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ENGINEERING PROPERTIES OF CLAY-RICE HUSK ASH COMPOSITES

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ABSTRACT

Sun-dried bricks (*adobe*) are out dated to many people. However, statistics show that one fifth of the world's population uses this material to build houses. The cost of better, alternative building materials are high. Therefore, there is need to improve the quality of sun-dried bricks. Laboratory experimental procedures are used to determine the specific gravity of the clay, plasticity Index, strength, shrinkage, cracks, and weight of natural clay mixed with Rice Husk Ash (RHA). Results showed that the average specific gravity of the clay is 2.65; shrinkage, plasticity, and cracking of the clay were improved in the composites. However, the compressive strength of clay was not improved by the addition of RHA.

Key words: Clay, Rice Husk Ash, Composites, Shrinkage, Plasticity Index

INTRODUCTION

In the light of ever increasing cost of building materials such as sandcrete blocks, asbestos, aluminum and zinc roofing sheets, various methods of reducing costs need to be considered. The building materials research and development in Nigeria and other similar bodies in developing countries have made significant efforts towards the production of cheap and readily available building materials. Indeed, research and development over the past decade or so have produced dramatic and quantifiable results. Some of the research work done to produce cheap alternative building materials are in the area of sun-dried Brick (*adobe*), cement stabilized blocks, fired-clay bricks and blocks, fiber concrete roofing sheets, fiber concrete roofing tiles, Rice Husk Ash (RHA) Pozzolanic cement, etc (Benard and Rena, 1995). When clay is formed into bricks and sun dried, it is known as *adobe (Madedor, 2005)*. Sun dried bricks produced by the Nigerian Building and Road Research Institute (NBRRI), using NBRRI machines have been used in rural housing (Madede, 1992). According to BS 3921, the usual brick size is 215 x 102.5 x 65mm. This allows for a 10mm mortar joint, this gives an overall walling unit size of 225 x 112.5 x 75mm. BS 3921 recognizes three qualities of bricks:

a. Internal quality: Bricks suitable for internal use only
b. Ordinary quality: Less durable than special quality
c. Special quality: Bricks that is durable even when used in situations of extreme exposure where the structure may become saturated or frozen e.g. retaining walls, sewage plants or pavement.

Lateritic soils, which become hard on air-drying, are highly suitable for making adobe (Nwachukwu and Ojosu, 1988). The traditional method involves kneading the clay with foot and the clay is made workable by adding water. The wooden mould is filled with clay with hand compaction. The brick is removed out of the mould and sun dried. Bricks made by this method are of low strength and have low resistance to water. The compressive strength is low, usually less than 1N/mm^2, but adequate for bungalows and hence suitable for most rural housing (Nwachukwu and Ojosu, 1988). Research has shown that controlling the water content and increasing the compaction pressure can improve the properties of the adobe bricks. Using a rigid mould can enhance its appearance. These improvements can be achieved if the bricks are made under pressure in a block-making machine (Self, 1980)

Rice husk ash (RHA) is obtained by burning rice husk. The burning could be in open heaps, or in a specially designed furnace. About 80% of the organic matter of the husk is burnt off and the resulting ash is the silica-rice husk ash. Rice husk starts to burn at about 350 degree Celsius and this causes a loss in weight in the husk (Neville, 1996). Investigations indicate that, as is the case with other pozzolanas, the reactivity of amorphous RHA is greater than that with crystalline phase (Mehta, 1992). Due to the method of burning rice husk to produce RHA and the duration, there is an appreciable quantity of black carbon residue in the ash. It is this black carbon particle with the numerous white ash particles that gives an impression of greyness to the eyes (Cook, 1977). Carbon does not possess pozzolanic properties, thus, it does not take part in the strength development process. It acts more or less as filler. The chemical composition of RHA reveals that it is richer in silica than Fly Ash. This shows that its level of reactivity is very high, most especially with lime. The aluminium and magnesium content of RHA are 0.592 and 0.15 percents respectively compared to those of Fly Ash (PFA) which are as high as up to 26 and 10 percents respectively; though alumina and magnesium have been found to participate in reaction process of pozzolan and cement (Cook, 1977). Table 1 shows the chemical composition of rice husk ash in percentages as presented by Cook (Cook, 1977).

Research (Safiuddin, 1990) on the potential of rice husk ash in Bangladesh, reveals that some of its physical properties are responsible for the role rice husk ash play in improving the material properties and durability of its composite. Some of these physical properties are: larger specific surface area, fine particle size. Table 2 shows some physical properties of RHA as published by Narayan (Narayan, 2005). Pozzolans, characteristically, have a glossy or non-crystalline ionic structure. The most natural pozzolanic materials are volcanic ash. Pozzolanic materials vary in activity, depending mainly on the degree to which they are crystalline, since crystallinity reduces activity. All natural pozzzolans are ground before use to increase the area of reactive grain surfaces (Neville, 1996). Pozzolanic materials such as RHA and Fly Ash are widely used in soil stabilization (Yange, 2004). Pozzolans, example, RHA do not only strengthen and seal its matrix; they also perform the following functions (Agus and Gendut, 2004):

i. It flows and blends freely in mixtures
ii. It decreases permeability and bleeding of its concrete
iii. It increase durability of its concrete composite
iv. It Reduces sulphate attack
v. It Reduces efflorescence
vi. It Reduces shrinkage
vii. It eases pumping of its concrete, hence, less energy; therefore, longer pumping distances are possible.
viii. It reduces segregation, improves cohesiveness of pozzolan- concrete reduces segregation that otherwise could lead to rock pockets and blemishes.

ix. It reduces bleeding, resulting in enhanced bond strength.
x. It resists chemical reactions and can therefore, protect against strong acid.

MATERIALS AND METHOD

Clay

The clay sample used was collected from a pit about 1m deep from the bank of River Benue, Makurdi Nigeria. The soil was collected with a hoe and shovel. The clay has brownish color. They following tests were performed on it:

Grain size analysis

500g of the clay sample was soaked in water for 24 hours. It was then washed and wet sieved using 2mm British Standard sieve. The retained sample was then oven dried. The sieving was done according to BS 812 part 1. Percentage retained on a sieve is given by

$$\frac{100\, W_R}{W_T} \qquad (1)$$

W_R is weight of sample retained in a sieve
W_T is total weight of sample
Cumulative percentage retained on any sieve is sum of percentage retained on all coarser sieves.

Specific gravity

The hydrometer analysis was performed on the clay sample according to BS 812 part 2.
The specific gravity is given by

$$G_s = \frac{B}{(P+B-P_s)} \qquad (2)$$

G_s is specific gravity
B is weight of soil sample
P is weight of bottle and water
P_s is weight of bottle + water + sample

Rice Husk Ash

The Rice Husk Ash (RHA) was collected from Wadata Rice-mill, Makurdi Nigeria. It was sieved through a 3oo micro-meter sieve.

Plasticity Index

200g of air-dried clay sample, that passed through 425 μm sieve each, was mixed with 0, 5, 10, 15, and 20 per cent of the RHA. Liquid limit (L.L.) and plastic limit (P.L.) of the mixed samples were carried out according to BS 1377.

Shrinkage

The Clay-Rice Husk Ash wet mixture was used to fill standard shrinkage mould of length 140mm (EN 680, 1993) and placed in an oven for 24 hours and then removed. The new length was then determined.
Shrinkage is given by

$$\frac{V_o - V_f}{V_o} \qquad (3)$$

V_o is original volume

V_f is final volume (volume after removing from oven)

Compressive strength

Rich Hush Ash of 0, 5, 10, 15 and 20 per cent were mixed with the clay sample. A uniform mix for each batch was achieved by mixing the ash and clay thoroughly. Water was added until it gave a good consistency, that is, a workable mix. Brick moulds of size 100 x 130 x 260mm were cast. Wooden moulds were used. Compression of the wet mix was done manually by hand. The bricks were dried for 7, 14, and 28 days at room temperature. They were then subjected to compression test according to BS 1881, part 116.

Compressive strength (σ), in N/mm^2, is given by

$$\sigma = \frac{1000R}{A} \quad (4)$$

R is the gauge reading

A is cross-sectional area of brick in square millimeter.

Durability

The durability of the bricks was determined by testing for the strength and observation of crack development on the bricks after a period of three months.

RESULTS AND ANALYSIS

Specific gravity

The values of specific gravity of the clay sample are shown in table 3. The average specific gravity of the clay is 2.58. Joseph Bowles's (1979) report gave specific gravity for cohesive soils containing clay, silt and sand as 2.68-2.72. The little deviation could be as a result of the presence of organic matter in the sample.

Plasticity Index

The values of consistency limits with plasticity Index (P.I.) are shown in table 4. The results show decrease in the plasticity Index of the clay with addition of RHA. This is an indication of a good stabilizing property of RHA on clay. Clay often swells and shrinks during wet and dry conditions respectively.

Compressive strength

The results of compressive strength at 7, 14 and 28 day, are shown in table 5. The results show that the inclusion of Rice Husk Ash does not improve the compressive strength of clay. However, 5 per cent of RHA could be added in order to enhance the stability of clay-bricks, as earlier mentioned.

Shrinkage

The results of shrinkage of clay-RHA bricks are shown in table 6. The results indicate that the inclusion of RHA in the bricks reduced the shrinkage of the clay-bricks. This shows that buildings made of clay-RHA adobe could be more stable than the ones made from clay alone.

Cracks

Physical observation of the bricks with the eyes showed that cracks were more pronounced in the ones without RHA than the others. Therefore, RHA helps reduce or minimizes the development of cracks in clay-bricks.

CONCLUSION

The astronomical rise in building materials has lead to the search for ones that are cheap and locally available, especially, in poor countries of the world. Sun-dried clay brick (*adobe*) has been in use in rural areas in Nigeria, example, Oyiwo, Aliade, Ikpayonge, etcetra, of Benue State. In order to improve the quality of *adobe*, the addition of Rice Husk Ash (RHA) to clay has been examined. Shrinkage, plasticity, and cracking of the clay-brick were improved in the composites. The compressive strength of the clay-brick was not improved by the addition of RHA. However, it was discovered that partial substitution of clay with about 5 percent RHA does not significantly reduce its compressive strength. Proper compaction of the composite and use of clean water, free from acids and organic matters, are desirable in the production of good bricks.

Table 1. Chemical composition of Rice husk ash

Constituent	$Si0_2$	Al_20_3	Fe_20_3	Ca0	Na_20	P_20_5	L.O.I
Percent	92.95	0.592	0.152	0.432	2.19	-	2.932

Table 2. Physical properties of RHA-Amorphous silica

Specific gravity	2.05-2.3
Colour	Grey
Odour	Odourless
Particle size	25 microns – mean
Appearance	Very fore
Physical state	Solid-non-Hazard one.

Table 3. Specific gravity values of the clay

Clay sample	A	B	C
Mass of bottle (g)	589	589	589
Mass of bottle + water (P) (g)	1574	1574	1600
Mass of bottle + water + sample (P_s) (g)	1942	1950	1600
Mass of sample (M_s) (g)	600	620	800
Specific gravity	2.59	2.54	2.60

Table 4. Plasticity Index

Percentage of RHA in the clay	Consistency Properties (%)			
	L.L.	P.L.	P.I.	Ls
0	34.4	14.74	19.66	11.43
5	31.7	15.38	15.52	10.00
10	27.5	16.03	10.47	9.29
15	25.3	16.58	8.72	7.86
20	23.08	17.54	5.46	6.43

Table 5. The results of compressive strength

Percentage of RHA in the clay	Average compressive strength (N/mm^2); Day		
	7	14	28
0	1.017	1.923	3.501
5	0.795	1.605	3.200
10	0.535	1.595	2.708
15	0.520	1.627	2.431
20	0.395	1.415	2.500

Table 6. Shrinkage of clay-RHA *adobe*

Percentage of RHA in the clay	Average Shrinkage; Day		
	7	14	28
0	0.285	0.255	0.30
5	0.195	0.230	0.24
10	0.190	0.205	0.23
15	0.165	0.230	0.23
20	0.165	0.210	0.23

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