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A comparative study on the strength characteristics of Grade 25 and Grade 30 rice husk ash blended cement concrete

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A comparative study on the strength characteristics of Grade 25 and Grade 30 rice husk ash blended cement concrete

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Abstract. Rice husk ash (RHA) is an agricultural waste which is a pozzolanic material that can be blended with cement in producing concrete. This research presents investigation carried out on the comparative strength characteristics of concrete produced with grade 25 and grade 30 cement blended concrete using a replacement level of 10% rice husk ash as substitute. Two mix ratios (1:2:4 and 1:1.12:3.01) were used. A total of 60 cube size of 150mm were cast, tested and their mechanical properties determined. The RHA was made in the laboratory by burning the husk obtained from Ifo in Ogun State Nigeria using an Electric furnace, with the temperatures of the furnace at about 700°C. The results showed that the compressive strength at 28 days decreased as the percentage replacement of Portland Limestone cement (PLC) with RHA increased from 0% to 10% respectively with compressive strengths of 29.78 N/mm^2 to 21.56 N/mm^2 for grade 25 concrete and 32.12 N/mm^2 to 26.82 N/mm^2 for grade 30 concrete. It was concluded that RHA replacement in concrete can be used for the production of concrete for light structural works in the development of sustainable and green structures.

Keywords Electric furnace; Portland limestone cement (PLC); Rice husk ash (RHA); Concrete; Compressive strength.

1. Introduction

Concrete is the second most used material in the world after water. If the cement industry were to be a country, it would be the third largest carbon dioxide emitter in the world with up to 2.8 billion tons, surpassing only China and the United State of America. It also magnifies the extreme weather in which it is used to shelter us from. Taking into considerations all stages of production, concrete is said to be responsible for 4 -8 % of the world's carbon dioxide. Only coal, oil and gas are greater source of greenhouse gases. Hence half of concrete's CO_2 emissions are created during the manufacture of clinker, the most-energy intensive part of the cement- making process. In cities, concrete also adds to the heat by absorbing the warmth of the sun and trapping gases from car exhausts and the air – conditioner units- though it is, at least, better than darker asphalt. It also worsens the problem of silicosis and other respiratory diseases [1].

The emission of carbon dioxide (CO_2) can be direct and indirect. Carbon dioxide is released as a by-product during the production of clinker that is when calcium carbonate is calcinated and turns to lime it is then considered as direct emission. Indirect emission comes from the burning of fossil fuels to heating of the kiln. An approximate of 4.9 million kJ is required to produce a ton of cement. Invariably, producing a ton of cement will generate approximately a ton of CO_2. CO_2 is a well-known greenhouse gas that has attributed to global warming and greenhouse effect [2].

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 economic advantages. The wastes generally have no commercial value and being locally available transportation cost is minimal [3].

Rice is a primary food source for billions of people. Rice husk is the outer cover of paddy and it covers 20-25% the paddy weight. In general, hundred million tons of rice husks are produced annually and create the disposal problem. Few hundred million tons of rice paddy are planted every year. According to Food and Agriculture Organization of United Nations, the data showed that the production of rice paddy is increasing annually. World rice paddy production for year 2010 was 701 million tons, year 2011 was 722 million tons, year 2012 was 734 million tons and year 2013 was 740 million tons [4].

The replacement of RHA in concrete was investigated, the workability of concrete decreased with increase in RHA beyond 10 percent. The optimum replacement of RHA was 10 % for both M40 and M50 grade blended cement concrete. It was concluded that the flexural and splitting tensile strength of M40 and M50 grade blended cement concrete decreased with an increase in percentage of RHA [5]. The use of RHA contributed not only, to the production of concrete of a higher quality and lower cost, but also contributed to the reduction of carbon dioxide (CO_2) emissions from the production of cement. The partial replacement of cement by RHA resulted in lower energy consumption associated with the production of cement [6].

Chloride penetration, permeability and corrosion resistance were investigated. The 30 % replacement of R.H.A reduced chloride penetration, decreased permeability, improved strength and corrosion resistance property [7]. RHA can be used in the development of low-cost SCC by incorporating 10 percentage replacements [8]. The objective of this study is to comparatively investigate the strength characteristics of Grade 25 and Grade 30 rice husk ash blended cement concrete using 10 % RHA replacement with Portland limestone cement.

2. Material and methods

Cement

Portland Limestone Cement (PLC) manufactured by Dangote Cement Plc of Grade 42.5R in Nigeria was used. The cement was stored away from air and moisture in the workshop to ensure the material was in good condition during the experimental period.

Rice Husk Ash

The Rice Husk used was obtained from a rice threshing floor at Ifo Local Government Area, Ifo, Ogun State. The RHA was made in the laboratory by burning the husk using an Electric furnace, with a temperature of the furnace at about 700°C. The resulting ash was collected and sieved through BS standard sieve size $45\mu m$ grey in colour.

Fine Aggregate

The fine aggregate that was used for concrete mixing was river sand (Ogun River sharp sand). River sand was selected because it was free from clay/silt content, organic material and chemical. The river sand was

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checked to ensure that it was free from other organic materials inside before used. Sharp Sand of sizes that passed through sieve size of 4.75mm was used as fine aggregate with a specific gravity of 2.63.

Coarse Aggregate

The coarse aggregate used was crushed granite. It was free of deleterious organic matter and passed through 20mm maximum sieve size. The aggregate used was cleaned and dried under the ambient temperature before concrete mixing.

Water

The quantity of water in the mix plays a vital role on the strength of the concrete.
Casting and curing of specimens were done with the use of potable water that was available at the department of Civil Engineering building Federal University of Agriculture Abeokuta.

Mix Proportion

The control concrete was designed to achieve Grade 25 and Grade 30.
Cement by weight was replaced by RHA in the range of 0%, and 10% for grade 25 and 30 concrete, to estimate the residual strengths of RHA concretes at 700°C duration of heating.

The mix design proportion used in this study were as shown in Tables 1 and 2:

Table 1. Mix proportion of Grade 25 concrete for different replacements.

S.No	RHA Replacement	Cement	Fine Aggregate	Coarse Aggregate	Water to binder ratio
1	0%	1	2	4	0.5
2	10%	0.9	2	4	0.5

Table 2. Mix proportion of Grade 30 concrete for different replacements.

S.No	RHA Replacement	Cement	Fine Aggregate	Coarse Aggregate	Water to binder ratio
1	0%	1	1.12	3.01	0.5
2	10%	0.9	1.12	3.01	0.5

Casting and Testing of Specimens:

All the ingredients were first mixed mechanically in dry condition in the concrete mixer. The concrete mix proportion is shown in Tables 1 and 2. The calculated amount of water was added to the dry mix and mixed thoroughly to get a uniform mix. Oil was smeared on the inner surface of the mould and the concrete was poured in to the mould. After 24 hours of casting, the specimens were de-moulded and cured for a period of 7, 14 and 28 days in a water tank. After the curing period was over, the specimens were tested. The material calculation for concrete cube is shown in Tables 3 and 4. For each mix, three cube specimens of size 150 x 150 x 150 mm. Cube were tested on 7, 14 and 28 days.

Table 3. Number of grade 25 concrete cube samples for each percentage replacement of OPC with RHA.

OPC-RHA %	Number of concrete cubes (Mix ratio 1: 2 : 4)			Total
	7 days	14 days	28 days	
100-0	3	3	3	15
90-10	3	3	3	15
Total number of concrete cubes needed = 30				30

Table 4. Number of grade 30 concrete cube samples for each percentage replacement of OPC with RHA.

OPC-RHA %	Number of concrete cubes (Mix ratio 1: 1.12: 3.01)			Total
	7 days	14 days	28 days	
100-0	3	3	3	15
90-10	3	3	3	15
Total number of concrete cubes needed = 30				30

3. Results and Discussion

3.1 Physical Properties of RHA, Cement, Fine and Coarse Aggregates

The specific gravity results showed that for the RHA it was 1.99, cement 3.06, sand 2.63 while granite was 2.66. The results of the moisture content tests were 6.82% for RHA, 0.50% for cement, 0.46% for sand and 0.05% for granite.

3.2 Compressive Strength RHA blended concrete of grade 25 and 30

The compressive strengths for 10% RHA replacements of grade 25 and 30 concretes are shown in Tables 5 and 6.

Table 5. Compressive strengths for 0% and 10% RHA replacements of grade 25 concrete.

Average Compressive strength of cube (N/mm^2) Grade 25 (1: 2: 4 Mix)				
Water/Binder Ratio	Age of Curing (Days)	Average Weight (Kg)	Density of Cube (Kg/mm^3)	Average Compressive Strength (N/mm^2)
CUBE TEST 0% RHA REPLACEMENT CURED IN FRESH WATER				
0.5	7	8.32	2.31	21.56
	14	8.48	2.35	23.25
	28	8.50	2.40	29.78
CUBE TEST 10% RHA REPLACEMENT CURED IN FRESH WATER				
0.5	7	8.58	2.01	9.32
	14	8.08	2.15	11.91
	28	8.24	2.25	17.37

Table 6. Compressive strengths for 0% and 10% RHA replacements of grade 30 concrete.

Average Compressive strength of cube (N/mm^2) Grade 30 (1: 1.12: 3.01 Mix)				
Water/Binder Ratio	Age of Curing (Days)	Average Weight (Kg)	Density of Cube (Kg/mm^3)	Average Compressive Strength (N/mm^2)
CUBE TEST 0% RHA REPLACEMENT CURED IN FRESH WATER				
0.5	7	8.38	2.48	22.37
	14	8.46	2.51	24.26
	28	8.27	2.45	32.12
CUBE TEST 10% RHA REPLACEMENT CURED IN FRESH WATER				
0.5	7	8.42	2.54	20.67
	14	8.18	2.42	20.96
	28	8.58	2.54	26.82

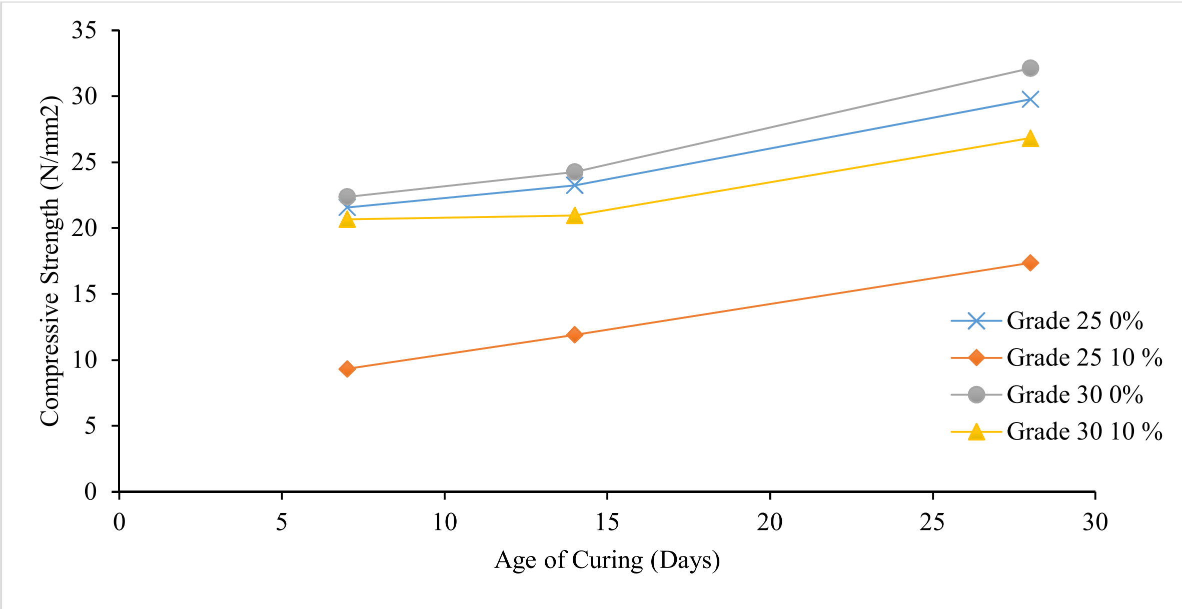

Figure 1. Compressive Strengths of Rice Husk Concrete for grade 25 and 30.

The compressive strength test was conducted on three concrete cube samples for 0% and 10% replacement of cement with RHA shown in fig.1 at the ages of 7, 14, and 28 days respectively. The results of the compressive strength of the concrete cubes with variation in percentage replacement are presented in Table 5 and 6 for 7, 14, and 28 days curing respectively showing the summary result of the average of compressive strength test.

It was observed that the compressive strengths reduced as the percentage replacement of RHA increased. However, the compressive strengths increased as the number of days of curing increased for each percentage RHA replacement. For the 10% RHA replacement, it showed an increase in compressive strength from 9.32N/mm^2 at 7 days to 17.37 N/mm^2 at 28 days (86.4% increment) for grade 25 concrete and an increase in compressive strength from 20.67N/mm^2 at 7 days to 26.82 N/mm^2 at 28 days (29.75% increment) for grade 25 concrete.

4. Conclusion

From the experimental investigation carried out, the following inferences on the RHA concrete are made;

- From the result it was observed that the compressive strengths reduced as the percentage replacement of RHA increased. However, the compressive strengths increased as the number of days of curing increased for each percentage RHA replacement.
- The results of the experimental investigation indicated that Rice Husk Ash (RHA) at 10% replacement of cement for grade 30 concrete having a compressive strength of 26.82 N/mm^2 can be used for concrete production while Rice Husk Ash (RHA) at 10% percentage replacement of cement for grade 25 concrete having a compressive strength of 17.37 N/mm^2 can be used for light concrete works.

5. Recommendation

From the conclusions of this investigation, the following recommendations are made:
1. The use of other admixtures with rice husk ash should be investigated in order to retard the hydration of water.
2. The use of super-plasticizer with RHA should also be investigated in order to improve the workability of the fresh concrete.
3. The effect of creep on the RHA concrete should be investigated.
4. The long-term behavior of Rice Husk Concrete should be investigated.
5. Similar studies should be recommended for concrete beams and slab sections to ascertain the flexural behavior of lightweight concrete made with this material.

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