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Effect of Rice Husk Ash on the Index Properties of Tropical Black Clay

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Abstract – Preliminary tests, in accordance with the British standard specification B.S 1377 (1990) and BS 1924 (1990), were carried out on Tropical Black clay treated with up to 16% rice husk ash (RHA) to assess the possible improvement of the index properties of the tropical black clay with increasing rice husk ash contents. The results obtained showed a decrease in the liquid limit (LL), plasticity index (PI) and Specific Gravity, from 65%, 39.2% and 2.45 for the natural soil to 52%, 18.6% and 2.32, respectively for samples treated with 16% RHA. Similarly, the particle size distribution of the tropical black clay treated with varying percentages of the additive, showed a decrease in the fine fraction from 88.6% for the natural soil to 87.6% when treated with 16% RHA. This signifies that there is improved index properties of tropical black clay would be obtained when treated at 16% RHA replacement.

Keywords: Liquid limit, Plastic limit, Plasticity index, Rice Husk Ash and Tropical Black Clay.

1. Introduction

The stability of structures founded on soil depends to a large extent on the interaction of the said soil with water. Construction on expansive soil always creates a problem for civil engineers because of its peculiar cyclic swell shrink behavior (Akshaya and Radhikesh, 2011). This type of soil swells when it comes in contact with water and shrinks when the water evaporates out. The clay mineral montmorillonite is mostly responsible for this type of nature of the soil. Movement in Tropical Black Clay also known as Black Cotton Soil (BCS) is usually in an uneven pattern and of a magnitude to cause extensive damage to the structure resting on them, thus this situation has a substantial effect on the structures founded on such soil. Also, road bases built on soils that are not easily drained are affected by the development of pore water pressure which causes the formation of potholes and eventually the total failure of such roads. Because of this movement, lightly loaded structures such as foundations, pavements, canal beds and linings and residential buildings founded on them are severely damaged (Chen, 1988). Proper remedial measures are to be adopted to modify the soil or to reduce its detrimental effects if expansive soils are identified in a project. In such an attempt to minimize these effects, such soils are subjected to treatments aimed at either disallowing water into them or allowing easy passage (drainage) of water and to prevent pore water development (Musa, 2008). There are different methods of altering the nature of this soil to make it fit for construction: replacing the existing soil (though not a feasible option), stabilization using suitable stabilizers such as industrial wastes are some of them. Many stabilization techniques are in practice for improving the expansive soils in which the characteristics of the soils are altered or the problematic soils are removed and replaced which can be used alone or in conjunction with specific design alternatives. Additives such as lime, cement, calcium chloride, Rice Husk Ash (RHA), fly ash etc. are also used to alter the characteristics of expansive soils (Venkara and Prasada, 2012).

Rice husk (RH) is the outermost layer of a rice grain which contains about 75% organic volatile matter and the balance 25% of the weight of this husk is converted into ash during the firing process in boilers known as rice husk ash. Lots of ways are been thought of for disposing them and this, by making commercial use of this RHA. RHA is a good pozzolan (ricehuskash.com). This study seeks to evaluate the potentials utilization of RHA treated black cotton soil for use as road subgrades.

2. Materials and Methods

2.1 Materials

2.1.1 Tropical Black Clay

The clay used for this work was collected from Baure Biu road in Yamaltu Daba L.G.A of Gombe State in the North Eastern part of Nigeria, by method of disturbed sampling. The top soil was removed up to a depth of 500 mm in order to remove deleterious materials. A portion was carefully sealed in polyethene bags and put in a container to avoid loss of moisture in order to get its natural moisture content. The clay was then transported to the laboratory where it was air dried, pulverized manually and passed through sieve size 4.75mm except for the portion of the sample that was used for sieve analysis.

2.1.2 Rice Husk Ash (RHA)

The RHA used for this work was obtained from Jalingo, Taraba State, Nigeria. The town is widely known for her cultivation and milling of rice in large quantities. The RH was obtained from the milling plants and burnt in an open.The RHA was transported to the laboratory and sieved through sieve aperture 425µm to remove larger particles of stones and charcoal. It was later sieved through sieve no. 200 (75µm) to remove soil fines present in the ash and it was stored in an air tight polythene bags to prevent any form of hydration. The ash obtained was then used in treating the tropical black clay in stepped concentrations of 0, 4, 8, 12 and 16% respectively. The oxide composition of the RHA was carried out at the Centre for Energy Research Technology (CERT), Ahmadu Bello University Zaria, Nigeria. The Oxide Composition is shown in Table 1.

Table 1. Oxide composition of Rice Husk Ash

Oxide	Al_2O_3	SiO_2	SO_3	CaO	Fe_2O_3	P_2O_5
Concentration (%)	2.15	72.65	1.67	1.87	1.65	8.83

2.2 Methods

All tests were performed in accordance with the British standard specification B.S 1377 (1990) and BS 1924 (1990). The following tests were performed on the natural and treated soil samples: liquid limit, plastic limit, shrinkage limit and sieve analysis.

3. Results and Discussion

3.1 Physical Properties of Tropical Black Clay

The physical properties of the natural soil are summarized in Table 2.

Table 2. Index properties of the Tropical Black Clay sample

Properties	Value
Percentage passing B.S sieve No. 200	88.6
Natural Moisture Content (%)	16.1
Liquid Limit (%)	65
Plastic Limit (%)	25.79
Plasticity Index (%)	39.21
Specific Gravity	2.45
AASHTO Classification	A-7-6
USCS	CH
Group Index (%)	45
Colour	Black-Grey

3.2 Plastic Limit (PL)

The plastic limit (PL) of the treated tropical black clay soil generally increased with higher doses of RHA content as shown in Fig. 1. PL values increased from 25.79% for the natural soil to 33.36% when treated with 16 % RHA. The increasing PL values could be due to higher quantities of RHA which introduced more pozzolanic substances from the ash (i.e., Ca^{2+}, Al^{2+}, Fe^{2+}, Si^{2+}) that required more water for hydration to go to completion. Similar results were obtained by other authors (Muntohar, 2002; Ijimdiya *et al*., 2012).

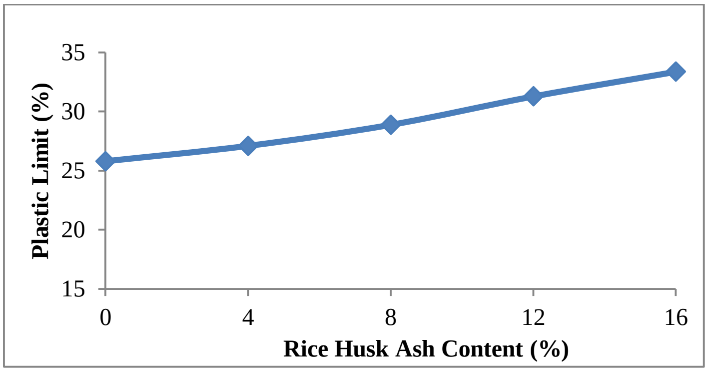

Fig. 1. Variation of Plastic Limit of tropical black clay soil with Rice Husk Ash Content

3.3 Liquid Limit (LL)

The variation of Liquid Limit (LL) of the RHA treated tropical black clay is shown in Fig 2. LL decreased from 65 % for the natural soil to 52 % when treated with 16% RHA content. The reduction in liquid limit with increasing RHA content could be due to agglomeration and flocculation of the clay particles, which was as a result of ion exchange at the surface of the clay particles as the Ca^{2+} in the RHA reacted with the lower valence metallic ions in the clay structure (Okonkwo, 2009; Ijimdiya, 2014).

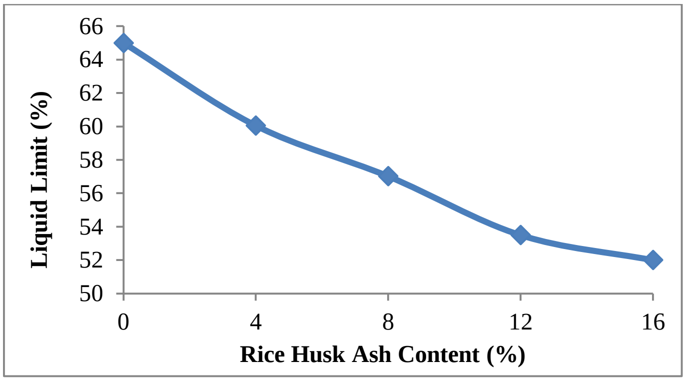

Fig. 2. Variation of Liquid Limit of tropical black clay soil with Rice Husk Ash Content

3.4 Plasticity Index (PI)

Fig. 3 shows the variation of the plasticity index of the RHA treated tropical black clay soil. PI decreased from 39.21 % for the natural soil to a minimum value of 18.64 % when treated with 16 % RHA content. The reduction in PI with higher doses of RHA could be attributed to agglomeration and flocculation Okafor and Okonkwo, 2009; Ebermu, 2011).

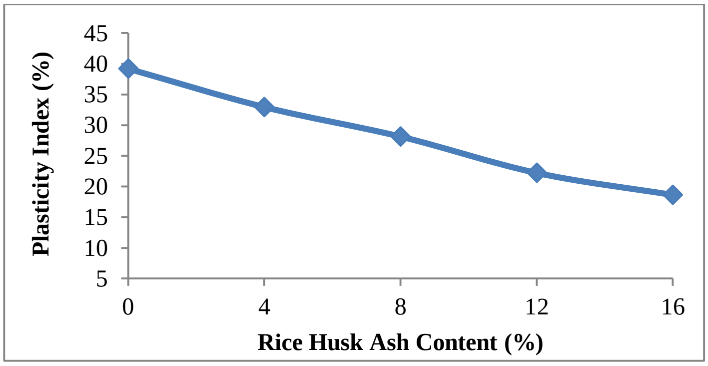

Fig. 3. Variation of Plasticity Index of tropical black clay soil with Rice Husk Ash Content

3.5 Particle Size Analysis

The particle size distribution of the natural and the treated soil is shown in Fig. 4. The fine fraction was observed to decrease with higher RHA contents. The decrease could be due to the aggregation of finer soil particles with the RHA to form of pseudo-Similar results was reported by other authors, Osinubi and Eberemu, (2008).

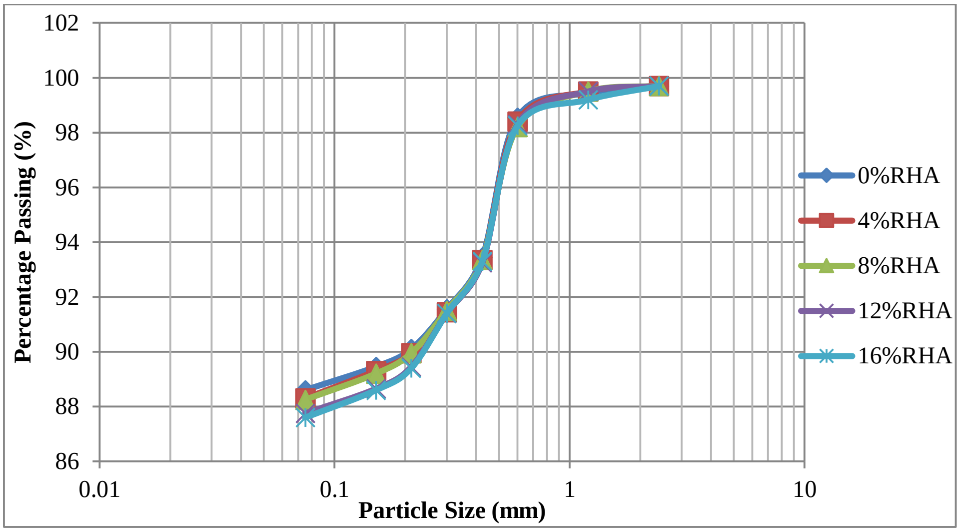

Fig. 4. Particle size distribution of Tropical Black Clay at different RHA Content

3.6 Specific Gravity

The variation of the specific gravity of tropical black clay withy higher doses of RHA contents is shown in Fig 5. It was observed that the specific gravity decreased from 2.45 for the natural soil to 2.32 when treated with 16% RHA content. The observed decrease could be attribute of the low specific gravity of RHA of 2.04 as compared to the specific gravity of the tropical black clay of 2.45.

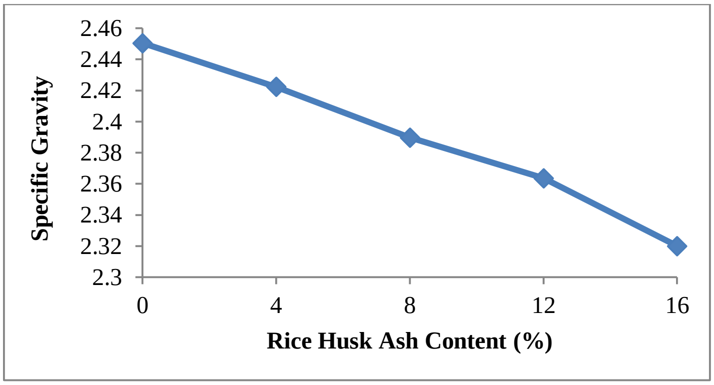

Fig. 5. Variation of Specific Gravity with Rice Husk Ash Content

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