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COMPRESSIVE STRENGTH OF RICE HUSK ASH-CEMENT SANDCRETE BLOCKS

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ABSTRACT

There is growing demand for alternative, low-cost building material in developing countries. The effect of partial substitution of ordinary Portland cement with Rice Husk Ash (RHA) on the compressive strength of hollow sandcrete block was investigated through laboratory experimental procedures. The specific gravity, initial and final setting times of RHA were determined. 150 x 450 mm hollow sandcrete blocks were cast, cured and crushed for 7, 14 and 28 days at 0, 10, 20, 30, 40, 50 and 60 percent replacement levels. Results showed that the compressive strength of blocks increased with curing age but decreased with increasing percentage of rice husk ash. It can be concluded from this study that Portland cement could partially be substituted with unground RHA to a level of 17.5 per cent to produce sandcrete blocks as building units.

KEY WORDS: Cement, compression, Rice-Husk-Ash and Sandcrete-block

INTRODUCTION

Majority of the people in the developing countries like Nigeria, live under $1 USD per day (UCS, 1999). One of the basic needs of the people is shelter. The high cost of building materials such as cement has deprived many people of having adequate houses of their own. Research aimed at finding alternative low-cost building materials such as cement, for the third World countries, has been on the increase (Helen et al. 2005) because the cost of cement which is one of the essential ingredients in sandcrete block production is rising.

Rice husks are natural wastes from rice-mill. They contain high percentage of silica (Narayan, 2005). The husks burn at a temperature of 500 to 700 degrees Celsius, resulting in rice husk ash (RHA). The ash has a specific surface as high as 5000 m^2/kg and a specific gravity of 1.9 to 2.4 (Neville, 1996). The quality of this material depends on burning time, temperature, cooling time, and grinding conditions (James and Rao, 1986a, 1986b). RHA is a natural pozzolana. ASTM 618 (1994) defines pozzolana as a "siliceous and aluminous material, which in itself possesses little or no cementitious value but will, in finely divided form and in the presence of water, chemically react with calcium hydroxide, at ordinary temperatures, to form compounds possessing cementitious properties". RHA, volcanic ash and diatomaceous earth pozzolans have wide spread availability on global basis (Helen et al. 2005).

Oywa (2002) reported that RHA could be used as a binder in the production of building blocks and that this could drastically reduce the use of cement whose price was prohibitive to most Kenyans. It was stated that milled rice would produce one-fifth its weight of rice husks which translates into about 200 kg per every tonne of unmilled rice.

Al-Khalaf and Yousif (1984) also investigated the use of RHA in concrete. The study revealed that the most convenient and economical temperature required for conversion of rice husk into ash is 500 °C. Day and Shi (1994) showed that many factors including fineness affect the reactivity of a pozzolan and also reported that a good linear correlation existed between fineness and the compressive strength at all ages and for all pastes

Compressive strength of blocks is a measure of the block's resistance to load application when placed in the crushing machine. Non load bearing blocks are subjected to a transverse breaking test load and the result must adhere to the specified standard. The process of testing the block's strength renders it useless; it is a destructive test. To obtain the compressive strength of the blocks, the crushing load at failure is divided by the cross-sectional area The recommended strength by BS 2028 (1968) are 3.45 N/mm^2 for the mean strength and 2.59 N/mm^2 for the lowest individual strength. From the above specification it implies that the least compressive strength of individual block must be at least 75 % of the mean value.

The Federal Ministry of Works and Housing Nigeria had specified the same strength requirements as stipulated in BS 2028 for sandcrete hollow blocks i.e. 2.8 N/mm^2 (average compressive strength at 28 days age). This strength requirement was lowered to 2.5 N/mm^2 by Nigerian Industrial Standard (NIS) (1976) though the 'Proceedings of the Conference on Material Testing Control and Research' (1978), Federal Ministry of Works and Housing, Lagos recommended 2.1 N/mm^2 for the mean strength and 1.7 N/mm^2 for the lowest individual strength (Federal Ministry of Works, 1979).

Oyetola and Abdullahi (2006) conducted tests on sandcrete blocks made with various percent replacements of ordinary Portland cement and RHA which was prepared using charcoal from burning firewood. The study recommended a replacement level of 20 %. The properties of RHA samples produced from different types of field ovens were examined by Nair et al. (2006) and suggestions were made on a sustainable but affordable option in rural building practice.

To a rural dweller, using the RHA as found in

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the open rice mill is the cheapest option because he does not have to incur extra expenses required by refined burning or grinding it. Sieving to eliminate coarse materials is the only cheapest treatment affordable to the rural dweller. The objective of this study is to investigate the effect of partially substituting Portland cement with RHA, which was obtained from the rice mill where the husk is burnt openly, on the compressive strength of hollow sandcrete blocks.

MATERIALS AND METHODS

The RHA was collected from Makurdi-Nigeria where rice husk was being openly burnt. The sample was sieved through 150-µm sieve. The other concrete ingredients are sand from River Benue, and pipe-borne water supplied to Civil Engineering Laboratory, University of Agriculture, Makurdi-Nigeria. The sand was graded according to BS 812:103:1985 and was found to belong to class C. The following tests were carried out.

The specific gravity of RHA was determined according to BS 4550 Part 3, 1978 using Kerosene having a specific gravity of 0.82. A total of four tests were conducted. The initial and final setting times of the RHA were determined with the Vicat apparatus according to BS 4550: Part 3:1978. The oxide composition of RHA was determined following standard procedures in the laboratory. The ratio of cement to sand in the sandcrete block is 1:4. The Portland cement was partially substituted with the following percentages of RHA: 0, 10, 20, 30, 40, 50, and 60. Three-sandcrete blocks size 150 x 225 x 450 mm each were cast according to ASTM-C192 (1990) for each point and the average compressive strength taken. Water was sprayed on each block every morning and evening for effective curing of the blocks. The curing was done for 7, 14 and 28 days for three sets of the blocks. The specimens were then subjected to compressive strength tests according to BS 1881: Parts 115 and 116, 1986 and 1983, respectively.

RESULTS AND DISCUSSION

The initial and final setting times of the RHA were found to be 4 ¼ and 72 hours respectively. These results show that true pozzolanic nature of RHA. Pozzolanas take longer time to hydrate due to near absence of alumina than Portland cement. The average specific gravity of the RHA was found to be 2.11, which is close to the values 2.13 and 2.14 reported by Oyetola and Abdullahi (2000) and Al-Khalaf and Yousif (1984), respectively. The value is within the range for pulverized fuel ash (pfa), which is between 1.9 and 2.4 as reported in Neville (1996). The value is in agreement with values cited in the literature (Basha et al., 2003).

Table 1 shows the chemical composition of RHA used in this study. The total percentage composition of iron oxide (Fe_2O_3), silicon oxide (SiO_2) and aluminium oxide (Al_2O_3) was found to be 54.4 %, which is lower than the required value for pozzolana (ASTM C618-78, 1978). This low percentage is because the RHA used was as found in the open dump and it was not subjected to further treatment apart from sieving through BS sieve 150 micron. This value is higher than the value of 48.36 % obtained for Acha Husk Ash (AHA) (Dashan and Kamang, 1999) which shows that RHA used is more pozzolanic.

Table 1: Chemical composition of RHA

Compound	(%)
SiO_2	49.8
Al_2O_3	-
Fe_2O_3	4.6
CaO	14.3
MgO	13.7
K_2O	2.1
Na_2O	4.8
MnO	2.9
P_2O_5	1.5
L.O.I	6.3

The loss on ignition (LOI) obtained was 6.3 % which is less than 12 % maximum as required for pozzolanas, but this is higher than 3.3 % obtained by Al-Khalaf and Yousif (1984) which suggests that the pozzolana will be less effective. AHA had an LOI of 43.57 % which suggests that it had greater unburnt carbon compound compared to unground RHA used in this study.

Figure 1 summarizes the variation of density of blocks with increasing percentage of RHA replacement at the three curing ages. Results indicate a reduction in density of sandcrete blocks with increase in the percentage of RHA content. RHA has a lower specific gravity than cement and this is responsible for the reduction in density of sandcrete blocks with increasing percentage of RHA.

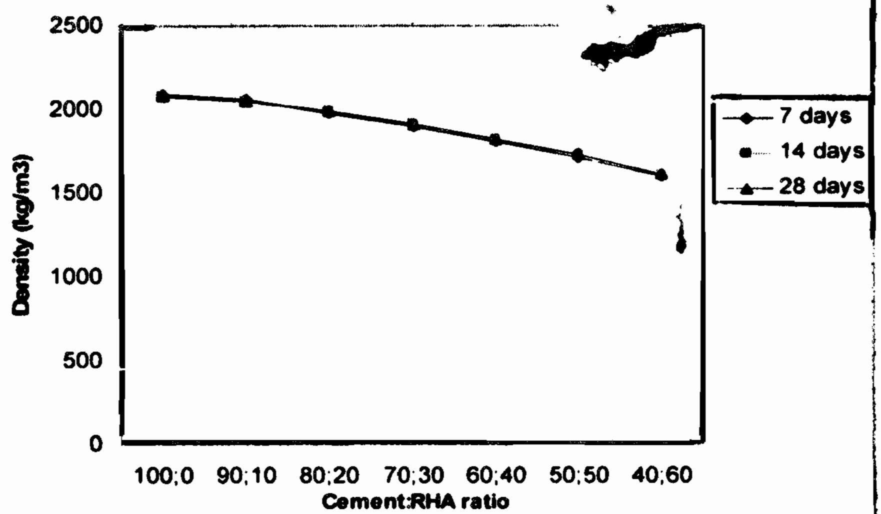

Figure 1:Variation of density of blocks

Figure 2 shows the variation of compressive strength with cement:RHA ratio for 7, 14 and 28 days. The highest mean compressive strength of blocks was 2.01 N/mm^2 at zero percent replacement and this reduced to 0.5 N/mm^2 at sixty percent replacement. For sandcrete blocks, the mean compressive strength should not be less than 3.45 N/mm^2 and the lowest individual strength of 2.49 N/mm^2 (BS 2028, 1968). Federal Ministry of Works (1979) also recommended mean strength of 2.1 N/mm^2 and minimum individual strength of 1.7 N/mm^2. From the above analysis, it is obvious that blocks made of cement and sand alone fell below the specifications of BS2028 (1968) and the Federal Ministry of Works and Housing.

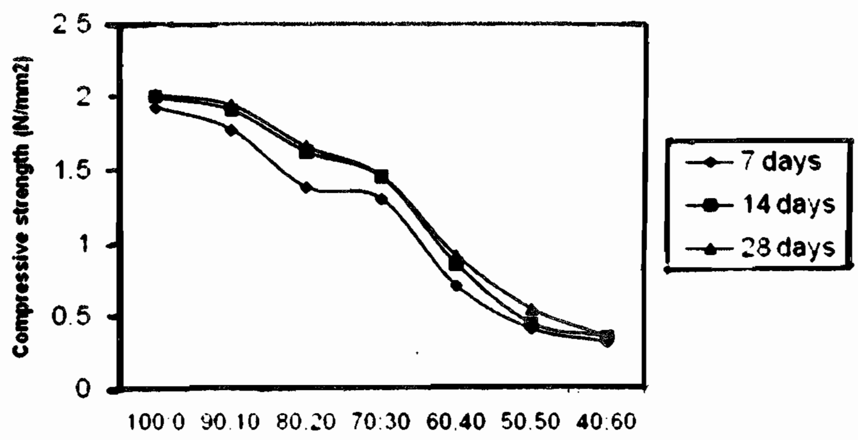

Figure 2:Compressive strength of blocks

However, it can be observed that when Portland cement was partially substituted with RHA to a level of about 17.5 percent, the mean compressive strength of 1.73 N/mm^2 was obtained. But, it must be stated that the standard procedure for testing compressive strength of a block requires that both faces be bedded with specified cement sand mortar for accurate horizontal and vertical levels prior to testing. For routine testing which was adopted in this study, each block was placed in between two pieces of insulating boards before it was compressed. This is because the standard method is time consuming and requires trained staff for accurate bedding. Boeck et al. (2000) found that a correction factor of 15 % could be added to the value obtained but the corrected value cannot be taken as accurate. Nevertheless the actual value would be expected to be greater than the value obtained from the test.

Oyetola and Abdullahi (2000) recommended an optimum replacement of 20 percent, the quality of RHA employed in their study was higher than that used in this investigation. The unground RHA used in this study represents the most economic state in which RHA can be employed in sandcrete block production by the rural dweller.

CONCLUSIONS

RHA as obtained in the open dump where burning was carried out openly can be used to partially replace cement by the rural dwellers in the production of hollow sandcrete blocks. This appears to be the most economic use to which RHA can be put because further burning and grinding to improve its pozzolanic activities were not carried out. The study has shown that Portland cement could partially be substituted with RHA to a level of 17.5 per cent by rural dwellers in the production of sandcrete blocks as building units. Further studies will involve grinding and controlled burning to improve its reactivity and the economic values.

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