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EFFECTIVENESS OF RICE HUSK ASH (RHA), LIME AND POLYPROPYLENE FIBER IN STABILIZATION OF MARINE CLAY

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ABSTRACT
This study focuses on the use of rice husk ash, lime and polypropylene fiber to stabilize marine clay which is dominant in the Niger Delta region of Nigeria. The California Bearing ratio (CBR) test was carried out to determine the thickness of sub-grade while the unconfined compressive strength test was done determine the strength.
KEYWORDS: marine clay, chikoko soil, soft soils stabilization, rice husk ash, lime, propylene fibre.

INTRODUCTION
The importance of soil in civil engineering cannot be over emphasized because every civil engineering structure, whether it is a building, bridge, tower, embankment, road pavement, railway line, tunnel or a dam, has to be built on the soil. One of the problems in geotechnical engineering is the presence of unsuitable soils on project sites. Some soils called soft soils which are predominantly marine clay, possess high amount of water up to 85%. The bearing capacity of soft soils are usually very low with low permeability and high compressibility. Structures constructed on soft soils can encounter engineering problems especially during settlement. Recently it has been discovered that appropriate chemical stabilization can improve undesirable characteristics of such soils thereby making it possible for structures to be constructed on it without the structures encountering any problem (Nontananandh et al., 2003). Hence, the aim of this research is to study the effect of consolidation stress on the strength properties of lime stabilized marine clay which is a soft soil locally known as chikoko soil found in the Niger Delta region of Nigeria. This marine clay known as chikoko soil occurs as dark grey, dark brown to black material with characteristic foul odor. It fails under light surcharge load and it is characterized with low shear strength, low compressibility and high water content (Huat 2007, Kalantari and Huat, 2008a, 2008b, 2009).
The Niger delta of Nigeria possesses large water bodies and due to population increase, most of the river bodies are been sand filled so as to cater for lack of lands to build structures on. Soils in this Niger delta area are sometimes too soft to carry the kind of structures that suit the trend of development around the world. Large scale settlement, differential settlement, shear failure are some of the challenges encountered in carrying out any building infrastructure in the Niger delta area. For these soils to be able to carry these structures there is need to stabilize them. The common additives used in this stabilization are cement and lime but due to the high cost of these materials, researchers have tried to look for cheaper and readily available additives that can replace these other costly additives. Some of these materials that have been researched and used are rice husk ash, fly ash, lime, fiber, blast furnace, etc. (Cokca et al, 2009; Neeraja (2010); Muntohar, 2009 and Otoko & Onuoha, 2015). Otoko et al., (2014) and did a research based on chikoko stabilization using waste rubber fiber. Rice milling generates a by-product know as husk. This surrounds the paddy grain. During milling of paddy about 78 % of weight is received as rice, broken rice and bran. 22 % of the weight of paddy is received as husk. This RHA in turn contains around 85 % - 90 % amorphous silica. So for every 1000 kgs of paddy milled, about 220 kgs (22 %) of husk is produced, and when this husk is burnt in the boilers, about 55 kgs (25 %) of RHA is generated. The use of rice husk ash will solve disposal problems, as the rice husk instead of been thrown away in water bodies it can now be used to stabilize soils. Soundara and Senthil (2015) and Al-Akhras et al (2008) researched on stabilization of soil using polypropylene fiber. The use of natural fibers' such as coir and commercial polypropylene fibres for soil improvement is highly attractive in countries like

India where such materials are locally and economically obtainable, in view of the preservation of natural environment and cost effectiveness.

MATERIALS AND METHOD

Overview of Rice Husk Ash (RHA)

Rice husk was gotten from a rice mill at Uzoakwa Ihiala in Ihiala L.G.A, in Anambra state, Nigeria, Figure 1. Chandrasekhar et al (2003) observed that Rice husk is an abundantly available waste material in all rice producing countries.

Figure 1: Rice Husk and Rice Husk Ash (RHA)

OVERVIEW OF LIME

Hydrated lime which is called calcium hydroxide is an inorganic compound with the chemical formulae (Ca $(OH)_2$). It is a colorless crystal or white powder and is obtained when calcium oxide called quicklime is mixed or slaked with water. Calcium hydroxide is relatively soluble in water, it is large enough that it will partially dissolve and release hydroxyl anions (OH^-) in solution according to the following; $Ca(OH)_2 \rightarrow Ca^{2+} + 2OH^-$

Polypropylene fiber: Polypropylene fiber having 12 mm length and aspect ratio 300 was purchased from the market, Figure 2. Its color was white, specific gravity was 0.91 and melting point was 1600 C.

Figure 2: Propylene Fibres being cut to 12mm Length

RESEARCH METHODOLOGY

This study is an experimental based research which focuses on the stabilization of marine clay (chikoko soil) using Lime and RHA. The rice husk was collected in a mill at Uzoakwa Ihiala in Ihiala local government area of Anambra State while the marine clay (chikoko soil) sample was gotten from Eagle Island, Port Harcourt, Figure 3. A large quantity of chikoko soil sample was collected at 1m depth for testing in the civil engineering laboratory of RSUST. The samples were put in polythene bags and covered to preserve the moisture content. The marine clay was spongy and highly compressible; the colour was black to dark-brown with an offensive odour.

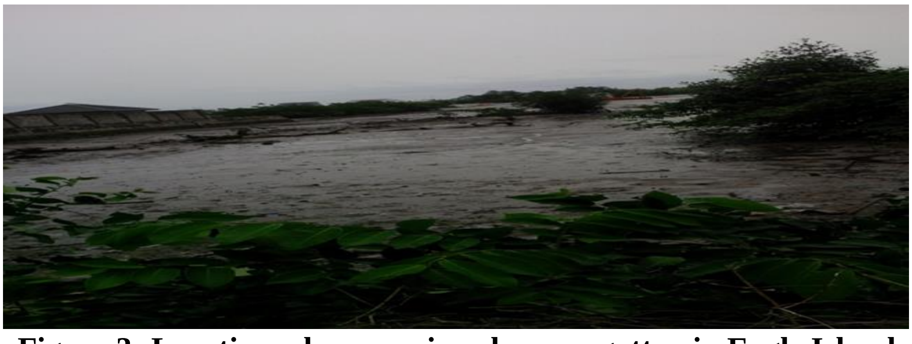

Figure 3: Location where marine clay was gotten in Eagle Island

The rice husk was burnt to get the rice husk ash and sieved to 425µ. The hydrated lime/polypropylene fiber was purchased from the local market. The laboratory test procedures carried out were based on British (BS1377; 1990) standards. The experimental research concentrated mostly on the laboratory testing to determine the important properties of the marine clay (chikoko soil), and rice husk ash and the appropriate mix ratio in percentage (%) that should be economical to give effective stabilization of the marine clay (Chikoko soil) in terms of strength. Experiments such as specific gravity test, atterberg limits (liquid limits, linear shrinkage limit, plastic limit, plasticity index), particle size distribution, swelling index, were carried out to know the physical and index properties of the marine clay (Chikoko soil). The engineering properties such as unconfined compression test (UCT) and standard proctor compaction test were also carried out on the soil sample before and after stabilization.

SAMPLE PREPARATION FOR CHIKOKO SOIL

Marine clay collected from Eagle Island was collected below ground water table and the sample was collected using a hand auger. The sample was collected and stored in polythene bags immediately to avoid moisture loss and they were transported to the laboratory. On arrival at the laboratory, the moisture content test was done(it is 100% saturated) before putting the sample into an electric oven, it was cut into small parts for easy drying and spread to dry outside under the sun for three days. After the drying of the marine clay up to minimal moisture content, the sample was manually grinded into fine aggregates using a mortar and a pistol.

OVERVIEW OF MARINE CLAY (CHIKOKO SOIL)

Marine clay shown in Figure 4 is a type of clay found in the coastal regions around the world. The marine clay varies in thickness; it is usually between 10m to 15m near the estuaries. It has the potential to swell upon wetting and shrink upon drying, it is high in plasticity.

Figure 4: Marine clay before and during grinding

EXPERIMENTAL METHODS

After grinding the marine clay (chikoko soil) sample, index tests were carried out on the samples before stabilization according to BS 1377 (1990) standards. The marine clay was stabilized using series of different mixtures of RHA and Lime. RHA of 0%, 5%, 10%, 15% and 20% were used for mix with 0%, 2%, 3%, 4%, 5% Lime only. California bearing test, proctor compaction and unconfined compression test were carried out on the soil before and after stabilization.

LABORATORY TESTS

1. Laboratory tests to determine the physical and index properties of marine clay (chikoko soil).
2. Laboratory tests to determine the strength of the stabilized marine clay (chikoko soil).

The testing of the physical properties of chikoko soil consists of moisture content, particle size distribution (sieve analysis), specific gravity test and atterberg limit test (liquid limit, plastic limit, plasticity index.

3. Shrinkage limit (SL).

In the laboratory test carried out, the density of the compacted soil is measured in terms of the dry unit weight of the chikoko soil. The dry unit weight is simply a measure of the amount of solid materials present in a unit volume of soil. The greater the solid materials, the stronger and more stable the soil will be. Optimum moisture content (OMC) also results in greater density. The test was done to determine the optimum moisture content (OMC) of the chikoko soil samples.

UNCONFINED COMPRESSIVE STRENGTH

Bearing capacity of foundations is based on strength. Unconfined Compressive Strength test (UCS) is a simple suitable test in this regard. Although they do not provide information on the influence of stress; and pore water pressures, they are nevertheless useful in estimating the undrained strength of stabilized soils.

CALIFONIA BEARING RATIO

The CBR test is done so as to determine the thickness of pavement. The volume of water is gotten from the OMC of compaction protector test.

RESULTS AND DISCUSSION

Results of laboratory tests to determine the physical and index properties of marine clay (chikoko soil) are presented in Table 1. It can be observed that the marine clay has a very high natural moisture content of 74.6%.

Table 1. Typical Physical Properties of Chikoko Soil.

S/NO	Physical Properties	Value
1.	Specific Gravity	1.60
2.	Bulk Dry Density (kg/m³)	1440
3.	Natural moisture content (%)	74.6
4.	Liquid limit (%)	69.80
5.	Plastic limit (%)	56.95
6.	Plasticity Index (%)	12.85
7.	Swelling index	0.164
8.	Compression index	0.0323
9.	Average moisture content (w)%	74.6
10.	Compaction Characteristics Optimum moisture content (%) Max. Dry Density (kg/m³)	 19 1320
11.	Classification	CH
12.	CBR Soaked (%) Unsoaked (%)	 2.79 40.8
13.	Colour	Dark Grey

Figure 5 shows the variation of unconfined compressive strength (UCS) of rice husk ash (RHA) stabilized Chikoko at 7 days curing. The UCS of Chikoko soil increased on addition of RHA and lime in different percentages. It can be observed that the highest strength occured at the addition of 5% of lime and 10% of RHA, while it decreased beyond at 10% of RHA. The strength increased because of the contribution of frictional resistance from RHA along with the cohesion from chikoko soil. The strength decreased beyond 10% of RHA because of reduction of cohesion component.

The maximum value of UCS obtained was 139.62 kN/m^2 at 10% addition of RHA and 5% of lime. In the addition of RHA and lime the strength increased because of the pozzolanic reaction of lime with the amorphous silica and alumina present in rice husk ash and soils. It was also noticed that addition of lime below 4% decreased the UCS, resulting in carbonation reaction due to addition of excess lime to react with insufficient amorphous silica and alumnia present in rice husk ash and chikoko soil.

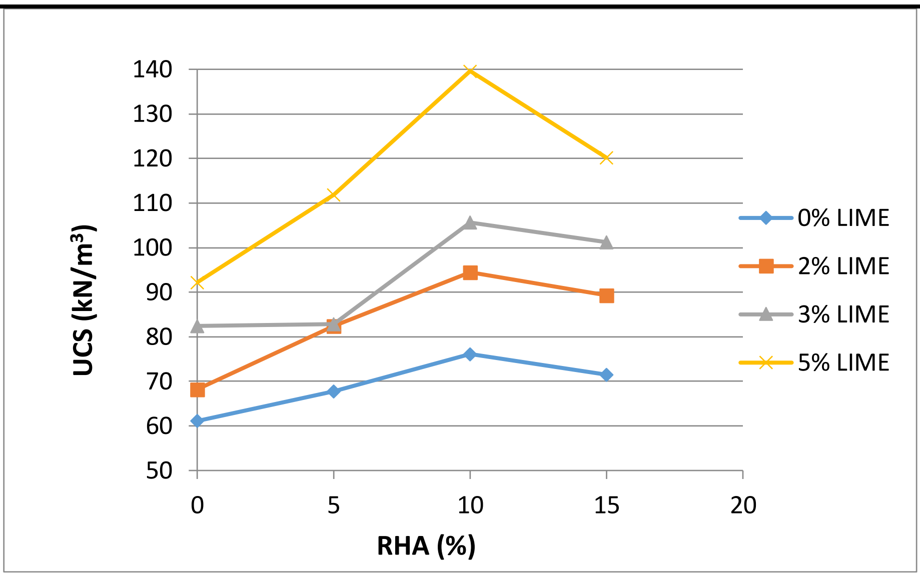

Figure 5: Variation of unconfined compressive strength with rice husk ash and lime at 7 days curing.

Figure 5 and 6 shows the variation of maximum dry density (MDD) and optimum moisture content (OMC) with different percentages of polypropylene fiber (fibre) respectively. The MDD of the soil decreased to 1760 kN/m^3 when stabilized with optimum percentage of rice husk ash (RHA) and lime. With increase in the percentage of polypropylene fiber to the rice husk ash-lime stabilized chikoko soil, a remarkable decrease to 1760 kN/m^3 when 2% fiber was added was observed, which is attributed to the lower value of specific gravity of fiber as compared to the soil. An increase in OMC was observed on addition of polypropylyene fibre. This was in accordance to the observations of Kumar, et al (2007) which he noted when adding polyster fiber to fly ash-lime stabilized chikoko soil.

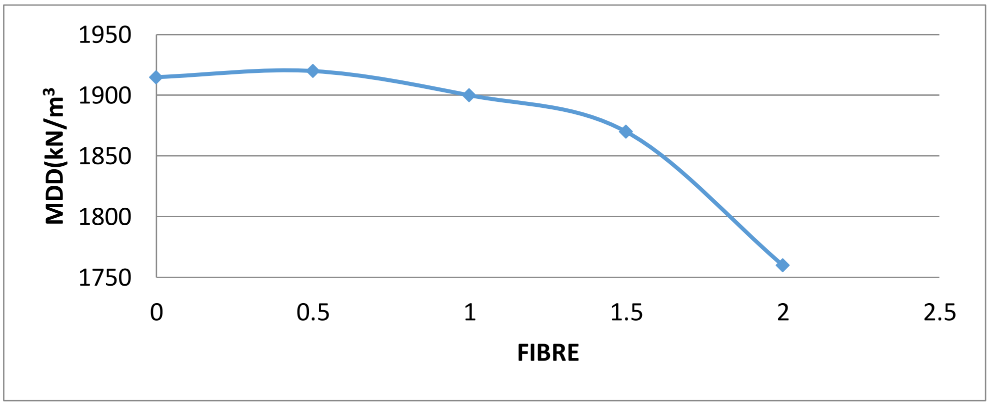

Figure 6: Variation of maximum dry density (MDD) with percentage of fiber

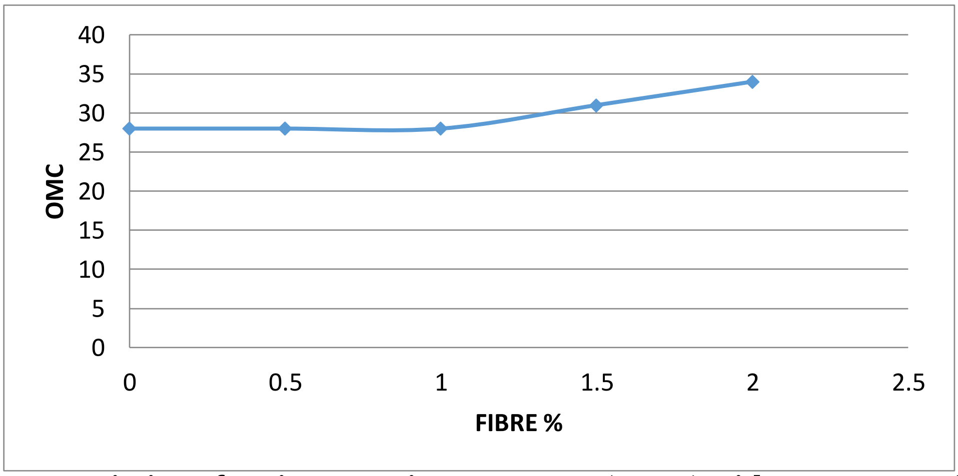

Figure 7: Variation of optimum moisture content (OMC) with percentage of fiber

Figure 7 shows the variation of rice husk ash-lime stabilized chikoko soil with different percentages of fibre and curing period. The UCS of the soil increased to 114 kN/m^2 at 0 day when stabilized with lime and rice husk ash. It had a maximum strength of 515.97 kN/m^2 at 28 days curing which is 8.35 times of the virgin soil. Unconfined compressive strength (UCS) increased up to 1.5% on addition of fibre and decreased thereafter.

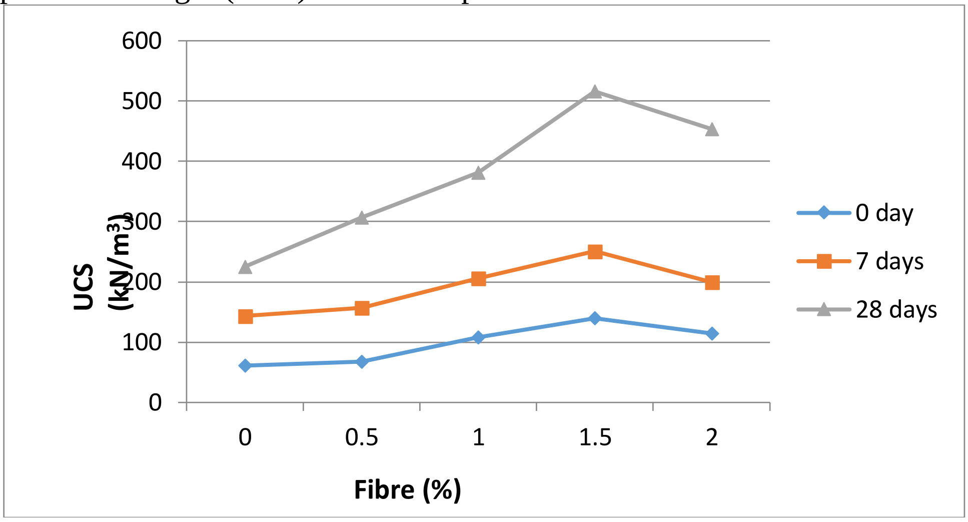

Figure 8: Variation unconfined compressive strength (UCS) kN/m^3 with percentage of fiber and curing period

Figure 8 shows the variation of soaked CBR of rice husk ash-lime stabilized chikoko soil with different percentage of fibre and curing period. The soaked CBR increased to 62.47% from 53.76% at 0 day curing when stabilized with optimum proportion of rice husk ash and lime. It further increased to 73.25% at 28 days curing. Adittion of fiber increased the soaked CBR of rice husk ash-lime stabilized soil.

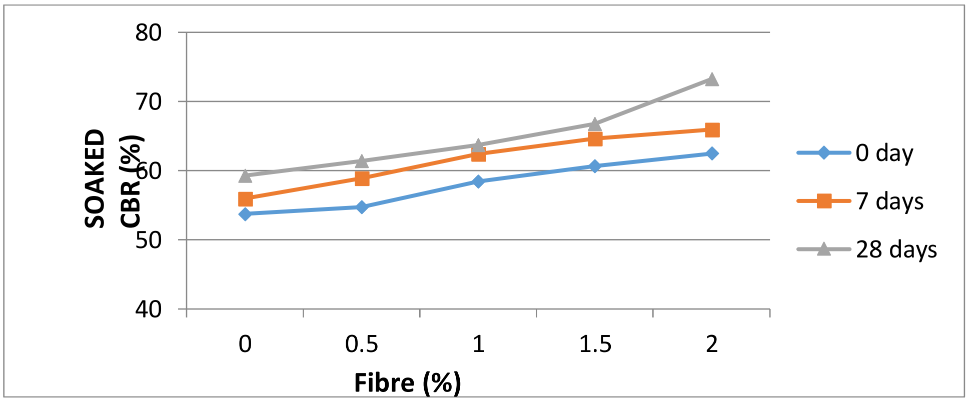

Figure 9: Variation of soaked CBR with percentage of fibre and curing period

Addition of fibers to the rice husk ash-lime stabilized chikoko soil mixes, increased the strength because cementing gel formed by the reaction of amorphous silica and alumina with the calcium of lime binds the fibres with the soil participles, hence the effective contact area of soil participles and fibre increases and the movement of fibre is also restricted.

The benefit of stabilization and reinforcement is achieved because the strength keeps on increasing with increase in curing period and addition fibers. Cai et al, 2006, observed that too much of fiber added reduces the benefit, as the fibers adhere to each other to form lumps and cannot contact with soil particles fully.

4. CONCLUSION

Based on the results of this study, the following conclusions were be drawn:

1. The unconfined compressive strength of Chikoko soil increased on addition of RHA and lime in different percentages. The highest strength occurred at the addition of 5% of lime and 10% of rice husk ash (RHA),

while it decreased beyond 10% of RHA. The maximum value of UCS obtained was 139.62 kN/m^2 at 10% addition of RHA and 5% of lime.

2. The unconfined compressive strength (UCS) of the soil increased to 114 kN/m^2 at 0 day when stabilized with lime and rice husk ash. It had a maximum strength of 515.97 kN/m^2 at 28 days curing which is 8.35 times of the virgin soil. Unconfined compressive strength (UCS) increased up to 1.5% on addition of fibre and decreased thereafter.

3. The optimum proportion of chikoko soil; rice husk; lime: polypropylene fiber was found to be 84.5:10:4:1.5. The addition of rice husk ash-lime decreased the maximum dry density (MDD) and increased the optimum moisture content (OMC) of the chikoko soil.

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