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Stabilization of a Deltaic Marine Clay (Chikoko) with Chloride Compounds:

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Abstract - ***The stabilization of a Nigerian deltaic clay, locally known as 'Chikoko' is necessary due to its extreme softness requiring expensive deep foundation. Light surcharge loads can cause considerable deformation and failure in this clay. This paper presents the investigation of the use of Sodium, calcium and Magnesium Chlorides in the stabilization of the Chikoko clay. The results show that the chloride contents are directly proportional to the maximum dry unit weight and the unconfined compressive strength (UCS) and inversely proportional to the optimum moisture content and the atterberg limits.***

Key Words: Chikoko, atterberg limits, chlorides, unconfined compressive strength, maximum dry unit weight, optimum moisture content**.**

Introduction

The Chikoko presents as dark brown, dark grey, to black fibrous material with characteristic foul odour. It has low strength and is highly compressible (Wong et al 2008, islam and Hashin 2008, Adesunloye 1987). This kind of peaty clay are found all over the world occupying about 4.5% of total land areas (Deboucha et al 2008).

Chikoko like other peaty clays can be strengthened by various techniques (Kalantari and Haut 2008). Hebib and Farrell (2003) supported foundation loads by combining surface stabilization with stabilized cement columns. Black et al (2007) transferred loads to the lower firm stratum by reinforced stone column.

However, Perloff (1976) defined soil stabilization as improvement of soil properties by adding something to it, to improve the soil moisture; soil cohesion and cement/water proof the soil (Jonathan et al 2004).

Chikoko is usually found in the mangrove swamp of the Niger Delta, Nigeria, and like other peats swell when in contact with water (Chen 1981). Cement and lime are most commonly used for the stabilization of this soil (Otoko 2014) to ensure high strength. As high strength may not always be required, cheaper additives such as chlorides and gypsum have been used to stabilize soils (Pyne 1955; Chen 1981, Ghafoori and Cai 1997, Ghafoori 2000, Azadic et al 2008).

This paper therefore, presents the stabilization of a deltaic marine clay (Chikoko) with Sodium, Calcium and Magnesium Chlorides.

Experimental Procedure

The Chikoko soil of the salt water swamp of the Niger Delta is selected for this study. The soil sample was taken from Eagle Island, Port Harcourt (fig. 1) at the depth of about a meter below top soil. The geological map of Port Harcourt is shown in fig. 2. The properties and classification of the soil are given in table 1, and the particle size distribution of the chikoko soil is given in fig.3

Fig.1 : Chikoko site at Eagle Island, Port Harcourt,

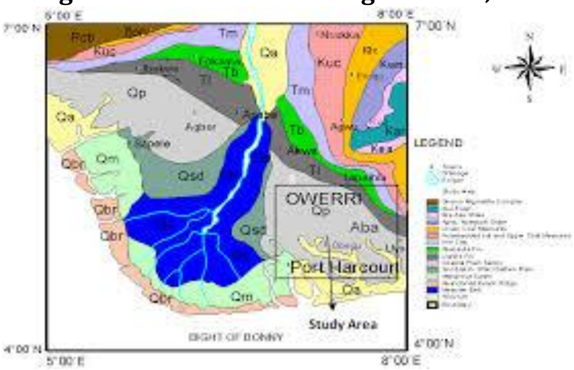

Fig. 2: Geological Map of Port Harcourt, Nigeria

Laboratory Tests

The Magnesium, Calcium and Sodium Chlorides were each dissolved in water, left for one day, mixed with soil and the soil prepared and tested according to ASTM (D1557) for modified proctor compaction, moisture content and dry unit weight relationship. The soil was compacted in 5 layers into 1000cm^3 mould, and the dry unit weight – moisture content relations for different percentages of the different chlorides determined (see fig. 4). Liquid limit was determined by the Cassagrande apparatus according to ASTM (D423-66), while the plastic limit was determined according to ASTM (D424-59), all to investigate the effect of the added chlorides on the consistency limits (see fig. 5).

Table -1: Physical properties of the Chikoko soil

S/No	Properties	Values
1	Depth of sampling (m)	1.0
2	Specific gravity	2.17
3	Bulk Unit Weight (kN/m^3)	14.5
4	Natural Moisture Content (%)	66.5
5	Liquid Limit (%)	70.0
6	Plastic Limit (%)	36.9
7	Plasticity Index (%)	33.1
8	Liquidity Index (%)	0.89
9	Shrinkage Limit (%)	18.4
10	Organic Content (%)	6.6
11	pH	6.8
12	Grain size distribution: (i) Clay size (%) (<0.002mm)	41
	(ii)Silt size (%) (>0.002<0.075mm)	40
	(iii) Sand size (%) (>0.075mm)	19
13	Activity	0.81
14	Free Swell Index (cc/g)	4.25
15	Salinity (g/l)	4.10

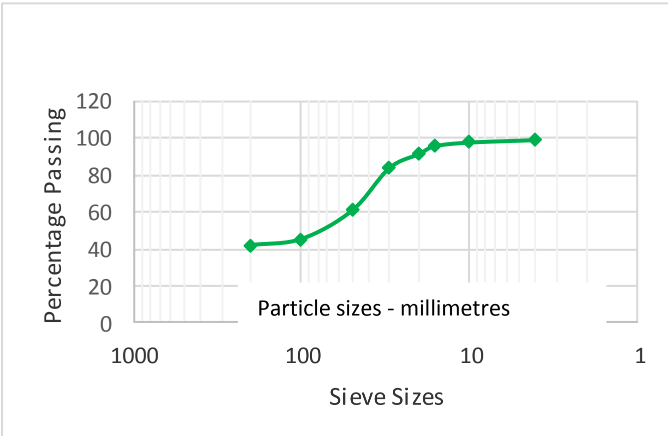

Fig. -3: Particle size distribution curve of the chikoko soil

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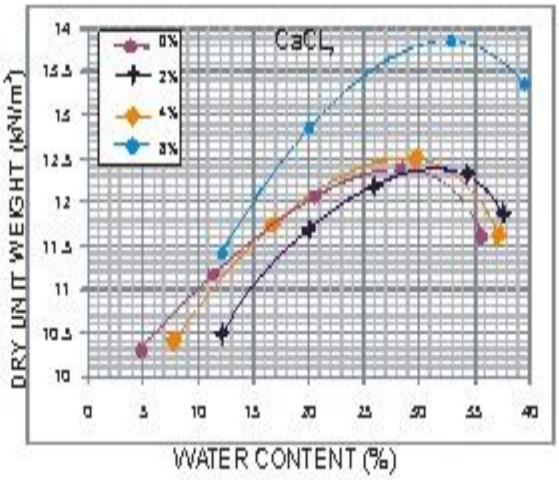

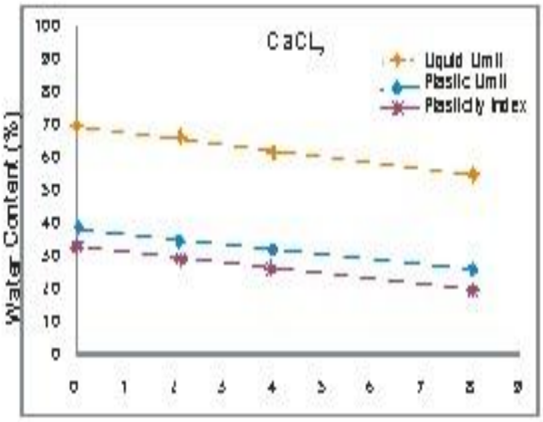

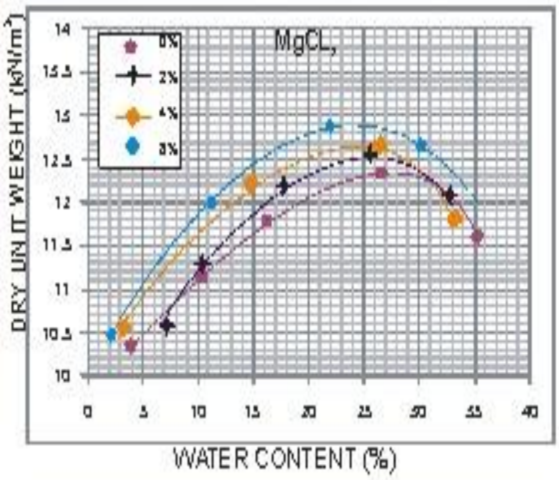

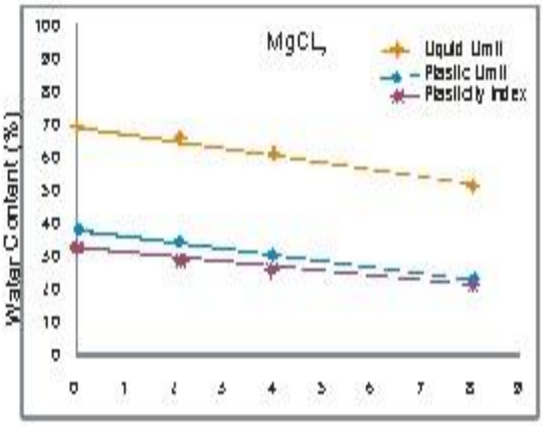

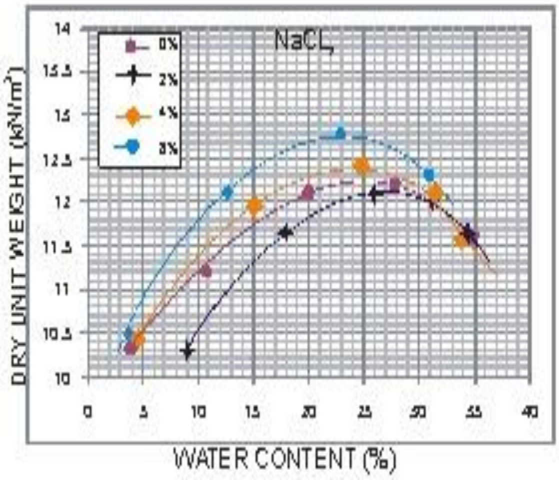

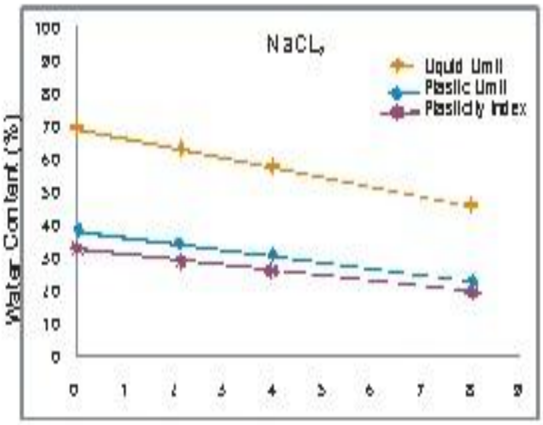

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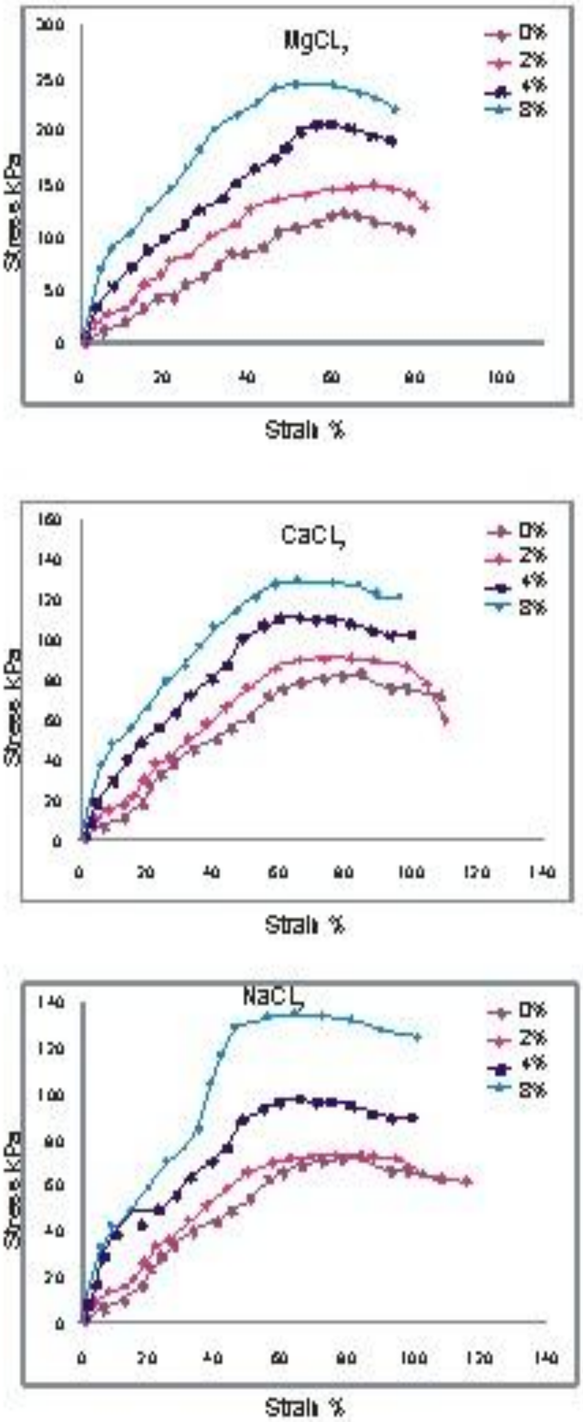

Fig. -6: Stress – Strain curves of Unconfined Compression Test.

Fig. 7: Picture showing compaction Test

Fig. 8: Picture showing Unconfined compression test

The stress- strain relationships of the soil are given in fig. 6, which shows that unconfined compressive strength is directly proportional to the chloride content which is in agreement with Perloft (1976).

Fig. 4 shows that the dry unit weight is directly proportional to the chloride content while the optimum moisture content is inversely proportional to the chloride content, both of which is in agreement with Frydman and Ehrenrich (1997), Wood (1971) and Lambe (1958).
The atterberg limits are shown in fig. 5; which are inversely proportional to the chloride contents, which is in agreement with Ventatabor (1977).

The stress- strain relationships of the soil are given in fig. 6, which shows that unconfined compressive strength is directly proportional to the chloride content which is in agreement with Perloft (1976).

Conclusion

There is considerable influence of the three chloride compounds studied, on the properties of the Chikoko soil. It is shown from this work, that the optimum moisture content and atterberg limits are inversely proportional to the chloride content, while the unconfined compressive strength and unit weight are directly proportional to the chloride content.

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REFERENCES

Adesunloye, M. O. (1987). Investigating the problem soils of Nigeria. *Proc of the 9th Regional conference of ISSMFE, Rotterdam, Balkema A. A, Publishers 103-112.*

ASTM (American Society for Testing and Materials) D1557 (1945) . *Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort.*

ASTM (American Society for Testing and Materials) D423-66 (1972*). Method of Test for Liquid Limit of Soils.*

ASTM (American Society for Testing and Materials) D424-59 (1971). *Standard Method of Test for Plastic Limit.*

ASTM (American Society for Testing and Materials) D2166 - 65. *Standard Test Method for Unconfined Compressive Strength of Cohesive Soil*

Azadi M.R.E., Sadein, M., Jafari, K., &Jajani, S. (2008). The Effects of Urmieh Salt Water on the CBR Test Results of GSCW and GSBW Soil Samples. *Electronic Journal of Geotechnical Engineering (EJGE), 13, Bund.J.*

Black A. J, Sivakumar V, Madhav R. M, & Hamil A. G. (2007). Reinforced Stone Column in Weak Deposit: Laboratory Model Study. *Journal of Geotechnical and Geo environmental Engineering, ASCE, 1154-1161.*

Chen, F. H. (1981). Foundations on Expansive Soils. Amsterdam*: Elsevier Scientific Publishing Company.*

Deboucha S, Hashim R, & Alwi A. (2008). Engineering Properties of Stabilized Tropical Peat Soils. *University of Malaya, Malaysia and Universitas Tanjungpura, Indonesia.*

Frydman, I. R. & Ehrenreich, T. (1977). Stabilization of heavy clay with potassium chloride. *Journal of Geotechnical Engineering, 8, 95-107.*

Ghafoori, N., & Cai, Y. (1997). Laboratory Investigation of Pulverized Coal Combustion Bottom Ash as a Fine Aggregate in Roller Compacted Concrete. *Proceedings of the third Canmet/ACI and International Symposium on Advances in Concrete Technology, Auckland, New Zealand, 24-27.*

Ghafoori, N. (2000). Large-scale Utilization of Illinois PCC Bottom Ash in Roadways and Parking Lots of a youth sports, safety Complex. *DCCA grant number 96-205103 (CRG27).*

Hebib S, & Farrell R., E. (2003). Some experiences on the stabilization of Irishpeats. Can. Geotech J*, 40:107-120.*

Islam, M. S. &, Hashim R. (2008). Use of Mackintosh Probe test for Field investigation in Peat Soil*. Proc Of International Conference.*

Janathan Q. Addo, Sanders, T. G. & Chenard, M. (2004). Road dust suppression *: Effect on unpaved Road Stabilization*

Kalantari B, & Huat B.B. K. (2008). Peat Soil Stabilization, using Ordinary Portland Cement, Polypropylene Fibers, and Air Curing Technique*. University of Putra Malaysia.*

Lambe, T.W. (1958). The structure of compacted clay. *Journal of Soil Mechanics and Foundation. 84, 55-70.*

Otoko, G. R (2014).A review of stabilization of problematic soils*. International Journal of Engineering and Technology Research. 2.(5), 1-6.*

Perloff, W. H. (1976). Soil Mechanics, Principals and Applications*. New York: John Wiley & Sons.*

Pyne, R.E. (1955). Discussion of paper by E. J. Yoder. Freezing and Thawing Tests on Mixture of Soil and Calcium Chloride. *Highway Research Board Bull. 100.*

Ventatabor Rad, G. (1977). Physico-chemical mechanism governing the plasticity behaviours of soils*. Journal of Indian Geotechnical. 7, 261-282.*

Wong, L. S, Hashim, R. & Ali F. H. (2008). Engineering Behaviour of Stabilised Peat Soil*. European Journal of Sci. Vol. 21, 581-591.*

Wood, K. B. (1971*).* Highway Engineering Hand Book. Chapter 21*. New York: McGraw Hill Book Company, Inc.*

BIOGRAPHIES

Chief, Sir (Egnr.) Dr. George Rowland Otoko obtained his Msc. degree and DIC in Soil Mechanics and Engineering Seismology from Imperial College, University of London in 1985 and Ph.D in Geotechnical Engineering from RSUST in 1996. He is an Associate Professor in RSUST, with over 43 publications in google scholar and research gate. He is a consultant to several organizations, handling major Geotechnical projects in Nigeria, amongst which are roads, bridges, fly-overs and SPDC oil drill locations.

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