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Experimental Study On Rice Husk As Fine Aggregates In Concrete

Obilade, I.O.
Department of Civil Engineering, Osun State Polytechnic, Iree, Nigeria

ABSTRACT

This paper reports on the influence of weight replacement and volume replacement of fine aggregate by rice husk on the workability, bulk density and compressive strength of concrete. Rice Husk was used to replace sand by weight and by volume respectively. The percentage replacement was 0%, 5%, 10%, 15%, 20% and 25%. The mix ratio adopted was 1:2:4 by weight and volume respectively. 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, Bulk Density and Compressive strength decreased as the percentage replacement of sand with rice husk increased. The compacting factor of the volume-batched concrete produced by volume replacement of sand by rice husk is higher than that produced by weight replacement. The bulk densities and compressive strengths of the volume-batched concrete produced by volume replacement of sand by rice husk are also higher than that produced by weight replacement. The research also revealed that there is the possibility of replacing fine aggregate with rice husk in the production of structural concrete. It is recommended that volume batching should be used in works involving Rice Husk.

KEYWORDS: *fine aggregate, rice husk, compacting factor, bulk density, compressive strength*

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I. INTRODUCTION

The construction industry relies heavily on conventional materials such as cement, granite and sand for the production of concrete. Concrete is the world's most consumed man made material (Naik, 2008). It's great versatility and relative economy in filling wide range of needs has made it a competitive building material (Sashidar and Rao, 2010). Concrete production is not only a valuable source of societal development, but it is also a significant source of employment (Naik, 2008). Historically, agricultural and industrial wastes have created waste management and pollution problems. However the use of agricultural and industrial wastes to complement other traditional materials in construction provides both practical and economical advantages. The wastes have generally no commercial value and being locally available transportation cost is minimal (Chandra and Berntsson, 2002).The use of waste materials in construction contribute to conservation of natural resources and the protection of the environment (Ramezanianpour, Mahdikhani and Ahmadibeni, 2009). Some of the waste products which possess pozzolanic properties and which have been studied for use in blended cements include fly ash (Wang andBaxter, 2007), Silica fume (Lee et al., 2005), Volcanic ash (Hossain, 2005), Corn Cob Ash (Raheem et al., 2010; Raheem and Adesanya, 2011).The rice industry produces wastes such as rice husks which are usually dumped in the open thereby impacting the environment negatively without any economic benefits. In Nigeria, rice husks are generally not used in construction. In order to make efficient use of locally available materials, this study was conducted to investigate and compare the influence of weight replacement and volume replacement of fine aggregate by rice husk on the workability, bulk density and compressive strength of concrete as well as to assess the suitability of rice husk concrete as a structural material.

II. MATERIALS AND METHODS

The Rice Husk used was obtained from Ile Ife, Nigeria. The granite used for this research work was 12mm size. It was sourced from a quarry in Igbajo in Nigeria. 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). 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. 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.

Batching of materials was done by both weight and volume. The percentage replacements of Ordinary Portland cement (OPC) by Rice Husk Ash (RHA) were 0%, 5%, 10%, 15%, 20% and 25% by both weight and volume. The concrete used in this research work was made using Binder, Sand and Gravel. The concrete mix proportion was 1:2:4 by both weight and volume. Cubic specimens of concrete with size 150 x 150 x 150 mm were cast for determination of all measurements. 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). The compressive 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.

III. RESULTS AND DISCUSSIONS

Compacting Factor

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

Table 1: Compacting Factor of Rice Husk Concrete

Replacement (%)	0	5	10	15	20	25
Weight Batch	**0.91**	**0.90**	**0.89**	**0.89**	**0.88**	**0.87**
Volume Batch	**0.94**	**0.93**	**0.93**	**0.92**	**0.91**	**0.91**

The Compacting Factor of both mixes decreased with increase in the percentage replacement of sand by rice husk. This is due to the increase in the specific surface as a result of the increase in the quantity of Rice Husk, thereby requiring more water to make the specimens workable. The workability of the volume-batched concrete produced by volume replacement of sand by rice husk is higher than that produced by weight replacement. Since sand is denser than rice husk, replacement by an equal mass of rice husk leads to a larger increase in volume than replacement by an equal volume of sand. Increase in the quantity of rice husk increase the specific surface area, thereby more water would be required.

Bulk Densities of Concrete Cubes : The Bulk Densities of Weight-Batched Rice Husk Concrete and Volume-Batched Rice Husk Concrete are presented in Tables 2 and 3 respectively. The variations of density of concrete with rice husk content are shown in Figures 1 and 2 respectively.

Table 2. Bulk Densities of Weight-Batched Rice Husk Concrete

Rice Husk Replacement (%)	Bulk Density (g/cm^3)		
	7 days	14 days	28 days
0	2.31	2.35	2.40
5	2.19	2.21	2.28
10	2.01	2.15	2.25
15	1.98	2.10	2.19
20	1.96	2.05	2.11
25	1.87	1.99	2.01

Table 3. Bulk Densities of Volume-Batched Rice Husk Concrete

Rice Husk Replacement (%)	Bulk Density (g/cm^3)		
	7 days	14 days	28 days
0	2.34	2.38	2.43
5	2.31	2.33	2.37
10	2.27	2.28	2.31
15	2.23	2.26	2.29
20	2.18	2.20	2.23
25	2.07	2.09	2.16

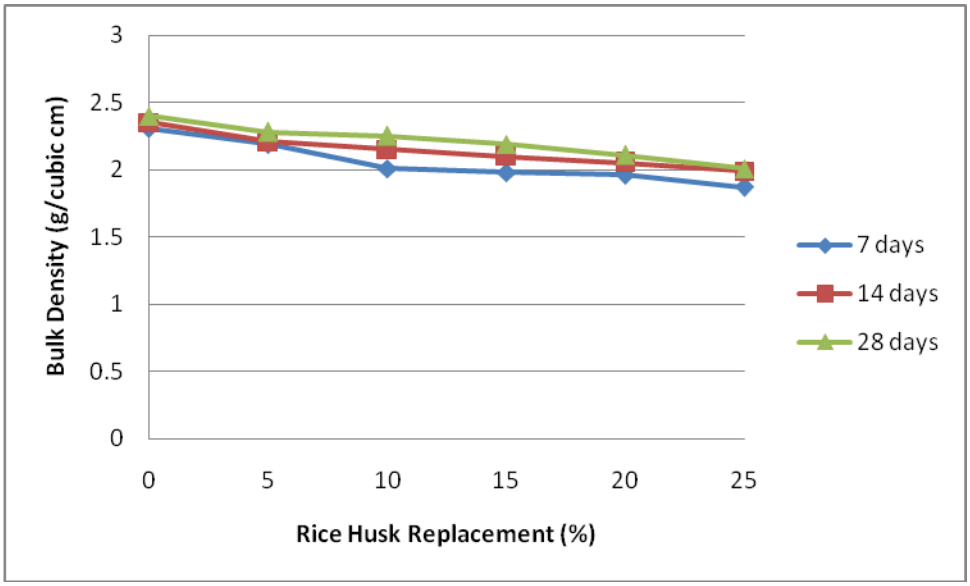

Figure 1: Bulk Densities of Weight-Batched Rice Husk Concrete

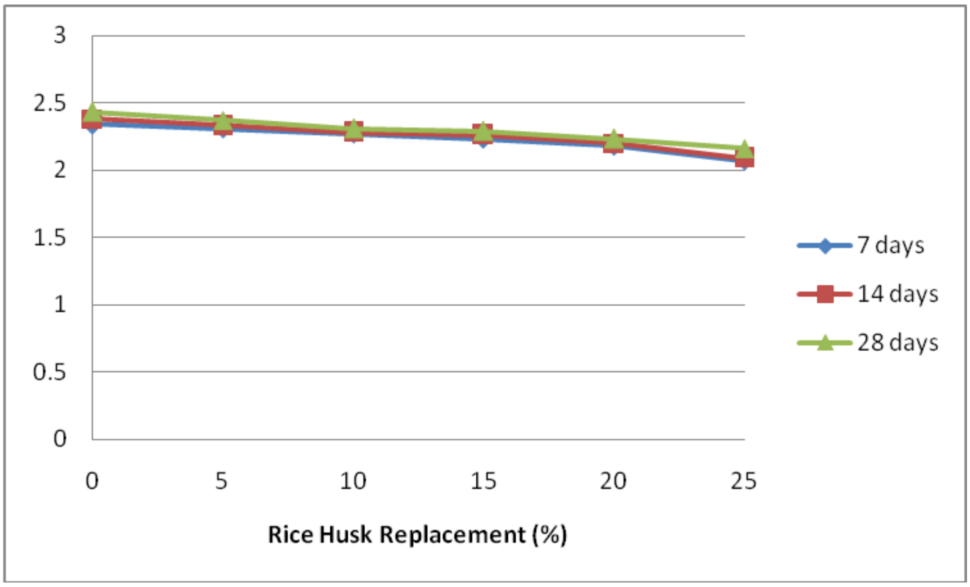

Figure 2: Bulk Densities of Volume-Batched Rice Husk Concrete

It can be observed that in both mixes, the density of concrete reduced as percentage content of rice husk increased. However, the densities of both mixes increased with age of curing. The maximum densities occurred at no replacement (100%) sand while minimum densities occurred at 25% rice husk replacement. The minimum 28-day densities of Weight-Batched Rice Husk Concrete and Volume-Batched Rice Husk Concrete are 2.01g/cm^3 and 2.16g/cm^3 respectively. It can be observed that the rate at which densities decreased with increase in the percentage replacement is higher for the Weight-Batched Rice Husk Concrete than for Volume-Batched Rice Husk Concrete. This can be attributed to the larger increase in the quantity of rice husk in Weight-Batched Rice Husk Concrete than in Volume-Batched Rice Husk Concrete. Replacement of sand by equal weight of rice husk leads to the introduction of more rice husk in the mix since sand is heavier than rice husk. This leads to an increase in volume without increase in weight which reduces the density.

Compressive Strength of Concrete Cubes : The results of the Compressive Strength tests of Weight-Batched Rice Husk Concrete Cubes and Volume-Batched Rice Husk Concrete Cubes are shown in Tables 4 and 5. The effects of replacement of sand with rice husk on compressive strengths of Weight-Batched Rice Husk Concrete Cubes and Volume-Batched Rice Husk Concrete Cubes are shown in Figures 3 and 4 respectively.

Table 4. Compressive Strengths of Weight-Batched Rice Husk Concrete

Rice Husk Replacement (%)	Compressive Strength(N/mm^2)		
	7 days	14 days	28 days
0	14.72	16.66	22.15
5	12.09	15.84	17.62
10	8.08	11.10	15.31
15	6.36	7.68	14.76
20	5.53	8.14	13.98
25	4.68	6.23	12.62

Table 5. Compressive Strengths of Volume-Batched Rice Husk Concrete

Rice Husk Replacement (%)	Compressive Strength(N/mm^2)		
	7 days	14 days	28 days
0	14.91	17.03	23.08
5	12.13	16.64	19.36
10	9.32	13.91	17.37
15	8.80	11.48	15.68
20	7.60	9.81	14.69
25	7.33	8.82	14.47

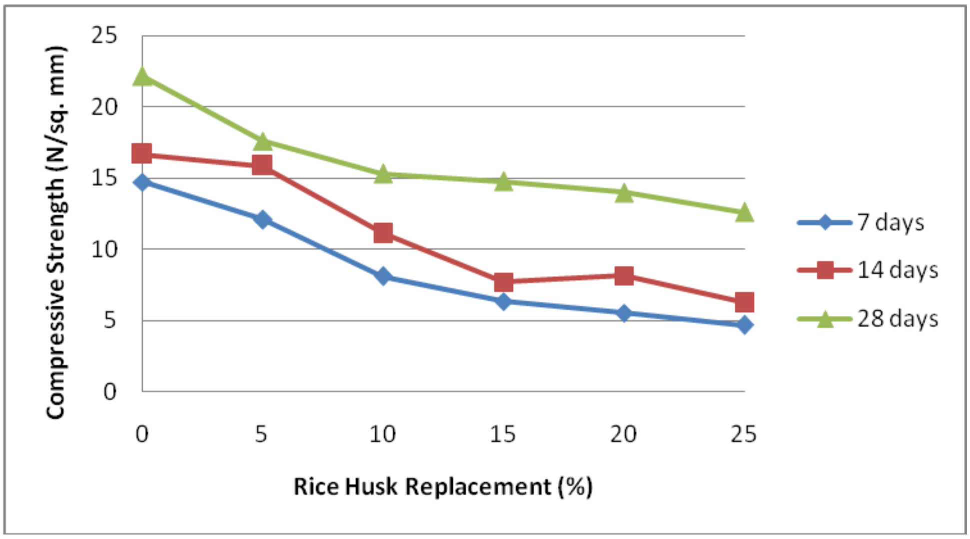

Figure 3: Compressive Strengths of Weight-Batched Rice Husk Concrete

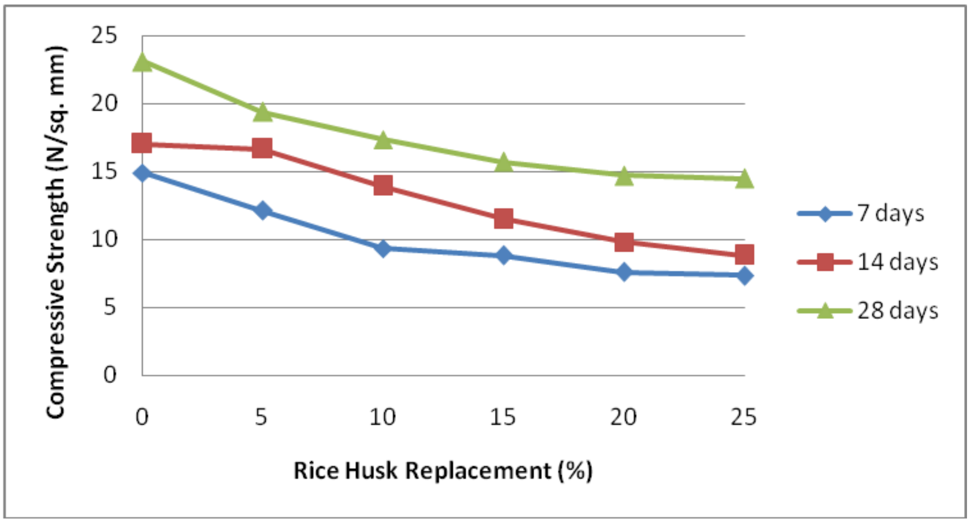

Figure 4: Compressive Strengths of Volume-Batched Rice Husk Concrete

It can be observed that the compressive strength decreased as the rice husk content increased. The compressive strength is maximum at 0% replacement by rice husk and minimum at 25% replacement. As rice husk content increases, the specific area increases, thus requiring more cement paste to bond effectively with the husks. Since the cement content remains the same, the bonding is therefore inadequate. The compressive strength reduces as a consequence of the increase in percentage of sand. The 28 day strength for 5% and 10% replacement in the Weight-Batched Rice Husk Concrete were above the specified value of 15N/mm^2 for Grade 15 light weight concrete (BS 8110, 1997) as shown in Table 6. The 28 day strength for 5%, 10% and 15% replacement in the Volume-Batched Rice Husk Concrete were above the specified value of 15N/mm^2 for Grade 15 light weight concrete (BS 8110, 1997) as shown in Table 6.

Table 6: 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

IV. CONCLUSIONS

From the investigations carried out, the following conclusions can be made:
There exists a high potential for the use of rice husk as fine aggregate in the production of lightly reinforced concrete.Weight-Batched Rice Husk Concrete and Volume-Batched Rice Husk Concrete show similar trends in the variation of bulk density, workability and compressive strength.
Loss of bulk density, workability and compressive strength is higher for Weight-Batched Rice Husk Concrete than Volume-Batched Rice Husk Concrete.

V. RECOMMENDATIONS

The following are recommended from this study:
The long-term behaviour of Rice Husk Concrete should be investigated.
Volume batching should be used in works involving Rice Husk.
Similar studies are recommended for concrete beams and slab sections to ascertain the flexural behaviour of lightweight concrete made with this material.

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