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USE OF RICE HUSK ASH AS PARTIAL REPLACEMENT FOR CEMENT IN CONCRETE

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ABSTRACT

This paper summarizes the research work on the properties of Rice Husk Ash (RHA) when used as partial replacement for Ordinary Portland Cement (OPC) in concrete. OPC was replaced with RHA by weight at 0%, 5%, 10%, 15%, 20% and 25%. 0% replacement served as the control. Compacting factor test was carried out on fresh concrete while Compressive Strength test was carried out on hardened 150mm concrete cubes after 7, 14 and 28 days curing in water. The results revealed that the Compacting factor decreased as the percentage replacement of OPC with RHA increased. The compressive strength of the hardened concrete also decreased with increasing OPC replacement with RHA. It is recommended that further studies be carried out to gather more facts about the suitability of partial replacement of OPC with RHA in concrete.

Keywords: Concrete, Rice Husk Ash, Compacting factor, Compressive strength

1.0 INTRODUCTION

The need to reduce the high cost of Ordinary Portland Cement in order to provide accommodation for the populace has intensified research into the use of some locally available materials that could be used as partial replacement for Ordinary Portland Cement (OPC) in Civil Engineering and Building Works. Supplementary cementitous materials have been proven to be effective in meeting most of the requirements of durable concrete and blended cements are now used in many parts of the world (Bakar, Putrajaya, and Abdulaziz, 2010).

Various research works have been carried out on the binary blends of Ordinary Portland Cement with difeerent pozzolans in making cement composites (Adewuyi and Ola, 2005; De Sensale, 2006; Saraswathy and Song, 2007; Ettu et al, 2013).

Rice Husk Ash (RHA) which is an agricultural by-product has been reported to be a good pozzolan by numerous researchers. Mehta and Pirth (2000) investigated the use of RHA to reduce temperature in high strength mass concrete and got result showing that RHA is very effective in reducing the temperature of mass concrete compared to OPC concrete. Malhotra and Mehta (2004) later reported that ground RHA with finer particle size than OPC improves concrete properties, including that higher substitution amounts results in lower water absorption values and the addition of RHA causes an increment in the compressive strength. Cordeiro, Filho and Fairbarn (2009) carried out elaborate studies of Brazilian RHA and Rice Straw Ash (RSA) and demonstrated that grinding increases the pozzolanicity of RHA and that high strength of RHA, RSA concrete makes production of blocks with good bearing strength in a rural setting possible. Their study showed that combination of RHA or RSA with lime produces a weak cementitous material which could however be used to stabilize laterite and improve the bearing strength of the material. Habeeb and Fayyadh (2009) investigated the influence of RHA average particle size on the properties of concrete and found out that at early ages the strength was comparable, while at the age of 28 days, finer RHA exhibited higher strength than the sample with coarser RHA. Rukzon, Chindaprasirt and Mahachai (2009) further studied the effect of grinding on the chemical and physical properties of rice husk ash and the effect of RHA fineness on properties of

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mortar and found that pozzolans with finer particles had greater pozzolanic reaction.

This research work examined the use of Rice Husk Ash as partial replacement for Ordinary Portland Cement in concrete. It invoved the determination of workability and compressive strength of the concrete at different level of replacement.

2. MATERIALS AND METHODS

2.1. Materials

2.1.1. Rice Husk Ash (RHA)

The Rice Husk used was obtained from Ile Ife, Nigeria. After collection, the Rice Husk was burnt under guided or enclosed place to limit the amount of ash that will be blown off.. The ash was ground to the required level of fineness and sieved through 600 μm sieve in order to remove any impurity and larger size particles.

2.1.2. Coarse Aggregate

The granite used for this research work was 12mm size. It was sourced from a quarry in Igbajo in Nigeria

2.1.3. Fine Aggregate

The sand used for this research work was sourced from Iree, Osun state, Nigeria. The impurities were removed and it conformed to the requirements of BS 882 (1992).

2.1.4. Cement

The cement used was Ordinary Portland Cement. It was sourced from Iree, Osun State, Nigeria and it conformed to the requirements of BS EN 197-1: 2000.

2.1.5. Water

The water used for the study was obtained from a free flowing stream. The water was clean and free from any visible impurities. It conformed to BS EN 1008:2002 requirements.

2.2. Batching and mixing of materials

Batching of materials was done by weight. The percentage replacements of Ordinary Portland cement (OPC) by Rice Husk Ash (RHA) were 0%, 5%, 10%, 15%, 20% and 25%. The 0% replacement was to serve as control for other samples.

2.3. **Concrete Mix Design**

The concrete used in this research work was made using Binder, Sand and Gravel. The concrete mix proportion was 1:2:4 by weight.

2.4. Casting of samples

Cubic specimens of concrete with size 150 x 150 x 150 mm were cast for determination of all measurements. Six mixes were prepared using different percentages of 0, 5, 10, 15, 20 and 25 RHA. The concrete was mixed, placed and compacted in three layers. The samples were demoulded after 24 hours and kept in a curing tank for 7, 14 and 28 days as required. The Compacting Factor apparatus was also used to determine the compacting factor values of the fresh concrete in accordance with BS 1881: Part 103 (1983).

2.5. Testing of samples

The compressive strength tests on the concrete cubes were carried out with the COMTEST Crushing Machine at The Sammya Construction Company, Osogbo, Nigeria. This was done in accordance with BS 1881: Part 116 (1983). The sample was weighed before being put in the compressive test machine. The machine automatically stops when failure occurs and then displays the failure load.

3. RESULTS AND DISCUSSIONS

3.1. Results of compacting factor test on fresh concrete samples

The results obtained from the compacting factor test on fresh concrete samples are given in Table 1.

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Table 1: Compacting factor values of RHA concrete

Percentage replacement of RHA (%)	Compacting Factor values
0	0.91
5	0.91
10	0.90
15	0.90
20	0.89
25	0.88

The table indicates that the compacting factor values reduce as the RHA content increases. The compacting factor values reduced from 0.91 to 0.88 as the percentage RHA replacement increased from 0% to 25%. These results indicate that the concrete becomes less workable (stiff) as the RHA percentage increases meaning that more water is required to make the mixes more workable. The high demand for water as the RHA content increases is due to increased amount of silica in the mixture. This is typical of pozzolan cement concrete as the silica-lime reaction requires more water in addition to water required during hydration of cement (Bui et al. 2005).

3.2. Bulk Densities of Concrete Cubes

The Bulk Densities of the Concrete Cubes cast at various days of curing are shown in Table 2 and Figure 1.

Table 2. Bulk Densities of Concrete Cubes with various percentages of RHA

Rice Husk Ash Replacement	Bulk Density (g/cm^3)		
(%)	7 days	14 days	28 days
0	2.32	2.37	2.43
5	2.30	2.31	2.33
10	2.26	2.28	2.30
15	2.25	2.25	2.30
20	2.07	2.25	2.29
25	2.04	2.13	2.28

The results of the bulk densities show that the bulk density reduces as the percentage RHA increases. This could be attributed to the increase in voids in the concrete cubes as the percentage RHA increases. However, the bulk densities increase as the number of days of curing increase as the concrete cubes become denser.

3.3. Results of Compressive Strength Tests on Concrete Cubes

The results of the compressive strength tests on concrete cubes are shown in Table 3 and Figure 2

Table 3: Compressive Strength of Concrete Cubes with various percentages of RHA

Rice Husk Ash Replacement	Compressive Strength (N/mm^2)		
(%)	7 days	14 days	28 days
0	17.51	21.60	29.15
5	16.88	17.44	27.68
10	12.01	12.83	20.88
15	11.24	12.55	18.70
20	10.86	11.51	18.59
25	7.95	8.98	13.29

The results of the compressive strength of concrete cubes show that the compressive strengths reduced as the percentage RHA increased. However, the compressive strengths increased as the number of days of curing increased for each percentage RHA replacement. It is seen from Table 3 that for the control cube, the compressive strength increased from 17.51 N/mm^2 at 7 days to 29.15 N/mm^2 at 28 days (i.e. about 66% increment). The 28 day strength was above the specified value of 25N/mm^2 for grade 25 concrete (BS 8110, 1997) as shown in Table 4. The strength of the 5% replacement by rice husk ash showed increase in compressive strength from 16.88 N/mm^2 at 7 days to 27.68 N/mm^2 at 28 days (64% increment). The 28 day strength was above the specified value of 25N/mm^2 for grade 25 concrete (BS 8110, 1997) as shown in Table 4. The strength of the 10% replacement by rice husk ash showed increase in compressive strength from 12.01 N/mm^2 at 7 days to 20.88 N/mm^2 at 28 days (74% increment). The 28 day strength was above the specified value of 20N/mm^2 for grade 20 concrete (BS 8110, 1997) as shown in Table 4.The strength of the 15% replacement by rice husk ash showed increase in compressive strength from 11.24 N/mm^2 at 7 days to 18.70 N/mm^2 at 28 days (66% increment). The 28 day strength was above the specified value of 15N/mm^2 for light weight concrete (BS 8110, 1997) as shown in Table 4.The strength of the 20% replacement by rice husk ash showed increase in compressive strength from 10.86 N/mm^2 at 7 days to 18.59 N/mm^2 at 28 days (71% increment). The 28 day strength was above the specified value of 15N/mm^2 for light weight concrete (BS 8110, 1997) as shown in Table 4.

Table 4: Recommended grade of concrete

(BS 8110, 1997)

Grade	Characteristic strength	Concrete class
7 10	7.0 10.0	Plain concrete
15	15.0	Reinforced concrete with lightweight aggregate
20 25	20.0 25.0	Reinforced concrete with dense aggregate
30	30.0	Concrete with post tensioned tendons
40 50 60	40.0 50.0 60.0	Concrete with pre tensioned tendons

4. CONCLUSIONS

From the investigations carried out, the following conclusions can be made:

The optimum addition of RHA as partial replacement for cement is in the range 0-20%.

The compacting factor values of the concrete reduced as the percentage of RHA increased.

The Bulk Densities of concrete reduced as the percentage RHA replacement increased.

The Compressive Strengths of concrete reduced as the percentage RHA replacement increased.

5. RECOMMENDATIONS

The following are recommended from this study:

The use of local materials like RHA as pozzolans should be encouraged in concrete production.

Similar studies are recommended for concrete beams and slab sections to ascertain the flexural behaviour of lightweight concrete made with this material.

Durability studies of concrete cubes made with RHA as partial replacement for cement should be carried out.

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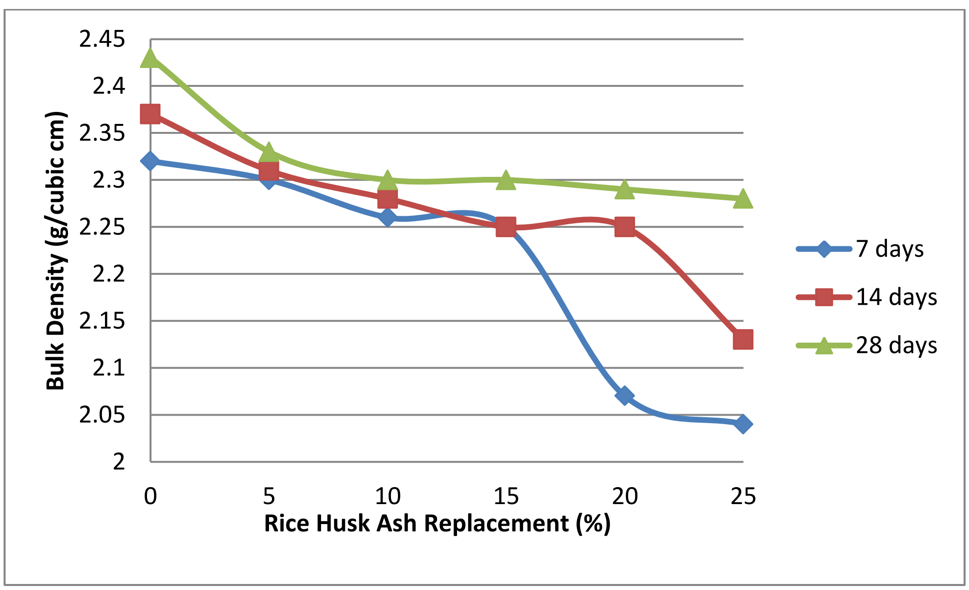

Figure 1: Effect of RHA content on Bulk Density of Concrete at different curing age

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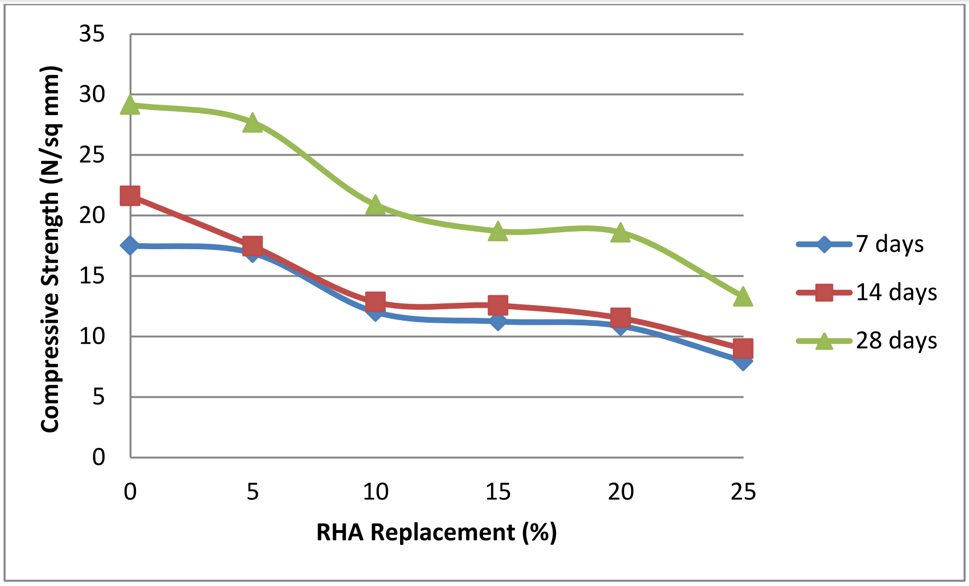

Figure 2: Effect of RHA content on compressive strength of concrete at different curing age