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Soft Soil Stabilization Using Palm Oil Fibre Ash

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***Abstract*—Palm oil trees are abundant in the Niger Delta of Nigeria and the effectiveness of using its fly ash (waste from the process of burning the palm oil fibre) in soft soil stabilization was investigated. Soft soil investigated is an extremely soft marine clay in the Niger Delta area locally known as "Chikoko". The fly ash (palm ash) is classified as class F according to ASTM C618. It is siliceous and aluminous with virtually little or no cementation value. Therefore for pozzolanic reaction it has to be combined into a little lime. An Optimum of 5% lime was obtained for pozzolanic reaction. This combines with 3% optimum palm ash to give best results of soaked and unsoaked CBR. Thus, the palm ash can successfully be used for soil subgrade stabilization.**

Keywords – Palm oil fibre; Palm ash; chikoko; marine clay; CBR

Introduction:

The Chikoko soft soil is characterized with high moisture content in excess of 80% and like other soft soils can also be easily interrupted by activities on its surface (Taha, 2009). It is also characterized with high compressibility, low bearing capacity, low strength and low permeability (Otoko 2014). As such, the Chikoko soil is referred to as problematic when structures are constructed on it. They are not also suitable as subgrade material and therefore require stabilization with lime, cement, chemical and other additives or replacement with soil of better quality. Soft soils vary in thickness in coastal areas (Abdullah and Chandra 1989). This also applies to the Chikoko soil of the Niger Delta, Nigeria (Otoko and Onuoha 2015)

Soil stabilization entails adding something to the soil to improve its engineering properties (Otoko 2014). Nontanamandt et al 2003 used chemical additives; while others like Indian department of transportation (2008) and Khairul and kok (2004) used lime and/or cement. Senol et al 2005 and Norazlan et al (2012) have shown that fly ash stabilization substantially increases the unconfined compressive strength (UCS) and California Bearing Ratio (CBR) of subgrades.

Palm ash will continue to be abundant as industrial waste product is continuously created. It is a pozzolana with no cementitious properites and a waste product produced by burning palm oil fibre to ash. It has successfully been used as additive in cement concrete (Awal and Hustin 1997) and can be successfully used in soft soil stabilization if combined with lime, as the palm ash is rich in silica and low in lime (CaO)

This study has shown that the abundant Chikoko soil in the Niger Delta of Nigeria can be successfully stabilized with 5% lime and 3% palm oil fibre ash, which is also abundant in the area.

MATERIALS

The Chikoko soft soil

The grey colour Chikoko soil was obtained from the Eagle Island in Port Harcourt, Nigeria at a depth of approximation 1.0m from ground surface. The samples were sealed with wax to ensure that the original moisture content was maintained prior to laboratory tests. Results obtained are shown in table 1, which can be classified as high plasticity slightly sandy clay.

Fig. 1: Mill in Elele from where

palm oil fibre was collected

Palm oil fibre ash.

The palm oil fiber was burnt at 850 - 950^{0}c to form ash. The palm oil fiber was actually obtained from a mill in Elele (fig .1)

Table 1: Properties of the Chikoko soil

S/No	Properties	Values
1	Depth (m)	1.0
2	Natural moisture content	74.6
3.	Liquid Limit LL (%)	79.2
4.	Plastic Limit PL (%)	38.5
5.	Plasticity Index (%)	40.7
6.	Liquidity Index	0.89
7.	Specific Gravity (GS)	2.58
8.	Particle Size Distribution Sand (%) Silt (%) Clay (%)	 14.2 40.1 45.7
9.	Compaction Characteristics Optimum Water Content (%) Max Dry Unit Weight (kN/m^3)	 19.8 15.6
10.	Classification	CH

Fig. 2: Picture showing burning of the palm oil fibre

Fig. 3: Picture showing palm oil fibre ash

Table 2: Properties of the Palm oil Fibre ash

S/No	Properties	Values
1.	Specific Gravity, (Gs)	1.69
2.	Particle size Distribution Sand (%) Silt (%) Clay (%)	 0.05 99.5 0.0
3.	Classification (ASTM C618)	Class. F

Table 2 shows the physical properties of the palm oil fibre ash, which is considered a light fine material due to its low specific gravity of 1.65 and fine sizes; while table 3 shows that the palm oil fibre ash is a siliceous material due to its high silica oxide content; and classified as class F according to ASTM C618 (table 3). It possesses pozzolanic properties due to its high silicon, Aluminum and iron oxide contents. However, is non self-cementing ash because of its little or no calcium and magnesium ions.

Table 3: Classification of the Palm oil fibre ash

Properties		$SiO_2 + Al_2O_3 + Fe_2O_3$	So_3	LOI
Chemical require-ments for Fly ash classifica-tion (ASTM C618)	**Class F** (Min (%)	70	5	6
	Class C (Max (%)	50	5	6
Result of chemical composition of palm oil fiber ash (%)		77.9	0.08	4.2

Lime Samples

Due to the non-cementing quality of the palm oil fibre ash, it was necessary to add lime to enhance pozzolanic

Fig. 4: Picture showing wet

Chikoko soil

reaction and thereby improve the engineering properties. Table 4 shows the composition of the lime (after Hafez et al 2008)

Table 4: chemical composition of Chikoko soil and Palm oil fibre ash

Chemical constituents	Concentrations		
	Chik-oko soil	**Palm oil fibre ash**	**Hydra-ted lime** (Hafez et al 2008)
Silicon Dioxide (Silica) $Si\,O_2$	62.96	68.95	20.63
Aluminum Trioxide $Al_2\,O_2$	17.18	5.39	5.87
Calcium Oxides (lime) CaO	0.16	5.57	63.55
Magnesium Oxide, MgO	1.05	3.09	2.52
Iron Oxide, $Fe_2\,O_3$	3.57	4.17	2.79
Potassium Oxide, K_2O	2.09	8.78	0.63
Sodium Oxide, Na_2O	0.22	0.15	0.85
Sulphate, SO_3	0.76	0.06	1.62
Loss on Ignition			1.54

EXPERIMENTAL TESTS

Sample preparation and laboratory test:

Samples were prepared and tested in accordance with BS 1377:1990 for Atterberg limits, moisture content, particle size distribution, specific gravity

and compaction characteristics; while the California Bearing Ratio (CBR) tests were determined for 0%, 2%, 3%, 4% and 5% palm oil fibre ash content with 5% lime content of stabilized soil. The soaked and unsoaked CBR tests were carried out on the stabilized soil at optimum moisture content and compacted to maximum dry unit weight.

Table 5: Results of soaked and unsoaked CBR

Samples	California Bearing Ratio (%)	
	Un-soaked	**Soaked**
Chikoko Soil (Control)	8.73	1.02
Chikoko Soil + 5% Lime	21.16	9.27
Chikoko Soil + 5% Lime + 2% palm ash	43.61	30.10
Chikoko Soil + 5% Lime + 3% palm ash	64.55	33.63
Chikoko Soil + 5% Lime + 4% palm ash	46.19	23.97
Chikoko Soil + 5% Lime + 5% palm ash	18.84	12.15

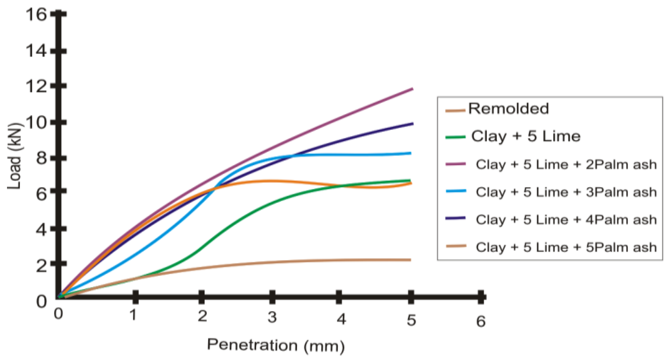
RESULTS AND DISCUSSIONS

Table 5 shows the CBR tests for soaked and unsoaked conditions respectively, for various palm oil fibre contents and 5% lime content. There is a general increase in the load as the palm oil fibre ash content increases, compared to the control (unstabilized soil)

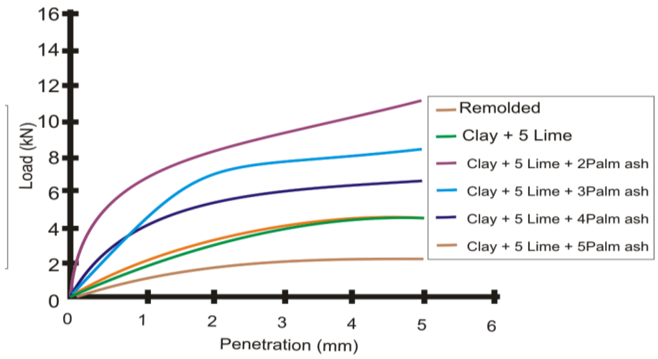
Fig. 5: Grinding the dry Chikoko soil

Fig. 6: Atterberg Limit tests of Chikoko soil

Figure 7 and 8 show how the soaked and unsoaked CBR relates with the lime and palm oil fibre ash content. It clearly shows that adding a combination of lime and the palm oil fibre ash generally gave higher CBR values than the control and the lime without the palm oil ash. Peak values of soaked and unsoaked CBR were obtained for 5% lime and 3% palm oil fibre ash. Hence 5% lime and 3% palm ash can effectively stabilize the Chikoko subgrade from 'poor' to 'good' conditions. Earlier studies by Koslanant et al (2006) show that lime can effectively stabilize soil by chemical reaction with silicate in the clay. Similarly, in this study the lime produces the binder by chemical reaction with



(a)



(b)

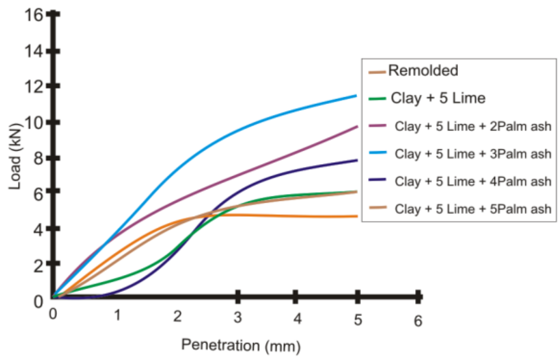
Fig. 7: Soaked CBR test results (a) Top (b) Bottom

silicate in the clay, while the palm oil ash produces the pozzolanic reaction.

The calcium silicate hydrate and calcium aluminate hydrate gels are formed as a result of pozzolanic reaction and subsequently crystallize to bind the structure together (Rogers et al 1996).

CONCLUSIONS

In conclusion, apart from solving the disposal problem that may be posed by palm oil fibre, Chikoko subgrade can successfully be stabilized with 5% lime and 3% palm ash; which were the



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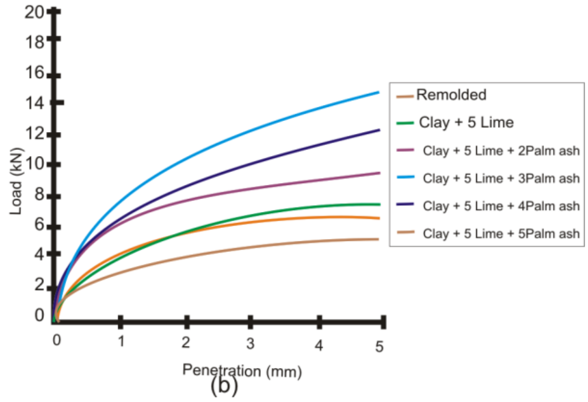
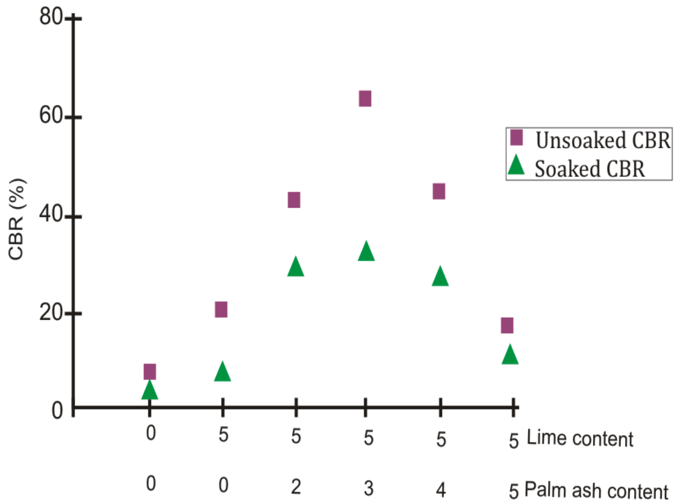


(b)

Fig. 8: Unsoaked CBR test results (a) Top (b) Bottom



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