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Modifying Effects of Rice Husk Ash On The Geotechnical Characteristics Of Low Shear Strength Soils.

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ABSTRACT: *The study is an investigation into the potency of rice husk ash (RHA) on some geotechnical engineering properties of soil samples with low shear strength classified as A-7-6 soils (AASHTO., 1986). The investigation includes evaluation of properties such as Specific gravity, Consistency limits, Compaction and Strength of the soil with RHA content of 2%, 3.5%, 5%, 6.5% and 8% by weight of the dry soil. The results obtained reveal that the increase in RHA content decreased the optimum moisture content but increased the maximum dry density. It was also observed that with the increase in the RHA content. Compressibility and plasticity are reduced while volume stability as well as the shearing strength of the soil increased. 8% RHA content was also observed to be the optimum content.*

Keywords: *Rice Husk Ash (RHA), Low Shear Strength Soil, Compaction, Potency.*

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I. INTRODUCTION

In developing countries considerable benefits can be achieved through increased understanding and adequate engineering interpretations of soil with low shear strength properties. For too long, engineering aspects of Soils usefulness have not been adequately harnessed, especially soils in the basement complex moreso that major research works on low shear strength soils were primarily on the sedimentary terrain. A lot of Laterite that are good for roads occur in tropical countries of the world, including Nigeria (Osinubi and Bajeh, 1994). There are instances where Laterites may contain an ample amount of clay minerals that their shear strength and stability cannot be assured under load. These types of Laterites are also common in many part of tropical terrain of Nigeria, and in most cases, sourcing for alternative may prove economically unwise hence the need to improve the available soil to meet the desired objective (Mustapha 2005). Rice husk is an agricultural waste obtained from milling of rice. About 10^8 tons of rice husk is generated annually in the world. In Nigeria, about 2.0 million tons of rice is produced annually [Oyetola *et. al*, 2006]. Rice husk ash was utilized in the past for upgrading of well –graded sandy soils through Soil Modification that requires the addition of a modifier (Cement, Lime etc) to a soil to change its index properties. Soil stabilization is also needed to treat soils to improve their strength and durability such that they serve better for engineering purpose beyond their original classification. The use of agricultural waste such as rice husk ash (RHA) will therefore considerably reduce the cost of road construction and their associated environmental hazards. It has also been shown by Sear (2005) that Portland cement, by the nature of its chemistry, produce large quantities of Co_2 for every ton of its final product. Therefore, replacing proportions of the Portland cement in soil improvement with a secondary cementitious material like RHA will reduce the negative environmental impact of the modification process having categorised the ash under pozzolana, with about 67-70% silica and about 4.9 and 0.95% aluminium and iron oxides respectively (Oyetola and Abdulahi 2006). The investigation on strength characteristics of expensive soil conducted by S.Narasmharaco et al (1987, 1996). G.Rajasojaran et al (2002). Ali M.A Abd.Allah (2009) are worthy of note. However, the previous works with RHA have shown that it has promising potentials to improve the engineering properties of soils for sub-grade purposes.

This work is focused on investigating the effect of RHA on some geotechnical properties of lateritic soil which are relevant for evaluating the performance of sub-grade soils.

II. STUDY AREA

The Soils Sample were collected from Akure South local Government Area of Ondo state in Nigeria, The area has higher occurrence of migmatite-gneiss with porphyritic granite and granitic gneisses of considerable quantities. They are either exposed or covered by shallow mantle of superficial deposits, of variable thickness. They are considered unsuitable for accumulation of groundwater unless they are highly weathered, fractured and/or jointed (Acworth, 1987). Rainfall is unusual heavy and the atmosphere is quite humid except in the dry season between November and March when it is usually very dry and hot with low humidity. The mean annual rainfall of the area is approximately 1700mm. The annual temperature is between 25°C-30°C and the mean relative humidity is over 75% during wet season.

III. MATERIALS AND METHODS

Two bulks samples of disturbed Soil with low shear strength were collected at an average depth of 1.0m from two trial pits, designated A and B respectively in the month of July on co-ordinates. The oxide composition of the used rice husk ash samples were as follows; $A_2O_{3:}$(4.9), $SiO_{2:}$(67.3), $Fe_2O_{3:}$(0.95), CaO: (1.36), MgO: (1.81), Loss on Ignition: (17.78), (After Okafor *et al.* 2009). The disturbed sample soils were air dried for minimum of four day to allow even moisture content and then analysed in the laboratory for Consistency limit, Grain size analysis, Compaction test, California bearing ratio, Specific gravity with different, percentages proportion of modifiers, ranging from 0% to 8%. The results of the geotechnical analyses are interpreted while the tests for identification of the low shear strength soils and determination of their geotechnical properties treated with RHA were carried out in accordance with the BS 1377 [BS 1377: 1990]. The standard Proctor was used for compaction test which was also used to determine the moisture content for the California Bearing Ratio (CBR) specimens. However to ensure effective segregation of soil grains, the soils were soaked and regularly agitated in a calgon solution for a period of 24hrs before wet sieving. Mineral identification was done using plasticity chart developed by Casagrande data in [Mitchell J. K.; 1976]. The properties and grading curve of the lateritic soil are shown in table 1 and figure 1 respectively.

IV. RESULTS AND DISCUSSIONS

TABLE: 1 RESULTS OF RHA EFFECT ON DATA VALUES FOR BOTH SOIL SAMPLES.

Sample type	Trial Pit A						Trial Pit B					
% /Test	0	2	3.5	5	6.5	8	0	2	3.5	5	6.5	8
Gs (%) BS NO 200 sieve	Clay : 57.7 , Silt : 17.6 , Sand : 23:9, Gravel:0.8						Clay : 47.2 , Silt : 18.3 , Sand : 29:3, Gravel:5.2					
AASHTO / USC Symbols	A-7-6 / SCH						A-7-6 / SCH					
CONSISTENCY LIMITS												
Liquid Limit, LL (%)	64	62.7	60.6	58.4	56.1	51.9	72.5	69.9	67.00	65.00	64.00	61.7
Plastic Limit, PL (%)	23.2	23.3	23.6	24.1	24.8	25.4	25.5	24.3	25.5	25.9	26.4	26.9
Plasticity Index, PI (%)	40.8	39.2	36.65	34.35	31.35	26.50	47	45.60	41.55	39.10	37.60	34.85
Linear Shrinkage	12.1	10	10	9.3	8.6	7.9	10.7	10	9.3	8.6	7.9	7.9
Shrinkage limit	8.2	8.7	8.7	9.1	9.6	10.1	8.2	8.7	9.1	9.6	10.1	10.1
Degree of expansion	Critical	Critical	Critical	Critical	Critical	Marginal	Critical	Critical	Critical	Critical	Marginal	Marginal
COMPACTION												
OMC (%:)	32. 6	31.50:	30.60	28.60	26.90	25.50	27.6	25.90	24.50	23.40	22.40	20.60
MDD (kg/m3)	1459	1430.3	1460.0	1522.7	1578.9	1625.1	1611	1611.9	1658.1	1694.5	1727.5	1783.6
CBR (%)	SK :USK	SK :USK	SK: USK	SK: USK	SK : USK	SK : USK	SK : SK	SK : USK	SK : USK	SK :USK	SK : USK	SK : USK
	4 :15	5 : 15	7 : 17	8 : 20	8 : 23	9 : 25	3 : 16	3 : 17	4: 18	6 : 20	8 : 23	9 : 25
Strength Rating	NS	NS	GS	GS	GS	GS	PS	PS	NS	GS	GS	GS

Legend

SK: USK : Soak and Unsoak , SCH : Soil of High Compressibility and Plasticity , NS : Normal Subgrade Strength

GS : Good Subgrade Strength , PS : Poor Subgrade Strength, CBR : Canifolial Bearing Ratio

OMC : Optimal Moisture Content., MDD : Maximal Dry Density

Grain Size Analysis

The results of the grain size analysis (Table 1) as presented show wide range of distribution with predominant fines particles, probably clay which must have made the soils sample to posses very low shear strength.

Consistency Limits

The relationship between liquid limit, Plastic limit and Plasticity Index and RHA content is shown in the plasticity chart (Table 1), (fig. 2a & 2b) for both Pits A and B where the plasticity index decreased from 47% to 26.50% and from 40. 80% to 34.86% respectively with increase in RHA content from 0% to 8%. This trend may be attributed to the replacement of the finer soil particles by the RHA with consequent reduction in the clay content and plasticity index. Similarly, the Liquid limit follows the same trend as the plasticity index pattern. This implies l reduction in the swell potential percentage and range of activity values from high to marginal according to Skempton 1956. The high plasticity and compressibility ability of soils content reduced appreciably thereby enhancing the engineering properties and usefulness of the soil samples. The linear shrinkage decreased from 12.1% to 7.9% and from 10.7% to 7.9%, with increase in RHA content from 0% to 8%. These according to Mckeen (1976), imply a change from critical degree of expansion to marginal. Such may be attributed to the usual replacement of the soil fines by RHA. The later is less in activity with changes in moisture content and therefore, reduced the linear shrinkage of the soil-RHA mix to enhance volume stability of the soil.

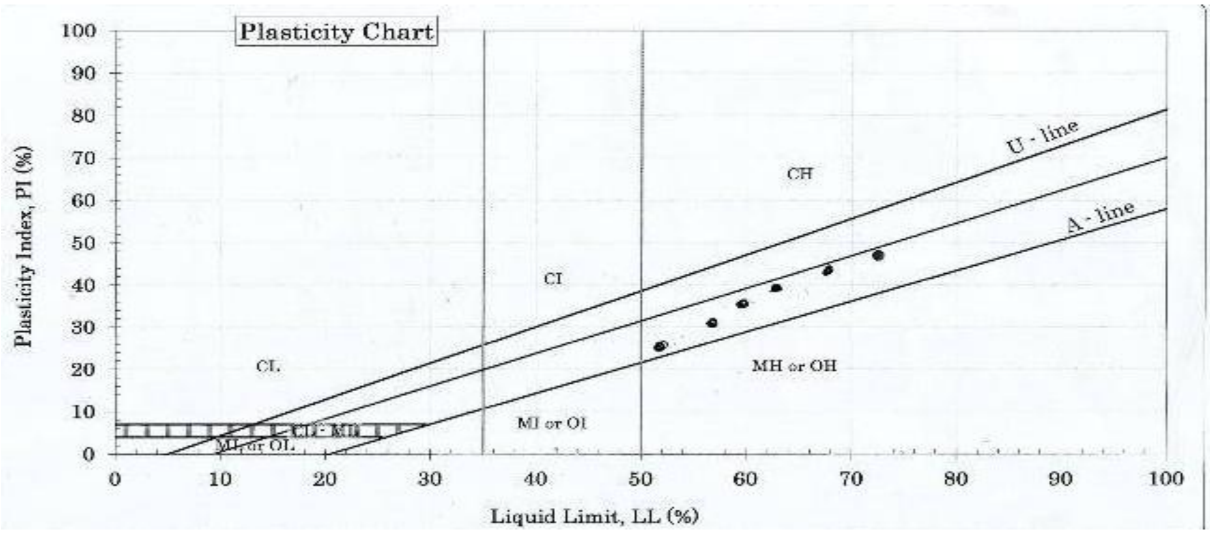

Fig. 1a; Showing the effect of RHA effect for sample A

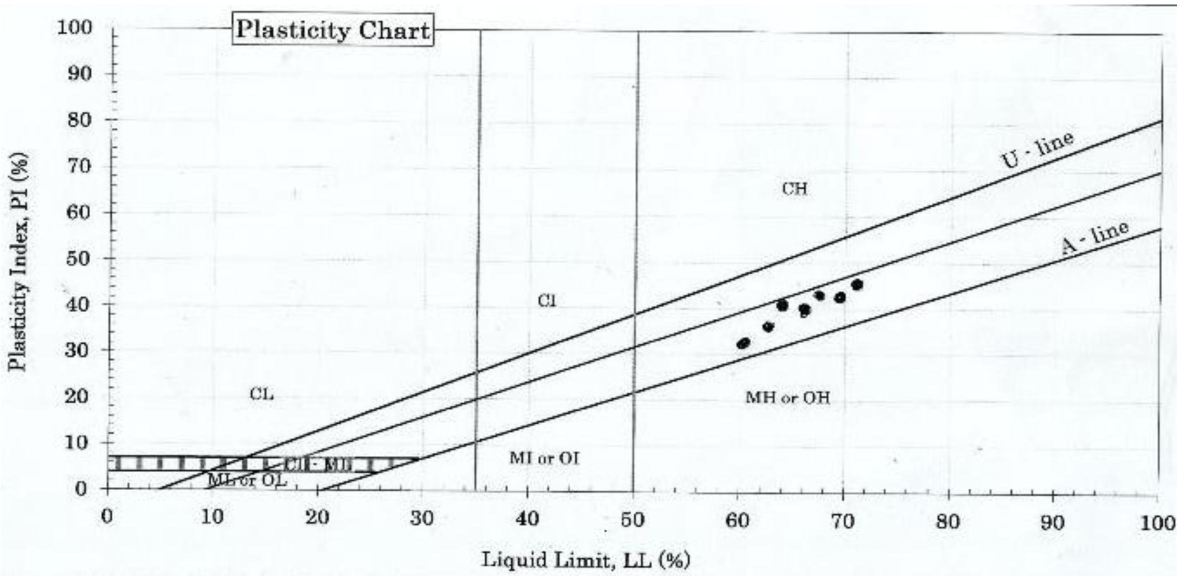

Fig. 1b; Showing the effect of RHA for sample B

Strength Characteristics

The relationship between California Bearing Ratio (CBR) and RHA (table 1), revealed that the CBR values and ratings increased from 14% to 21%, and from 16% to 24% for the unsoaked soil sample from Pits A and B respectively, and from 5% to 9% and from 3% to 7% for the soaked samples respectively. The strength rating progresses from average Strength to high quality Strength. This revealed the potency of the modifier on the soils samples strength transformation. Showing an improved engineering usefulness of the soil and more satisfying result when the additive is added. The consistent increment in the CBR values and rating after 2% RHA can be attributed to the gradual formation of cementitious compounds between the RHA and CaoH contained in the soil. The consistent and persistent increase denotes that no extra RHA was immobilized against many studied works. Cohesion rather being body reduced has been increasing indicating an increase in the silt and clay content of the soils samples. The bond in the soil-RHA mixture is perceived to be strong with the increasing CBR values. The CBR is a measure of the strength of the sub-grade and 8% RHA content gave the highest improvement of the CBR of the soil and hence would appear to be the optimum RHA content.

Compaction Test

The relationship between the OMC and MDD and the increase contents of the RHA (Table 1) Show the effect of RHA content on the optimum moisture content (OMC) and maximum dry density (MDD) of the two trial Pits (A and B) soils samples (Table 1). The results indicated that as the RHA contents increase from 0% and 8%, the MDD increase from 1459kg/m^3 to 1625.1kg/m^3 and from 1611 kg/ m^3 to 1783.6 kg/ m^3 for both soils samples A and B respectively, while the OMC decreases from 32. 6%: to 25.50% and from 27.6% to 20.60% for both Trial Pits A and B respectively. The results revealed a change from intermediate OMC content with lower MDD to low OMC with higher MDD. This resulted into better strength rating that implies higher shearing strength and bearing capacity for both soils.

V. CONCLUSIONS

The studied soil samples could be classified to be A-7-5 of well-graded sand (SW). OMC and the MDD of the soils were increased by RHA and increase in RHA content must have decreased the plasticity index of the soil and this is a confirmation that the reduction in the activity of the mixture have occurred with the addition of RHA. Thereby increased the volume stability as well as the shearing strength of the soils.

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