STRENGTH CHARACTERISTICS OF RICE HUSK ASH AND CORN COB ASH BLENDED CEMENT CONCRETE

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Abstract

The study investigates the mechanical properties of concrete incorporating Rice husk Ash (RHA) and Concorb Ash (CCA) as cementitious binders. Concrete cube was prepared from a standardized prescribed mix of 1:2:4. The cement component in the reference mix was replaced with combined % weight of rice husk ash and corncob ash. The physical and chemical composition of RHA and CCA were examined as well as the workability and compressive strength properties of varying percentage of RHA and CCA blended cement concrete. Water–cement ratios of 0.6, was adopted for the reference and blended mixes. A total of 75 concrete cubes of different percentages by weight of combination of RHA and CCA to Portland cement in the order of 0%, 10%, 20%, 30%, and 40% were cast. The strength measurements of concrete were performed at the ages of 7, 14, 21, 28 and 56 days.

The results revealed that compressive strength increased with increase in curing age but decreased as the RHA and CCA contents increased. The compressive strength of concrete cubes with the combination of RHA and CCA was lower at early stages but improves significantly up to 56 days. The highest compressive strength was 22.94N/mm^2 and 26.27N/mm^2 at 56 days for 0% and 10% combination of RHA and CCA respectively

Based on the test results the study concluded that 10% RHA and CCA content is adequate as supplementary cementitious material for blended concrete.

Keywords. Compressive strength, Blended cement concrete, Corncob Ash, Rice husk ash, Percentage replacement

1.0. INTRODUCTION

The search for alternative binder or cement replacement materials led to the discovery of the potentials of using industrial by-products and agricultural wastes as cementitious materials. If these fillers have pozzolanic properties, they impart advantages to the resulting concrete and also enable larger quantities of cement replacement to be achieved (Binici and Aksogan (2006).

The overall relevance of concrete in virtually all civil and building construction works cannot be overemphasized. Civil engineering practice and construction works depend to a very large extent on concrete, as it is one of the major building materials that can be delivered to the job site in a plastic state and can be moulded insitu or precast to virtually any form or shape. Its basic constituents are cement, fine aggregate (sand), coarse aggregate and water, while its quality is determined by that of its constituent materials. It is expected that the concrete produced at any given instance should among other qualities have satisfactory performance on compressive strength requirements as well as satisfactory durability in the environment in which the structure is placed (Umoh, 2012). The compressive strength of concrete is considered as one of the most important properties in the hardened state; and the design of concrete structures is based primarily to resist compressive stresses.

Concrete is of the most important element of building structure and well-designed concrete can be a durable construction material; however, the environmental impact of Portland cement production is a growing concern, as cement manufacturing is responsible for about 2.5% of total worldwide emission from industrial sources. One effective way of reducing the environmental impact of Portland cement is to use natural pozzolans or supplementary cementing materials, as partial replacement for cement a strategy according to (Aldea, *et al*., 2000) has a potential to reduce costs, conserve energy, and reduced waste volumes. Materials cost, according to Ayangade *et al.* (2004), accounts for two-third of building production cost, It is therefore necessary to look inward and consider how the cost of the widely accepted convectional materials such as cement, sand, granite, and wood can be reduced to affordable level without compromising standards. One of the suggestions in the forefront has been sourcing, development and use of readily available local natural materials suitable for the production of any component of a building as alternatives to more expensive conventional building materials (Morel *et al*. 2001; Kayali *et al*., 2008), the alternative natural materials are Rice husk ash and Corncob ash. It is now possible to replace 50 to 70% Portland cement with one or several supplementary cementing materials, such as coal fly ash, granulated blast furnace slag, natural Pozzolans, silica fume and rice husk ash to produce blended Cement concrete, with dramatic improvements in the properties of the concrete.

Ternary blended concrete has the advantages of high strength, low permeability, elimination of thermal cracking and resistance to sulphate, corrosion and alkali-silica reaction. Other advantages include improved workability, reduction in the energy used in cement production, reduction in greenhouse gasses emissions, increased production capacity, and recycling of SCMs (Malhotra, 2004). In addition, ternary blended cement system could potentially be used in the concrete construction industry in lowering down the volume of Portland cement used.

Corn cob is the hard thick cylindrical central core of maize (on which are borne the grains or kernels of an ear of corn). Adesanya and Raheem A.A. (2010) described Corn cob as the agricultural waste product obtained from maize or corn; which is the most important cereal crop in sub-Saharan Africa. According to Food and Agriculture Organization (FAO) data, 589 million tons of maize were produced worldwide in the year 2000 (FAO Records; 2002). The United States was the largest maize producer having 43% of world production. Africa produced 7% of the world's maize (IITA Records; 2002). Nigeria was the second largest producer of maize in Africa in the year 2001 with 4.62 million tons. South Africa has the highest production of 8.04 million tons (FAO Records; 2002).

Corn Cob Ash (CCA) is gotten from the combustion of corn cobs either by open burning or the use of an incinerator. There had been various research efforts on the use of corn cob ash (CCA) and other pozzolan as a replacement for cement in concrete. Olutoge et al (2010); presented a comparative study on fly ash and ground granulated blast furnace slag (GGBS) high performance concrete, Ogunfolami (1995); considered mixing of the CCA with Ordinary Portland cement at the point of need (i.e. on site). Adesanya and Raheem (2010); studied the workability and compressive strength characteristics of Corn cob ash (CCA) blended cement concrete. Adesanya and Raheem (2009); also assessed the development of Corn cob ash (CCA) Blended Cement.

Rice husk ash (RHA) is an agricultural waste which is produced in millions of tons. Waste managers have found it difficult over the years to dispose this agro-waste. Rice husk ash (RHA) is obtained by the combustion of rice husk and has been found to be super Pozzolanic. RHA is a highly
reactive pozzolanic material suitable for use in lime pozzolans mixes and for Portland cement replacement. RHA is very reach in silicon dioxide which makes it very reactive with lime due to its non-crystalline silica content and its specific surface. In this study, Rice husk and Corncob ashes are used as cement supplements with a view to ascertaining the optimum replacement level that will enhance the strength performance in the blended cement concrete.

2.0 MATERIALS AND METHODS

2.1 Materials

The materials used in this research were Ordinary Portland cement manufactured by Dangote Cement Company. It was obtained from a certified local dealer to ensure recent supply and free from adulterations. The fine aggregates (river sand) with maximum size of 2.8mm, free of clay, loam, dirt and any organic or chemical matter, was used for this study. The coarse aggregate (granite chipping) was predominantly of size 14mm, the materials were source from Akure in Ondo State. The Corncob were collected from a dump site along Ondo road, about two kilometres from the Federal University of Technology, Akure. The Corncob were spread in an open space in the laboratory for 4-5 days The rice husk were obtained from a local rice production factory at Army Barrack along Ondo Road Akure and taken to the laboratory where they were spread in an open space for 7-8 days The Corncob and dried Rice husk leaves were calcined, each material separately, in a furnace to a temperature of 550^{o}C for 20 minutes. The water used in this research was fresh, colourless, odorless and tasteless potable water that is free from organic matter obtained from Department of Building Workshop, Federal University of Technology Akure.

2.2 Mix proportions

A mixture of 1:2:4 mix ratio representing cement: fine aggregate: coarse aggregate was used as the reference mix. The cement constituent was subsequently replaced with percentage combination of Corncob ash and Rice husk leaf ash (by mass). The percentage of the CCA and RHA was varied between 10% and 40%, at 10% interval.

2.3 Mixing of Constituent Materials

The cement, RHA, and CCA were measured and mixed together until a uniform colour was obtained. The blended mix was spread on already measured fine aggregate placed on an impermeable flat form and mixed thoroughly before the coarse aggregate and water were added.

2.4 Workability Tests on fresh concrete

Slump tests was carried out on the fresh concrete to determine the workability of each mix. The test was done in accordance with the requirement of BS EN 12350 – 2 – (2009), for slump test.

2.5 Casting and testing of specimen

The concrete cubes were cast using 100mm x 100mm x 100mm cube moulds. The cube moulds were assembled prior to mixing and properly lubricated with engine oil for easy removal of the hardened concrete cubes. Each mould was then filled with prepared fresh concrete in three layers and each layer tamped with tamping rod using thirty five (35) strokes uniformly distributed across the seldom of the concrete in the mould . The top of each mould was then smoothened and levelled with hand trowel and then the outside surfaces cleaned. The cast cubes were left for 24 hours under a room temperature for the cubes to set before the moulds were removed. After 24 hours, the cubes were taken to the curing tank for curing (BS EN 12390-2, 2009). Fifteen (15) concrete cubes were cast for each percentage replacement and a total of seventy-five (75) cubes for the whole experiment. The concrete specimens were tested for compressive strength in a compression testing machine of capacity 2000KN at ages of 7, 14, 28 and 56 days in accordance with BS EN 12390-3 (2009) and BS EN 12390-6 (2009), respectively. Slump test was carried out to determine the effect of RHA and CCA on the workability of fresh concrete at each percentage replacement of cement with RHA and CCA. The test was carried out in accordance with the requirements of BS 1881: part 102 (1983). .

3.0 Results and Discussion

3.1 Chemical Composition

Table 2. shows the results of the analysis of the chemical composition of Rice husk ash and Corncob ash. The table indicated that SiO_2 forms 67.41 % of Corncob ash and about 73.68% of Rice husk ash. For Al_2O_3 it was 8.39% of Corncob ash and 0.68% of Rice husk ash while 2,54% of Corncob ash and 0.93% was recorded for Fe_2O_3. The results also showed that all samples of CCA and RHA had combined percentages of silica (SiO_2) and alumina (Al_2O_3) and iron oxide (Fe_2O_3) of more than 70% a requirement of which a good pozzolans should meet (Syagga *et. al* 2001; Pekmezei and Akyuz, 2004 and Justnes *et. al*.2005). The requirements of ASTM C 618 for a combined SiO_2+ Al_2O_3 + Fe_2O_3 of more than 70% was also satisfied (Siddique, 2004). The slump value decreases as the BLA content increases. This means that the concrete becomes less workable (stiff) as the BLA content increases. Hence there is a higher demand for water with increasing BLA content.

3.2 Compressive Strength

The compressive strength for the mixes as shown in Figure 1. generally indicated an increase in strength with curing age. The compressive strength values for the various curing age and for different mixtures of various percentages of RHA and CCA at percentage replacement of 0%, 10%, 20%, 30% and 40% was shown in Table 4, At 7 days the compressive strength ranged between 10.19 N/mm^2 and 9.09 N/mm^2 for 0% and 40% RHA and CCA respectively. The compressive strength increases from 10.19 N/mm^2 to 10.90 N/mm^2 representing 6 % increase.
The result of compressive strength at 14 days hydration indicated an increase in compressive strength of 80.17% for 0% replacement content, 52.94%, 13.10% and 39.05%, 53.61% for 10% 20%, 30% and 40% respectively. The compressive strength for 10% is 15.96% which is higher than the compressive strength of 20%, 30% and 40% replacement. 0% has the highest percentage replacement at 14 days.

At 21 days the compressive at 0%, 10%, 20%, 30% and 40% were 21.09 N/mm^2, 16.86 N/mm^2, 14.36 N/mm^2, 13.62 N/mm^2 and 5.59 N/mm^2 representing an increase of 4.87%, 5.64%, 26.97%, 7.75% and 1.08%

The strength at 28days increases to 21.11%, 10.71%, 9.91% and 34.17% for 10%, 20%, 30%, and 40%b replacement. The highest percentage increase of 34.10% was recorded at 21 and 28 days. At 56 days of hydration it was observed that the compressive strength shows a remarkable improvement than at 14 and 28days.of hydration. 0% recorded the highest compressive strength of 22.94% percentage replacement, 26.27 N/mm^2, 19.70 N/mm^2, 17.60 N/mm^2, and 9.60 N/mm^2 for 10%, 20%, 30% and 40% respectively.

Table 1. Slump value of RHA and CCA Blended Cement concrete

Slump value of RHA and CCA Blended Cement concrete					
% RHA and CCA Replacement	0	10	20	30	40
Slump (mm)	58	57	56	55	42.5

Table 2. Chemical Composition of RHA and CCA

Constituents oxide	**CCA**	**RHA**	**OPC BS 12 Limit**
SiO_2	**67.41**	**73.68**	**17-25**
CaO	**10.85**	**1.32**	**60.67**
Al_2O_3	**8.39**	**0.68**	**3-8**
Fe_2O_3	**2.54**	**0.93**	**0.5-6.0**
MgO	**4.05**	**0.37**	**0.1-4.0**
SO_3	**1.40**	**0.14**	**1-2**
Total % of $SiO_2 + Al_2O_3 + Fe_2O_3$	**78.34**	**75.29**	

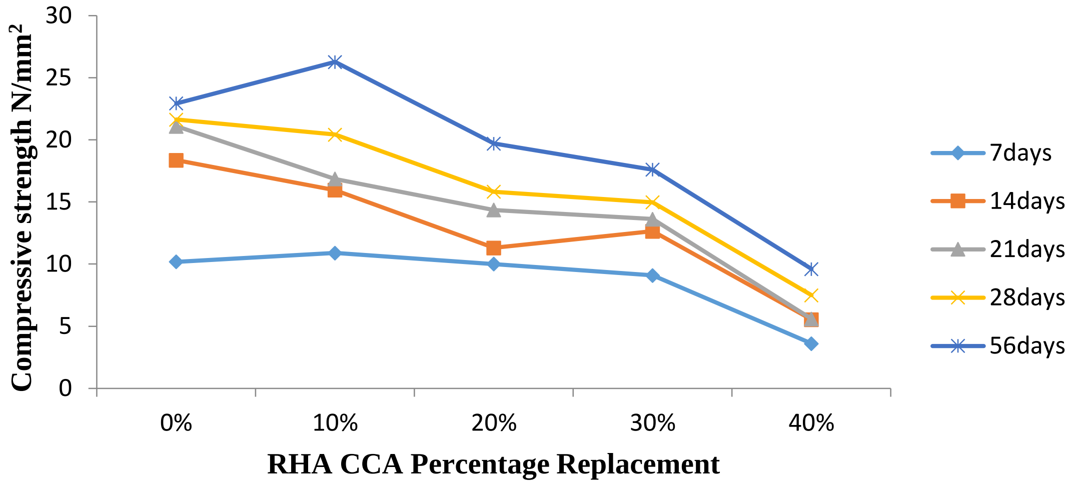
Table 3. Mix. Composition of RHA and CCA blended cement Concrete

%	Cement (kg)	Rice Husk Ash (kg)	Corn cob Ash (kg)	Sand (kg)	Granite (kg)
0	4.67	0	0	9.32	18.65
10	4.20	0.23	0.23	9.32	18.65
20	3.74	0.47	0.47	9.32	18.65
30	3.27	0.70	0.70	9.32	18.65
40	2.80	0.93	0.93	9.32	18.65

Table 4. Compressive strength (N/mm^2) of concrete for varying percentage of RHA and CCA

% CCA and RHA Replacement	Curing ages				
	7	14	21	28	56
0%	10.19	18.36	21.09	21.64	22.94
10%	10.90	15.96	16.86	20.42	26.27
20%	10.00	11.31	14.36	15.82	19.70
30%	9.09	12.64	13.62	14.97	17.60
40%	3.60	5.53	5.59	7.50	9.60

Figure 1. Compressive strength of concrete for varying percentage of RHA and CCA



4.0 CONCLUSIONS

From the experimental investigation of compressive strength of concrete incorporating Rice husk ash and Corncob ash the following conclusion can be drawn

1. The results of the Chemical composition of the Rice husk ash and Corncob ash revealed that- that all samples of CCA and RHA had combined percentages of silica (SiO_2) and alumina (Al_2O_3) and iron oxide (Fe_2O_3) of more than 70% a requirement of which a good pozzolans

2. Rice husk ash and Corncob ash used met the physical and chemical requirement as specified by ASTM C618 (2008). The compressive strength increases with curing age and percentage replacement up to 10% and then decreases with increase in the RHA and CCA.

3. The slump value decreases as the RHA and CCA content increases. This means that the concrete becomes less workable (stiff) as the RHA and CCA contents increases. Hence there is a higher demand for water with increasing RHA and CCA content.

4. Rice husk ash and Corncob ash concretes do not attain their design strengths at 28days. The strengths of corn cob ash concrete are dependent on its pozzolanic activities.

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