American Journal of Materials Engineering and Technology, 2014, Vol. 2, No. 3, 34-37
Available online at http://pubs.sciepub.com/materials/2/3/2

DOI:10.12691/materials-2-3-2

Analysis of the Effect of Blending Nigeria Pure Clay with Rice Husk: A Case Study of Ekulu Clay in Enugu State

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Received May 19, 2014; Revised June 09, 2014; Accepted June 20, 2014

Abstract This work presents the comparative study of pure clay with that blended with rice husk in Enugu State, Nigeria. This researc*h* was carried out to investigate its physical properties, such as; modulus of plasticity, porosity, bulk density, water absorption, making moisture, modulus of rupture, shrinkage and apparent density. In order to ascertain the influence of rice husk on these properties of the clay in the area in question. The results obtained revealed that the blended clay with rice husk and pure clay were fired at furnace to the turn of 900°C, 1000°C, 1100°C and 1200°C respectively. They were then tested for apparent density, porosity, and modulus of rupture and water absorption capacity. The results obtained showed that the maximum service temperature of the blends was presented to be the best under a given temperature. There was also observed decrease in the bulk density, shrinkage with an increase in the plasticity.

Keywords: *clay, Rice-husk, physical properties, furnace, temperature soil, blend*

Cite This Article: Emmanuel I. Ugwu, and Dickson A. Famuyibo, “Analysis of the Effect of Blending Nigeria Pure Clay with Rice Husk: A Case Study of Ekulu Clay in Enugu State.” *American Journal of Materials Engineering and Technology*, vol. 2, no. 3 (2014): 34-37. doi: 10.12691/materials-2-3-2.

1. Introduction

The oldest clay deposit was found in Africa by archeologists some ten thousand years ago (Norton, 1974, Dinadale, 1986 and Prudence, 1987). This is an abundant fine earthy powder produced by the weathering and disintegration of granite and feldspathic rocks (Idenyi et al. 2003). In the southern part of Nigeria, most regions are richly blessed with natural resources like clay. These clay-based materials occur both in the plain and river rime areas (Amaefule, 1990). In recent times, coconut fibers, laterites, and other useful materials have been mixed in different proportions to produce roofing sheets and bricks as building materials. The rate of development and application of such new materials and the constant demand for high quality building/agricultural materials necessitated the need for this study. The use of these material resources was made possible by the application of heat in transforming the soft clay deposit into something malleable, hard, and durable (Norton, 1974; Dinadele, 1986; Owate, 1988 and Ogbi, 1984). The use of these material resources was made possible by the application of heat in transforming the soft clay deposit into something malleable, hard, and durable (Norton, 1974; Dinadele, 1986; Owate, 1988 and Ogbi, 1984).

It is believed that the history of ceramics really began with recognition of clay as useful raw material. The characteristic features of interest include plasticity; resistance to high temperature, malleability can be shaped to any form and complex composite formulations, adding various substances to clay with a view to improving the properties and usefulness (Mohammed 2013).

The various characteristic properties of most clay products are believed to be the consequence of impurity additions, sintering firing procedure, (Nweke and Ugwu 2007). As it is clear and well knows that clay–based materials are especially abundant in high temperature areas like Nigeria, since it possesses the ability to resist compressional forces to a reasonable extent. Ito has earlier investigated the effect of rice husk and tapioca waste used as organic amendment on clay soil biological properties during which he found that moderate rate of rice husk decomposition process slightly increased the soil organic matter surface layer that might have led to somewhat decreased particle density due to much available water content enhancement (Ito,2000).While Brook on the other hand has tried to upgrade clay soil as a construction material using a waste material such as rice husk ash and flyash He blended these materials with clay and carried test on the strength during which it was discovered (Yadu, etal 2011,Mallihi and Bankole 2011) apart from the work of (Koteswara, et al 2011) had worked on clay soil stabilization by blending it with some percentage rice husk ash respectively.

This work is therefore based on finding the influence of blending clay soil with rice husk in order to know if the blending would improve the quality and the properties as regards the applicability of clay to the modern technology apart from other operations and structural applications. Furthermore, this would enhance the process of modification, proper utilization and development of clay based raw materials and also to see if we can make use of natural waste material which is in abundant especially that of rice husk that is lying waste here and there in our area as one the major rice producing area in Nigeria.

2. Experimental Procedure

Clay samples were obtained by creping out the surface where it is deposited (about 2ft), and collecting the in-situ clay.

3. Preparation of Sample

Sample preparation involved 4 stages, and they are:
1. Drying;
2. Crushing;
3. Gyrating;
4. Making of mold.

The silicability test of clay sample was carried out to determine its behavior (ie, to know if the clay is totally or partially dissolvable). This is done by putting a few samples in a beaker containing water and waiting for 4 minutes. (Ekulu clay was observed to be 100% dissolvable)

Drying; Sample preparation started by drying the clay sample by exposing it to air in an open field.

Crushing; This process was carried out manually (crushing with mortar and pestle). The dried sample was crushed into thin particles (no part of it was removed).

Gyrating; The mixed fine particles of rice husk ash and clay particles were further projected to a gyrator to get the suitable mix of the particles needed for the experiment.

Two kilogram of fine husk ash was measured with the help of a weighing balance, and 785cm of water was added to it to form mould. The was blended with rice husk ash using a suitable mathematical ratio of 75% and 25% rice husk used to blend 2 kilogram of the pure clay ; such as $\frac{75\%}{100\%}\times\frac{2000g}{1}=1500g\left(1.5kg\right)$ and $\frac{25\%}{100\%}\times 2000g = 500g\left(0.5kg\right)$ respectively.

After that stage rectangular mold of the pure clay and blend clay were formed respectively. The following properties; apparent porosity; bulk density, total shrinkage, water absorption and apparent density were determined from the mold formed.

We started by marking out 5cm with the help of a vernier caliper on the mould surface, and record it as the original length (W.L), then put the mould in a dryer for 24-hour at a temperature of 110°C and placed the vernier caliper on the area marked to determine its dry length (D.L). The mold samples were taking to the kiln and fired at temperature ranges of; 900°C, 1000°C, 1100°C and 1200°C respectively.

Determination of Shrinkage (%)

Shrinkage is determined by measuring the ratio of the change between the original length and the dry length to the dry length and multiplies it by one hundred (100) in percentage.

Mathematically, it is represented as:

For wet-dry shrinkage% $=\frac{\left(W.L-D.L\right)}{D.L}\times 100\%$

For dry-fired shrinkage% $=\frac{\left(D.L-F.L\right)}{D.L}\times 100\%$

For total shrinkage % $=\frac{\left(W.L-F.L\right)}{F.L}\times 100\%$

The brick test is another stage where we used the rectangular mould. In this stage, five (5) parameters are obtained, such as;

i. weight of the original sample (O.W)
ii. Dry weight (D.W)
iii. Soaked weight (S.W)
iv. Fired weight (F.W)
v. Suspended weight(SP.W)

The original weight is taken when it is in wet form before projecting it to a dryer at about 110^{0}C. For 24-hour, the dry weight is measured and then the clay is fired in a kiln and recorded as fired weight. The sample is soaked in water for 24-hours and also weighed to determine its soaked weight and then divide the soaked weight by two to determine its suspended weight.

Note that all the weighing is been done on electric sensitive weighing machine.

Determination of Bulk Density

Bulk density is determined by measuring the ratio of dry weight (D.W) to the change between soaked weight (S.W) and the suspended weight (SP.W).

Mathematically, it is represented as: Bulk density (g/cm^3) $=\frac{D.W}{\left(S.W-Sp.W\right)}$.

The porosity, σ of the materials as obtained by our calculation using the formula: $\alpha=\frac{f_d}{t_d}$ was comparable to the of (ASTM C373) American standard of testing material test method

Where f_d = final density and t_d = theoretical density. Also the, Shrinkage, bulk density and apparent density were also looked at. The results displayed are those showing the total shrinkage (%), the making moisture, % apparent porosity, bulk density, apparent density and the water of All of the physical properties except modulus of elasticity and making moisture were investigated at temperature range of 900°C, 1000°C, 1100°C and 1200°C.

4. Results/Discussion

The results obtained from the experiment are depicted in the Table 1 to Table 6.

All the physical properties of both pure and blended clay with rice husk were investigated at the temperature range of 900°C, 1000°C, 1100°C and 1200°C.

From the observation in Table 1, it was found that percentage apparent porosity of blended clay with rice husk is experiment. Similarly characteristics were observed for apparent density and percentage water absorption capacity as shown in Table 2, Table 3 and Table 5.

However, in Table 4 it is seen that the bulk density and percentage total shrinkage of pure clay are higher for all the temperature than the blended clay with rice husk while the plasticity of the blended clay is higher as compared to pure clay as shown in Table 6.

Table 1. %Apparent porosity of pure clay and blended clay with rice husk ash for various Temperatures

Temperature °C	Pure Clay	Blended Clay
900	35.78	67.1
1000	35.33	66.39
1100	35.07	66.15
1200	33.91	65.75

Table 2. Apparent density (gm/cm^3) of pure clay and blended clay with rice husk ash

Temperature °C	Pure Clay	Blended Clay
900	2.56	4.02
1000	2.55	3.99
1100	2.54	3.98
1200	2.52	3.95

Table 3. % Water absorption of pure clay and blended clay

Temperature °C	Pure Clay	Blended Clay
900	21.8	49.99
1000	21.45	49.69
1100	21.43	49.5
1200	21.29	49.26

Table 4. Bulk density (gm/cm^3) of pure and blended clay

Temperature °C	Pure Clay	Blended Clay
900	1.66	1.35
1000	1.65	1.34
1100	1.64	1.34
1200	1.25	49.26

Table 5. Total % Shrinkage of pure and blended clay

Temperature °C	Pure Clay	Blended Clay
900	6.4	4.4
1000	8.6	4.8
1100	9.2	5
1200	9.6	5.8

Table 6. Modulus of plasticity of pure and blended clay

Temperature °C	Pure Clay	Blended Clay
900	2.829	3.211
1000	3.163	3.274
1100	3.065	3.207
1200	3.019	3.231

The modulus of rupture of pure clay is more as compared to the blended clay. From all indication, the blending of rice husk affected the pure clay at all fired temperatures. There is a general decrease in maximum dry density with increase in optimum moisture content due to the replacement of soil (Osinubi, 1999, Gidiggasu 1976) by rice husk in the mixture which 0f course has relatively lower specify gravity as compared to the clay soil. It may also be attributed to the fact that the presence of rice husk results in creation of large voids and hence less bulk density of the blended clay. The decrease in the maximum the clay soil could either be modified or stabilized or both in order to change its index properties which would invariably enable their strength and durability to be improved such that they become totally suitable for construction beyond their original classification. (Mohammed, 2013). This is due to the fact that clay tend to have low shear strength and looses shear strength upon wetting or other physical disturbances. It can be plastic and compressible and expand when wetted and shrinks when dried.(Brooks ,2009).

This effect has continued to deter people from making maximum use of clay soil (Ito etal 2008) investigated the effect of rice husk and tapioca waste (cassava peel) used as organic amendments on soil physical and biological properties. The results showed that moderate rate of rice husks decomposition process slightly increased the soil organic matter of surface layer that may have lead to somewhat decreased particle density and available water content enhancement. Brooks (2009) made a trial to upgrade expansion soil as construction material using rice husk ash and fly ash, which are waste materials.

Remolded clay was blended with rice husk and fly ash and the strength test conducted (Yadu et al 2011) also presented the laboratory study of black cotton soil stabilized with fly ash and rice husk where we confirmed that the soil was stabilized with different percentage. The moisture and density curves depicted that increase in the addition of rice husk resulted in an increase in optimum moisture content and decrease in maximum dry density.

Study on lime stabilized lateritic soils using rice husk ash as admixture showed that there is significant improvement on index and geotechnical properties according to the test.

In terms of compaction, characteristics, addition of lime and rice husk ash decreased the maximum dry density and increased the optimum moisture content. (Mallibi and Bankole 2011).

The variation of plasticity limit for the blended clay at different temperature as compared the pure clay as shown in Table 6 is due to the presence of rice husk which increases the plastic limit as observed by Muntohart, Hantoro, 2000 that plasticity of clay soil is increased when lime and rice husk is added in clay (Muntohart and Hantoro 2000). As observed in the result as shown in table. 4, there was a decrease in the bulk density could be attributed to the replacement of clay soil by rice husk in the mixture which invariably lowered the relative density as compared to the pure clay soil as explained by (Osula 1999; Ola, 1975). In another perspective, it might be considered to be as a result of coating of the soil by rice husk which led to development of large particle size with large void and hence less density. (Osinubi and Katte, 1997).

Table 7. Modulus of rupture of pure blended clay

Temperature °C	Pure Clay	Blended Clay
900	15.13	8.45
1000	18.86	10.5
1100	19.89	19.58
1200	27.23	8.67

5. Conclusion

From the results of the investigation carried out within the scope of this work, it was observed that the addition of rice husk to the clay resulted led to the increase in modulus of rupture and a general decrease in maximum dry density with increased optimum moisture content and increase in the modulus of plasticity. Apart from these, there was enormous effect on the properties of clay when it is blended with rice husk.

Acknowledgement

Our gratitude to the management of PRODA Emene, Enugu for allowing us to use their equipment especially, kiln to carry out this work. We are also indebted to Eni Sabastine O. for his contribution in carrying out the reading during the experiment.

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