EFFECT OF RICE HUSK ASH STABILIZATION ON THE COMPRESSIVE STRENGTH OF OIL CONTAMINATED SOILS

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ABSTRACT

The paper presents the results of a laboratory study carried out on oil contaminated soil samples treated with Rice Husk Ash (RHA) contents at the Standard Proctor compaction energy. The results obtained showed improvements in the properties of the RHA treated oil contaminated soil samples. The Atterberg limits decreased with higher RHA content and maximum Unconfined Compressive Strength (UCS) value of 405 kN/m^2 at 2 % oil/ 2 % RHA content was obtained.

Keywords: Unconfined compressive strength, Standard Proctor, Rice husk ash and oil contamination.

1.0 INTRODUCTION

Since the discovery of oil in Nigeria in 1956, the Niger Delta region has suffered negative environmental consequences of oil exploration and exploitation. Oil spill were basically attributed to be due to human error, corrosion and equipment failure which accounted for 38 percent of the incidents while the remaining 62 percent of incidents were allegedly caused by sabotage (Ijimdiya, 2012). The harmful effects of oil spill on the environment are many. Large areas of the mangrove ecosystem have been destroyed, which was in the past a major source of wood for the indigenous people. Oil pollution changes the geochemical composition of the soil, river and other components of the environment (Okoh, 2003). Oil spills in the Niger Delta have been a regular occurrence, and the resultant degradation of the surrounding environment. This study is aimed at investigating the potential use of the oil contaminated soils samples by treating the soil using Rice Husk Ash (RHA) in order to make them suitable for use in road sub-base.

Rice husk is an agricultural waste product obtained from the milling of rice. Globally, approximately 600 million tonnes of rice paddy are produced annually and on the average, 20% of the rice paddy is husk, giving a total production of 120 million tonnes of husk (IRRI, 2007). In Nigeria, statistics showed that about 3.0 million tons of rice is produced annually (IRRI, 2007). Rice husk ash has been shown to be a good pozzolana with its properties similar to that of cement, having about 67 – 70 % silica and about 0.95-4.9 % aluminium and iron oxides, respectively (Oyetola and Abdullahi, 2006). The silica is substantially in its amorphous form after burning at temperatures below 700^{0}C (Oyetola and Abdullahi, 2006). Such a material could be used as a good substitute for cement because of its high silica content. It is expected that an improved geotechnical properties of this soil will be attained which would in turn reduce cost of construction of road sub-bases.

2.0 MATERIALS AND METHODS

2.1 Materials

2.1.1 Soils: The soil samples used for the investigation was obtained from a borrow pit at Shika, Zaria, Nigeria. The borrow pit is precisely located at 0344054N, 1238202E, UTM co-ordinates, acquired using a hand held global positioning system equipment, Garmin 45 GPS. A disturbed sample was obtained at a depth of 1.5 meters.

The soil was subjected to tests in accordance with British Standard Code of practice BSI 1377 (1990), for the natural soil, and BSI 1924 (1990) for the contaminated and treated soil samples respectively. The soil belongs to a group of ferruginous tropical soil derived from acid igneous and metamorphic rocks (Osinubi, 1998).

The soil is classified as inorganic clay of low plasticity (CL) based on the unified soil classification system (USCS) with group name lean clay. American Association of State Highway and Transportation Organization classify the soil type as A-6 with group index of 16 (i.e. A-6 (16)).

2.1.2 Rice Husk Ash: The rice husk used was obtained from a rice milling industry at Kura Local Government Area of Kano state. The husks were stock piled and burnt in the open air which was allowed to ash for 24 hours. The ash was sieved through BS No. 200 sieve (75µm aperture). The oxide composition of RHA was determined using an Atomic Absorption spectrometer (AAS). A summary of the properties of the RHA is shown in Table 1.

2.1.3 Characteristics of the Oil used: The oil utilized in this study is stale motor oil which was collected from Oando lubrication workshop opposite Ahmadu Bello University, Zaria, main campus, Kaduna State. The oil was collected in a closed container and stored in a cool dry place. The physical properties of the oil such as specific gravity, flash point, fire point, viscosity and density are, 0.70, 168 °C, 220 °C, 1.17 cP, and 0.76 g/cm^3 respectively.

Table 1: Chemical Composition of Rice Husk Ash

Oxide	Concentration (%)
SiO_2	61.40
Al_2O_3	4.90
Fe_2O_3	1.76
CaO	1.25
MgO	8.02
K_2O	15.2
Na_2O	0.60
MnO	3..36
P_2O	1.21
Loss of Ignition (%)	7.43

2.2 Methods

2.1.1 Atterberg Limits: The Atterberg limits consisting of liquid limit, plastic limit, and shrinkage limit were determined in accordance with the Bristish Standards (BSI, 1377: 1990).

2.2.2 Unconfined Compressive Strength: The unconfined compressive strength (UCS) was determined in accordance with British Standards (BSI, 1377, 1924: 1990). Thoroughly mixed air dried soil-oil- RHA mixtures were compacted at optimum moisture content (OMC) using the Standard Proctor (SP) compaction energy. The compacted soil-oil-RHA mixtures were prepared by adding RHA in step concentrations of 2, 4, and 6%. The compacted samples were extruded from the mould using a cylindrical steel measuring 76 mm by 38 mm diameter. The samples were sealed in polythene bags and kept in the humidity room at a constant temperature of 25 ± 2^{o}C for 7 days curing period. The samples were then placed in a load frame driven at a constant strain of 0.10 %/min until failure occurred. Three specimens were used for each test and the average result taken.

3.0 RESULTS AND DISCUSSION

3.1 Atterberg Limits

Figures 1- 4 show the variation of the consistency limits of oil contaminated soils with increasing RHA content. From the plots, it was observed that liquid limit, plastic limit, linear shrinkage and plasticity index increased with oil contamination. However, with the inclusion of RHA into the soil-oil matrix, the consistency limits decreased. At 2 % Oil/0 % RHA the liquid limit, plastic limit, linear shrinkage and plasticity index were 42, 33, 4.9 and 9 % respectively. And at 8 % Oil/6 % RHA liquid limit, plastic limit, linear shrinkage and plasticity index recorded were 30, 26, 3.5 and 7 % respectively.

The decreases recorded in the consistency limits observed with the inclusion of RHA could be due to cation exchange reaction. This is in agreement with the findings in the literature Osinubi, 1995,1999; Osinubi and Stephen, 2005; Ijimdiya, 2007, 2008, 2010. The more active and higher valence cations in RHA (i.e. Ca^{2+}) replaced the weakly bonded ions in the clay structure.

The liquid limits of the RHA treated specimens are greater than the minimum liquid limit requirement of 35% recommended by the Nigerian General Specification (1997). In the same vein the plastic limits of the RHA treated samples is greater than the minimum plastic limit requirement of 12% recommended by the Nigerian General Specification (1997).

3.2 Unconfined Compressive Strength

The variation of unconfined compressive strength (UCS) of oil contaminated soil samples with increasing RHA content is depicted in Figure 5. The UCS values of the oil contaminated soil samples at 2, 4, 6 and 8 % oil contents at 0 % RHA were 186, 180, 152 and 104 kN/m^2. This shows a decrease in UCS with higher oil contents. For soil – oil - RHA mixtures of 2% Oil/0% RHA, 2 % Oil/ 2 % RHA, 2 % Oil/ 4 % RHA and 2 % Oil/ 6 % RHA the UCS values recorded were 186, 405, 311, 233 kN/m^2 respectively. Similar trends were obtained at other levels of oil contamination. The peak UCS value recorded at 2 % RHA content could be attributed to the adhesion of the individual soil particles into a denser matrix of the soil-oil-RHA mixture to achieve an increased bonding between the particles resulting to a greater load resistance. With further increase in RHA content, at all levels of oil contamination considered, there was a consistent decrease in the UCS values. This could be due to the segregation of the bonded soil particles as the fines content increased with higher RHA content.

The peak UCS values obtained for RHA treated specimens are lower than the conventional 1720 kN/m^2 for 7 day strength of cement stabilized base course soil (TRRL, 1977).

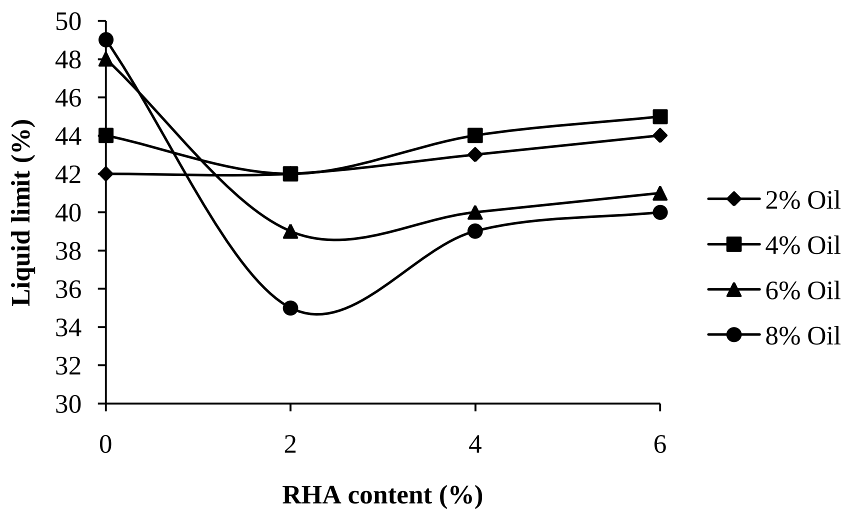

Figure 1: Variation of liquid limit of soil-oil-RHA mixtures

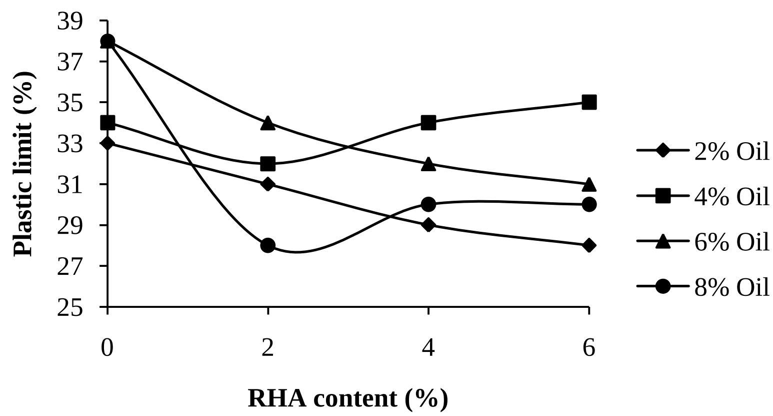

Figure 2: Variation of plastic limit of soil-oil-RHA mxtures

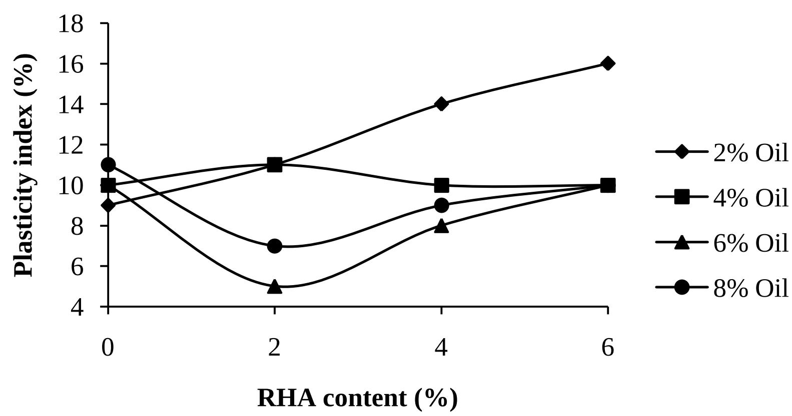

Figure 3: Variation of plasticity index of soil-oil-RHA mixtures

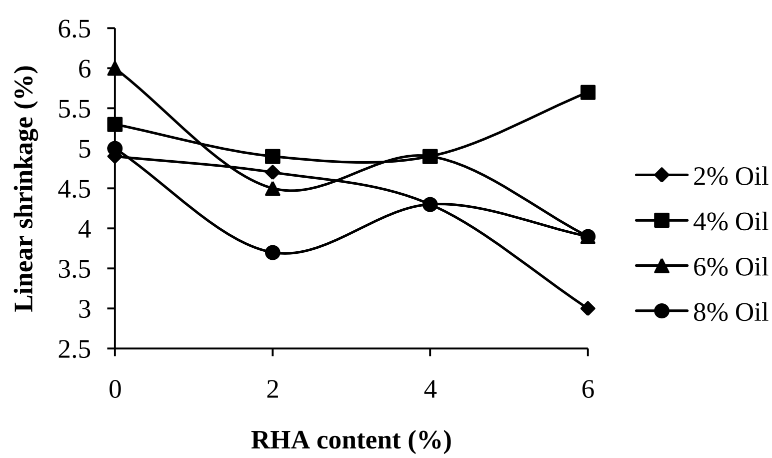

Figure 4: Variation of linear shrinkage of soil-oil-RHA mixtures

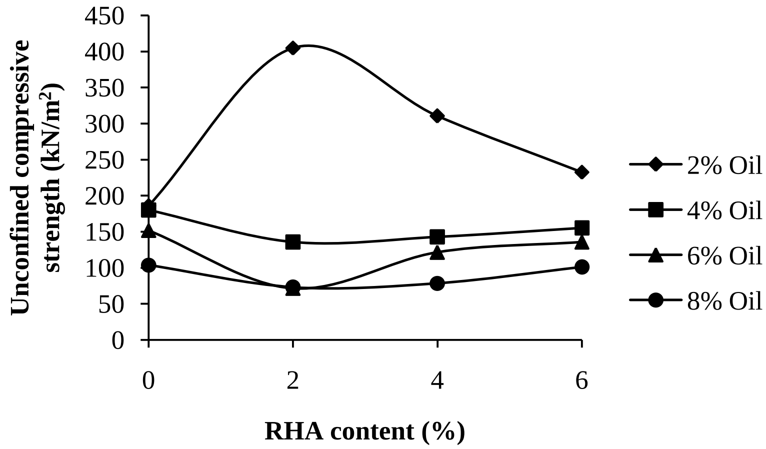

Figure 5: Variation of UCS with RHA content at 7 days curing period

4.0 CONCLUSION

Based on the results obtained from the investigation carried out, the following conclusions can be made:

1. The lateritic soil used is an A-6 or CL soil in AASHTO and USCS classification systems, respectively.
2. The used oil has the following physical properties: specific gravity, flash point, fire point, viscosity and density as, 0.70, 168 ^{0}C, 220 ^{0}C, 1.17 cP, and 0.76 g/cm^3 respectively.
3. The UCS of the RHA treated oil contaminated soils peaked at 2 % oil/ 2 % RHA content with value of 405 kN/m^2 at 7 days curing period.
4. There was an initial increase in the UCS of the soil-oil-RHA matrix as the oil content increased. At 2 % oil/ 2 % RHA content the highest UCS value of 405 kN/m^2 was recorded and this did not meet the minimum requirement of 1720 kN/m^2 recommended by TRRL (1977) for use in sub-grade construction. However, RHA stabilized oil contaminated soil samples can be recommended for use in sub-grade construction for lightly trafficked roads.
5. Furthermore, it is expected that there would be an increase in strength due to time-dependent pozzolanic reactions in the soil-oil-RHA mixtures, hence yielding higher strengths.

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