Influence of Curing Methods on Some Properties of Rice Husk Ash Concrete

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Abstract

The paper investigated the most appropriate curing method for rice husk ash (RHA) concrete. The study confirmed the strength performance of concrete with 5% replacement of RHA at 7, 14, 28 and 56 days of curing under three curing methods namely spraying, immersion and covering with polythene; with the targeted concrete strength value of 30N/mm^2 at 28 days. After curing, 29.6 N/mm^2, 29.2 N/mm^2 and 29.2 N/mm^2 were obtained for RHA concrete under spraying, immersion and polythene methods at 28 days and 31.6 N/mm^2, 36.4 N/mm^2 and 24.0 N/mm^2 at 56 days respectively. The overall results suggest that RHA concrete cured by immersion in water produced a better compressive strength just as in normal concrete. Therefore, based on the findings, immersion in water is recommended as the most suitable curing method for RHA concrete at 5% replacement level.

Keywords: *Concrete, Curing method, Rice husk ash,*

Introduction

Rice husk ash (RHA) used in this research is produced by controlled burning of rice husk. This is because RHA is a highly reactive pozzolanic material leading to a significant improvement on strength and durability of normal concrete. Curing has a major influence on the properties of hardened concrete such as durability, strength, water-tightness, wear resistance, volume stability, and resistance to freezing and thawing, creep, chemical attack and density. For curing to be beneficial in concrete it should start as soon as concrete hardens since the detrimental effect of early improper curing are irreversible. American Concrete Institute, (1991).

Concrete curing is one of the most important and final steps in concrete production though it is also one of the most neglected and misunderstood procedures. It is the treatment given to newly placed concrete during which it hardens so that it retains enough moisture to minimized shrinkage and resist cracking (Lambert Corporation, 1999).

For curing to be beneficial in concrete, it should start as soon as concrete hardens since the detrimental effect of early improper curing are irreversible (American Concrete Institute, 1991). In addition to increasing the strength of concrete, proper curing reduces the porosity and provides a fine pore size distribution in concrete microstructure (Alamri, 1988). Therefore, a selection of suitable curing method such as water ponding (immersion), spraying or sprinkling of water, or covering with polythene sheet material in order to produce strong and durable concrete is very necessary.

However, when a certain percentage of cement is being replaced with rice husk ash (RHA) in the concrete production, curing conditions could affect strength differently. Admixtures have shown to cause more compressive strength losses in uncured concrete specimens than normal concrete mixes (Ramezanianpour and Malhotra, 1995; Ozer and Ozkul, 2004).

Since the end of the 1960s, extensive research has been carried out on the preparation, properties and applications of RHA in pastes, mortars and concretes and many papers and patents have been published on this subject. This study presents the influence of different curing methods on the compressive strength of RHA concrete with 5% replacement with the view of proposing the most appropriate method for Nigeria RHA concrete.

Materials and Methods

Sized crushed coarse aggregate with maximum size of 20mm was used in a saturated surface dry condition based on BS 812 (1996). And the fine aggregate used was also in saturated surface dry condition. The percentage passing 600µm of the fine aggregate was 40%, and also conforms with BS 812, (1996).

The cement used in the study was ordinary Portland Cement as is the most widely used cement for construction in Nigeria and conform with BS 812 (1996). The water used in the research for preparing concrete and curing purposes was fresh tap water in the Concrete Laboratory of Building Department of Ahmadu Bello University, Zaria.

Rice husk used in this research was locally sourced from local rice processing plant in Wuntin Dada area of Bauchi town, in Bauchi state. The ash from rice husk was produced by controlled burning using kiln in the Department of Industrial Design of Ahmadu Bello University, Zaria. The ideal temperature of 700°C used for producing RHA was adopted (Nick & Emmet, 2009). The chemical analyses of the ash were carried out in multi-use laboratory, Chemical Engineering Department of Ahmadu Bello University Zaria to confirm the level of presence of silicon content and other chemical compositions in RHA. The results of chemical and sieve analyses of RHA are as shown in tables 3 and 4 respectively. The concrete was designed according to United States Department of environment (USDoE) method, and the dosage of RHA used was 5% adopted from the work of Mauro et al., (2003).

Design Method for Concrete

A concrete of grade 30N/mm^2 at 28 days was design using the Department of Environment (DOE) Method. The design was made for 36 cubes each for both control and 5% replacement as shown in table 1. The proportions of each ingredient for 36 cubes were also shown in the table.

Table 1. Concrete Mix Design for 0% replacement of OPC for 36 cubes.

Quantity	Cement (kg)	Water (kg)	Coarse aggregate (kg)	Fine aggregate (kg)
1m^3	360	240	1125	750
0.036m^3 (36 no. cubes)	12.96	8.64	40.50	27

Table 2. 5% replacement of RHA required for 36 cubes.

Quantity	Cement (kg)	RHA (kg)	Water (kg)	Coarse aggregate (kg)	Fine aggregate (kg)
1m^3	360	0.00	240	1125	750
0.036m^3 (36 no. cubes)	12.31	0.65	8.64	40.50	27

Production of test specimens

Cast iron moulds of 100mm x 100mm x 100mm were used to produce the concrete cubes. The moulds were oiled for easy removal of concrete cubes. The concrete was placed in approximately three equal layers and each layer was rammed with 25 strokes of 50mm round ended rod. The top of the cubes was marked after a while for identification purpose. Immediately after this, the specimens were kept under normal temperature in the laboratory. The specimens were removed from the cast iron moulds at the age of 24 + 2hours.

Curing of specimens

The specimens were cured under the three curing methods until the days of testing. The methods used for curing were spraying with water, immersion into water and covering with polythene. In spraying with water method, the specimens were kept moist by spraying the specimens with water two times daily (morning and evening) up to the days of crushing. In immersion in water, the specimens were immersed into water until the days of crushing. In covering with polythene, the specimens were covered with polythene until the days of crushing. The specimens were tested at 7, 14, 28 and 56 days of curing.

Testing of the hardened properties of specimens

The compressive strength, abrasion resistance and water absorption test of specimens were carried out at 7, 14, 28 and 56 days. All the specimens were tested at saturated surface dry condition. The crushing was carried out at 7, 14, 28 and 56 days respectively for the three methods of curing, using the hydraulic crushing machine of 1000kN capacity in the Building Department concrete laboratory of Ahmadu Bello University, Zaria. The failure load was divided by the cross-sectional area to obtain the strength, which is in accordance with BS 1881: Part 116; 1983 Method for determination of compressive strength of concrete cubes.

The abrasion resistance test was carried out in accordance with African Regional Standard (1996). The surface of the concrete cubes was subjected to brushing by means of a wire brush. The brushing consists of one forward and backward motion per second for one minute i.e. 60 cycles. The cubes where weighed before and after brushing and recorded the masses as M_1 and M_2 respectively. The mass of the detached matter i.e. $M_1 - M_2$ was recorded and the percentage weight loss of all the specimens were recorded and compared.

Water Absorption test was carried out in accordance with Indian Standard 456 (2000), dry cubes were put in an oven at a temperature of 105°C to 115°C. The weight (W_1) of each cube was recorded after allowing them to cool at room temperature. The cubes were then immersed in water for 24 hours. The specimens were then taken out of water and allow to surface dry, thereafter it was weighed again and recorded as W_2.

The water absorption in %

$$= \frac{W2-W1}{W1} \times 100$$

Results and Discussion

It can be observed that the percentage of the silicon dioxide (SiO_2), iron oxide (Fe_2O_3), aluminum oxide (Al_2O_3) gives a total of 88.55% for RHA, this satisfies the requirements of the ASTM C 618 which give a minimum of 70% of the class N (raw or calcined natural pozzolana). It was also observed that RHA contains higher content of SiO_2.

Table 3. Chemical Composition of RHA

Constituents	% compositions RHA
SiO_2	86.98
Al_2O_3	0.84
Fe_2O_3	0.73
CaO	1.40
MgO	0.57
SO_3	0.11
Na_2O	2.46
K_2O	-
P_2O_5	9.43
Loss on ignition	5.14

Source: experimental work (2016)

Table 4. Sieve Analysis of Rice husk ash. (RHA)

The result of particle size distribution analysis of RHA is as follows

Sieve Size	Weight retained (g)	% returned	% passing
2.36	0	0	100
1.18	0	0	100
600	34	5.8	93.2
425	41	8.3	85
300	150	30	55
212	57	11.4	43.6
150	81	16.2	27.2
63	100	20.0	7.4
Pan	35	7.4	0

Source: experimental work (2016)

Plate I. Compressive strength test on RHA specimens

The results of compressive strength have been presented in graphical representation of average compressive strength versus curing age for different methods of curing used in the experiment as in fig. 1-4

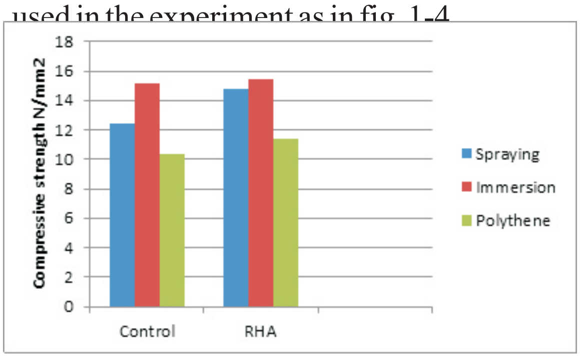

Fig.1. Compressive strength test at 7days

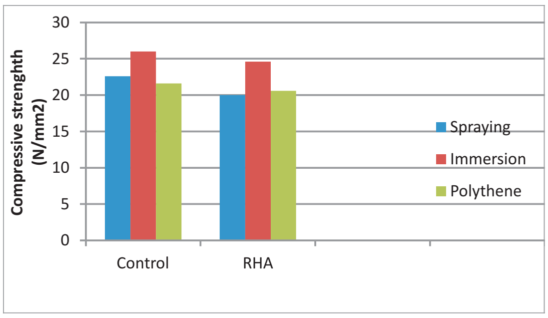

Fig.2. Compressive strength at 14 days

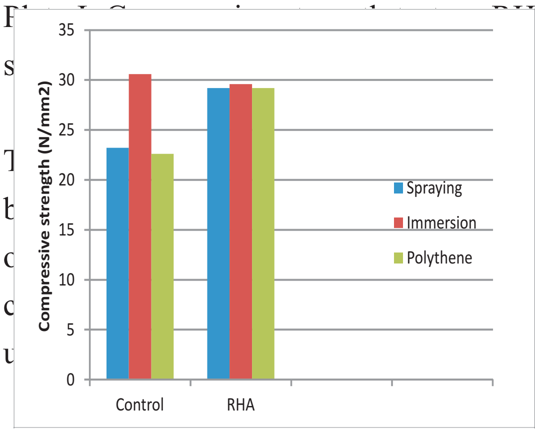

Fig.3. Compressive strength test at 28 days

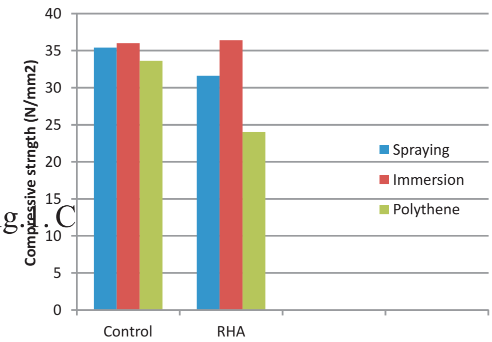

Fig.4. Compressive strength test at 56 days

The RHA specimen shows an increment in compressive strength over the control specimens under spraying method and covsering with polythene methods of curing at 56days, but under the immersion method, the control is higher in compressive strength. This may be due to improved pore structure and lower porosity resulting from greater degree of cement hydration reaction without any loss of moisture from the concrete specimens.

The increment in compressive strength of RHA specimen over control under spraying and covering with polythene methods can be attributed to the pozzolanic reactions which aid the production of more calcium silicate hydrate (CSH) and calcium aluminate, thus influencing the strength.

Abrasion resistance test on specimens

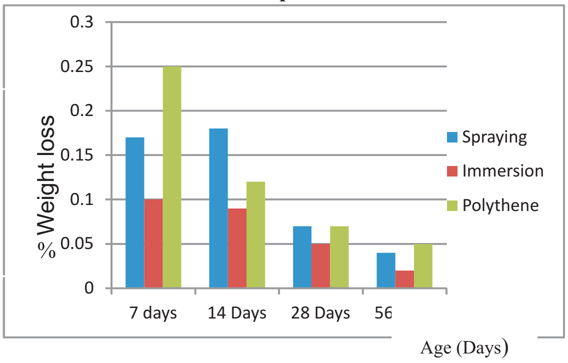

Fig.5.Abrasion resistance test for control

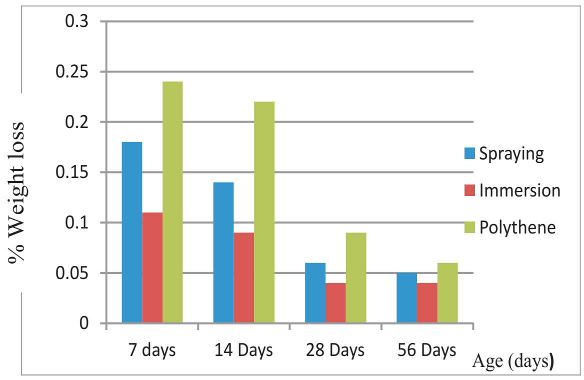

Fig.6. Abrasion resistance test for RHA

Abrasion resistance test on control samples showed that the abrasion resistance of the concrete increased with the increase in maturity age. Concrete subjected to immersion have the highest abrasion resistance compared to those under spraying and covering with polythene.

The abrasion resistance of RHA concrete specimens also increased with the increase in maturity age. This showed that the RHA specimen subjected to immersion have the highest abrasion resistance compared to those under spraying and covering with polythene. This can be attributed to sufficient moisture and suitable vapour pressure which are maintained to continue the hydration of cement.

Water absorption test of specimens

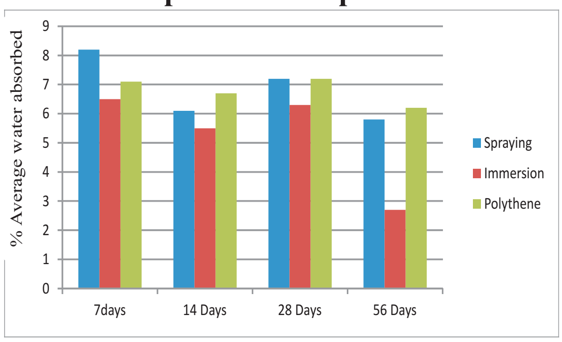

Fig.7. Water absorption test on RHA specimens .

The water absorption of RHA concrete specimens decreased with the increase in maturity age. This showed that RHA concrete subjected to immersion have lower water absorption at 56days.

RHA specimens subjected to covering with polythene have a lower absorption as the maturity age increases. One of the main sources of contamination of concrete in structure is water absorption which influences durability of the concrete and also has the risk of alkali aggregate reactions.

Conclusion

It is concluded that RHA can provide a positive effect on the compressive strength of RHA concrete at early ages. Besides, in the long term, the compressive strength of RHA concrete produced by controlled incineration shows better performance. This was also confirmed by Aitcin (1998), confirmed that adding RHA would contribute to the strength enhancement at later ages only and the strength would be comparable to the OPC concrete.

Curing by immersion in water proved to be the most suitable curing method for RHA specimens, because it produces no loss of moisture, therefore enhances cement hydration reaction, followed by spraying method of curing which produces higher compressive strength than covering with polythene. This can be attributed to the reduced in moisture movement from RHA specimen leading to enhanced degree of hydration of cement. Immersion method should be use in curing RHA concrete in order to achieve good harden properties. Spraying method can be adopted in the case of water shortage instead of covering with polythene method.

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