | 14.8 | 39.2 | A-2- | GOOD |
| %                    |      | 5    | 5    | 8    | 8    | 5   | 5    | 6/SM |

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

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Figure 3.2: Subgrade Stabilization Test of Lateritic Soil from Oyigba in Ahoada-West L.G.A of Rivers State with CLBF + Lime at Different Percentages and Combination

Figure 3.3: Subgrade Stabilization Test of Lateritic Soil from Anakpo in Ahoada-West L.G.A of Rivers State with CLBF + Lime at Different Percentages and Combination
Figure 3.4: Subgrade Stabilization Test of Lateritic Soil from Upatabo in Ahoada-West L.G.A of Rivers State with CLBF + Lime at Different Percentages and Combination

Figure 3.5: Subgrade Stabilization Test of Lateritic Soil from Ihubuluko in Ahoada-West L.G.A of Rivers State with CLBF + Lime at Different Percentages and Combination
Figure 3.6: Unconfined Compressive Strength (UCS) of Niger Deltaic Lateritic Soils Subgrade with CLBF + Lime of (Odioku, Oyigba, Anakpo, Upatabo and Ihubuluko Towns), Ahoad-West L.G.A, Rivers State

Plate i. Costaceae Lacerus plant
Plate ii. Costaceae Lacerus stem
CONCLUSIONS

The following conclusions were made from the experimental research results

i. Preliminary investigations of the engineering Properties of soils at natural state are percentage (%) passing BS sieves #200 are 28.35%, 40.55%, 36.85%, 33.45% and 39.25% (laterite)

ii. Soils are 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.

iii. Consistency limits (Plastic index) properties decreased with increased in CLBF + Lime inclusion to lateritic soils

iv. Swelling potential of treated soil decreased with the inclusion of CLBF + Lime of 0.75% +7.5% percentage ratio to soils

v. Unconfined compressive strength results showed tremendous increased with increase in additive percentages to soil ratio.

vi. California bearing ratio of unsoaked and soaked reached optimum values percentage inclusion at 0.75% +7.5% , beyond this value, crack was formed which resulted to potential failure.
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