PRODUCTION OF CONCRETE ROOFING TILES USING RICE HUSK ASH (RHA) IN PARTIAL REPLACEMENT OF CEMENT

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Abstract – *This research deals with the effects of using rice husk ash (RHA) as a partial weight of cement replacement in concrete roof tile production. The work is based on an experimental study of roof tiles produced with ordinary Portland cement (OPC) and 5 %,10 %, 15 % , 20 % and 25 % (OPC) replaced by RHA. The rice husk ash used was produced by open air burning the rice husk. The tests which were performed evaluate the performance of this material were: specific gravity normal consistency, setting time, compressive strength, rupture strength and water absorption. The results show that addition of RHA show better results for 10 % replacement level than OPC at 28 days.*

Key Words**:** ***Rice husk ash*** **1, Ordinary Portland cement 2, Compressive (Crushing) Test 3, Rupture Modulus Test 4, Roof Tiles 5.**

1.INTRODUCTION

Building materials have undergone a lot of modification from ancient times till this present technology era. With everyone seeking for affordable and comfortable houses to live in, every scientist and engineer is working hard to develop and optimize new building materials that would be durable and cost effective. Building materials range from roofing sheet, block, concrete, gravel, sand, clay, stone, cement, roofing tiles, steel, fine aggregate, coarse aggregate, laterite among others.

Cement as the major classical binder in construction industry is very expensive. This is because of phenomenal population growth and urbanization which have triggered high demand of cement for several construction purposes to meet up with the need to expand infrastructures (Otuoze, et.al 2012). Therefore the need to connect the gap between demand and high price has warranted the need to investigate the use of cheaper alternative sources. Rice is the major staple that is consumed worldwide and is grown on every continent except Antarctica (Kartini, 2011). It is a primary source of food for billions of people, and ranks second to wheat in terms of area and production. Nigeria which ranks as the 17th largest rice producing country in the world (Omatola, 2009), cultivates rice in virtually all the agro-ecological zones in Nigeria and the most important region for rice production being River Niger basin (Nnamdi, 2011).

1.1 Statement of Problem

Demand for cement in construction has increased over the years as a result of over dependence on the modern building materials, which are so expensive that low income earners cannot afford building houses of their own. A look around the environment reveals enormous production of agricultural waste, some of which can be converted into use in the construction industry in other to provide alternative quality but less expensive roofing tiles within the reach of the poor. This research aims to explore the viability of using rice husk ash, as an agricultural waste with a mixture of cement to produce roofing tiles as an alternative in providing affordable concrete roof tiles.

1.2 Significance of study

The use of cement, combined with RHA to produce roof tiles will impact significantly in the reduction of roofing tile construction costs, while still converting the country's deposits of agricultural waste which is obviously an environmental health hazard to economic purposes for national development.

1.3 Aim and objectives

1. To determine the physical properties of materials used i.e. rice husk ash, cement and fine aggregate.

2. To produce concrete roof tile using Rice Husk Ash with replacement of cement with ash at (5, 10, 15, 20 and 25 %)

3. Testing the produced sample for physical variations from the control sample produced. (Compressive strength and rupture modulus)

4. To compare the obtained result with standards for concrete roof tiles.

1.4 Scope and limitations

This study focuses on use of rice husk ash as partial replacement for cement in the production of concrete roofing tiles. It makes use of the growing rice husk waste, produced in Makurdi Metropolis of Benue State by varying its proportions (5, 10, 15, 20 and 25 %) in partial replacement of cement used in concrete roof tiles.

2.0 PREPARATION OF RICE HUSK ASH

Rice husk was burned in open air and allowed to continue burning for 72 hours to achieve total ashing. The Ash was then sieved through a 300 µm size sieve to remove some of the impurities (like sand) from the RHA sample in accordance with the recommendation of ASTM C191.

2.1 Physical Properties of Rice Husk Ash

The physical properties of Rice Husk ash that were determined include; specific gravity as detailed in ASTM D854 -00, particle size distribution as detailed in ASTM C0136-05, consistency of RHA with OPC paste as detailed in ASTM C1398-98E01.

2.2 Compressive (Crushing) Test

The compressive strength of the tile was tested as detailed in ASTM – C365 standard.

2.3 Rupture Modulus Test

The modulus of rupture test was carried out as detailed in ASTM - C1492 standard.

3.0 EXPERIMENTAL TEST PROCEDURES ON ROOF TILES

Due to the preciseness required in the production of roofing tiles and the time available for this research, the replacement levels were limited to a maximum of 25 %. The viability of the tile and not its usability was tested, using the compressive strength and modulus of rupture. There has been no simulation of installed tile to examine performance in rainfall and wind condition.
This study has produced 75 samples each of the replaced cement ratios including the control samples. This gave a four (4) sample per test for each tile batch mix, testing of the tile was done for the following durations after casting; 2 4 hrs, 7 days, 14 days, 21days and 28days curing. A total of 450 samples were produced averaging 5 samples for each batch per test for every stage in the curing process to monitor strength gain.

4.0 RESULTS AND DISCUSSION

The Specific gravity of fine aggregate and RHA, specific gravity is averaged 2.65 and 1.83 respectively, this lies between the standard stipulated in ASTM D854- 14 of 2.5 – 3.0. Finess modulus of the fine aggregate was calculated to be 3.62, this is greater than the range stipulated by the ASTM C33 which is 2.3 – 3, this is because the size of fine aggregate particle for the sample had particles with sizes greater than 5mm. The oxide composition of RHA and OPC, the percentage of silica content of the RHA was found to be 68.12 %, which indicates higher silica content than in cement. This value is closer to the required value of 70 % minimum for pozzolanas. The standard consistency of RHA and OPC increased linearly with replacement of RHA at higher percentages hence it required more water for the mix in percentages. The results of workability test carried out as mixing was carried out for different replacement levels hence prompting a change in water/binder ratio. The average densities of the tile specimen with lowest recorded density at 20 and 25 % replacement for 28 days curing which is 1981 and 2018 kg/m3.

4.1 Presentation of results

Table 4-0-1: Specific gravity of Sand

Procedure	Test I	Test II	Test III
Weight of sand (g) B	600	600	600
Weight of density bottle	589	589	589
Weight of bottle + water (g) P	1593	1593	1593
Weight of bottle + Sand (g)	1189	1189	1189
Weight of bottle + sand + sand (g) PS	1968	1967	1964
Specific gravity Gs = $\frac{B}{P+B-PS}$	2.67	2.65	2.62

$$\text{Average specific gravity Gs} = \frac{2.67+2.65+2.62}{3}$$

$$= 2.65$$

Table 4-0-2: Specific gravity of Rice husk ash

Procedure	Test I	Test II	Test III
Weight of ash (g) B	29.5	29.5	29.5
Weight of bottle + water (g) P	105.2	104.9	104.8
Weight of bottle + sand (g)	39.5	39.5	39.5
Weight of bottle + water + sand (g)	111.2	110.7	110.4
Specific gravity Gs = $\frac{B}{P+B-PS}$	1.86	1.86	1.76

$$\text{Average specific gravity Gs} = \frac{1.86+1.86+1.76}{3}$$

$$= 1.83$$

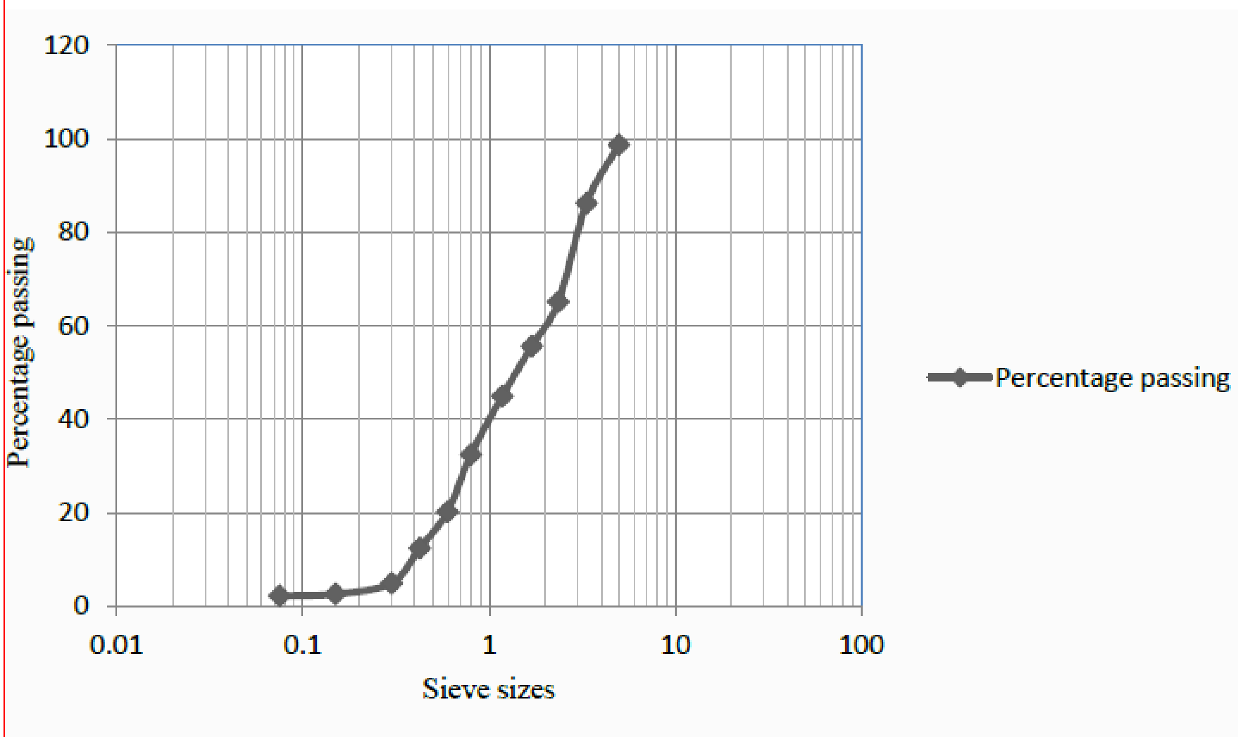

Figure 3: Grain size distribution curve for sharp sand

Table 4-0-5: Setting time

Replacement of OPC by RHA (g)	Initial setting time (min)	Final setting time (min)
0%	78	309
5%	90	288
10%	102	267
15%	122	258
20%	118	255
25%	98	242

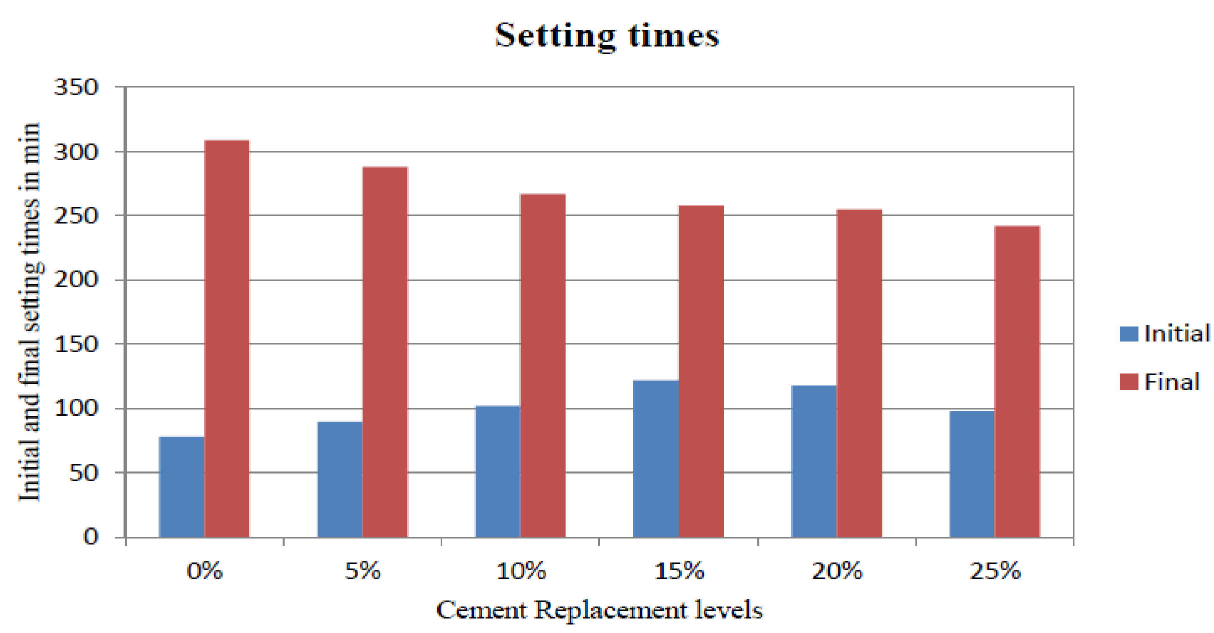

Figure 4: Initial and final setting time

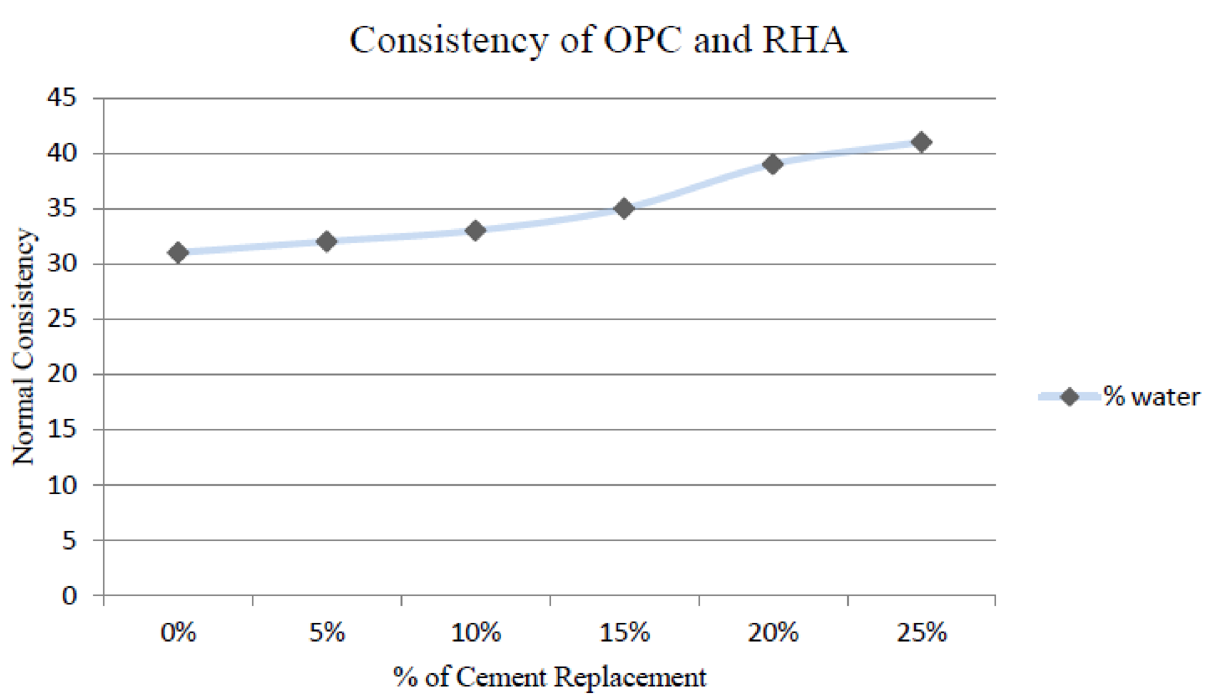

Figure 5: Normal consistency versus percentage replacement

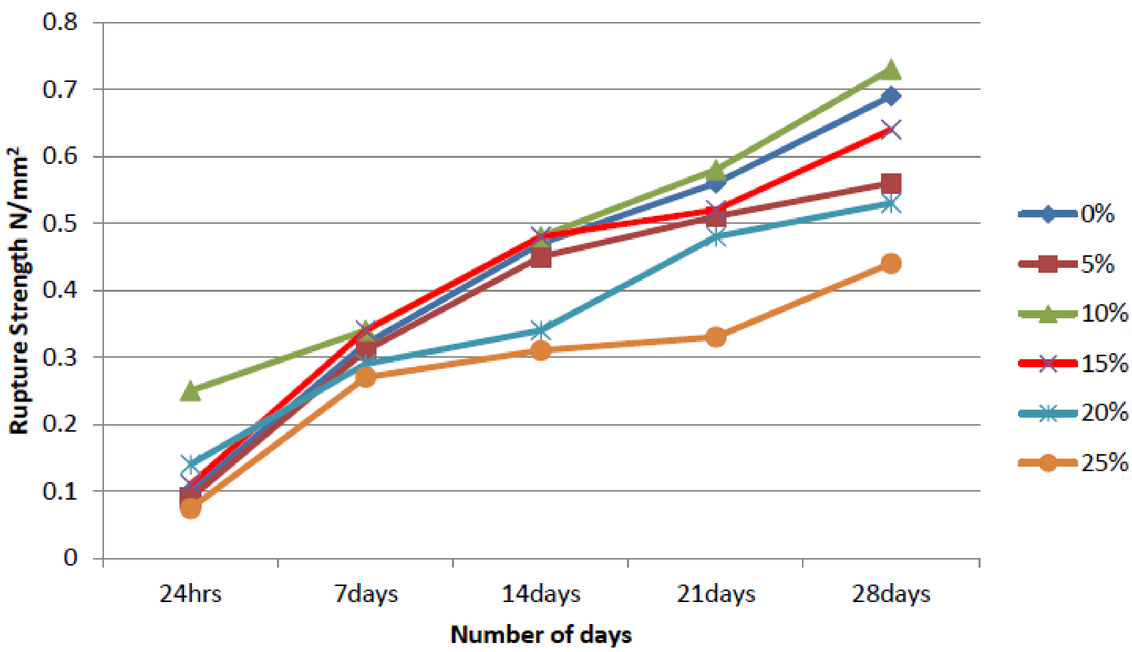

Figure 6: Rupture strength graph

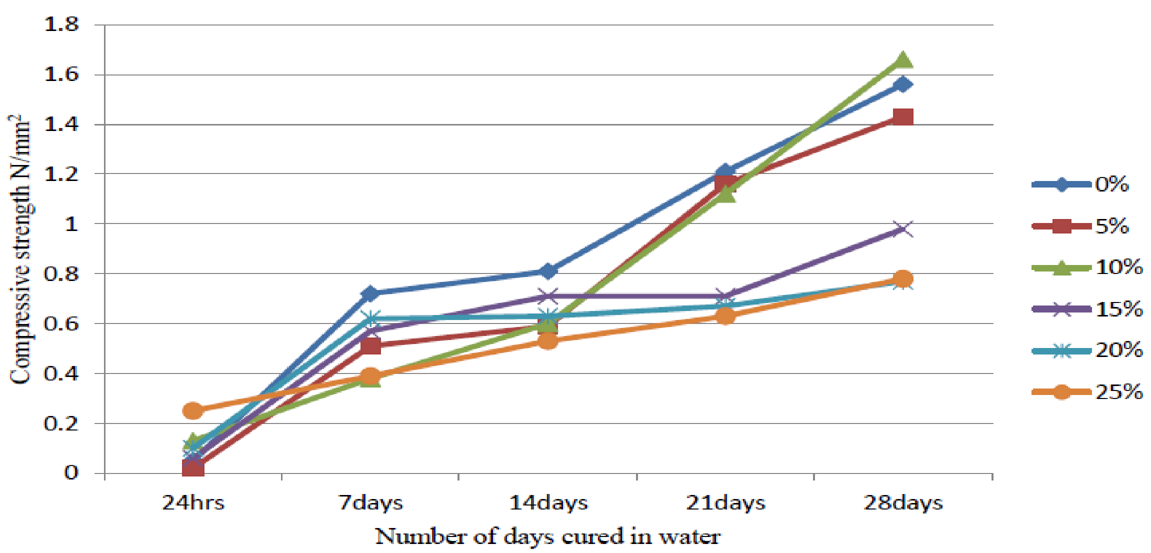

Figure 7: Compressive strength graph

5.0 CONCLUSION

RHA blended with concrete increases the water binder ratio of each particular mix batch. This study revealed that the setting time duration decreases linearly from 0 % replacement to 15 % and slightly picks up from 20 % to 25 %. However, the initial setting time was observed to increase from 0 % - 15 % and a sharp decrease was shown from 20%-25 %.

Addition of RHA in a mortar mix increases workability in so far as the w/c ratio is balanced to meet the standard consistency of cement paste. RHA blended concrete can improve the compressive strength as well as the tensile and flexural strength of concrete. RHA helps in enhancing the early age mechanical properties as well as long-term strength properties of concrete tiles.

Inclusion of RHA as partial replacement of cement enhanced the compressive and ruptured strength of the produced concrete tile; the maximum compressive strength which was recorded at 10 % replacement to be 1.66 N/mm^2 grew slightly higher than the control test sample with an average strength of 1.56 N/mm^2. The strength recorded by other researchers like Mahmud et al. (1996) reported 15 % cement replacement by RHA as an optimal level for achieving maximum strength. Also Zhang et al. (1996) suggested 10 % RHA replacement exhibited upper strength than control OPC at all ages.

RECOMMENDATIONS

From the results of the tests and analysis carried out in the study, the following recommendations can be made:

1. Concrete roof tiles can be produced using rice husk ash (RHA) as a partial replacement for Ordinary Portland Cement (OPC) because of its unique property of improving the properties of the mortar mix, from compressive strength to rupture strength and most importantly the average density of the tile.

2. In producing concrete roof tile, it is imperative to grade the fine aggregate to be used to enhance inter-granular locking of the fine aggregate. The most efficient ratio suggested to be graded is 5 mm-2.36 mm (40%), 2.36 mm-1 mm (20 %) and 1mm- 75 μmm (40 %).

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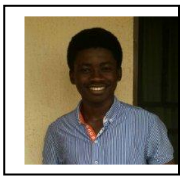

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