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The Compressive Strength of Self Compacting Concrete (SCC) Using Rice Husk Ash (RHA) as Partial Replacement of Cement

A. A. Amolegbe, M. A. Oyelakin, M. O, Oyeleke, A. K. Ajala, W. O. Oyeniyan

Department of Civil Engineering, Federal Polytechnic, Offa
Corresponding Author: contactamolegbe@yahoo.co.uk

Abstract – Self-compacting concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The properties of SCC have been studied in many researches due to its importance and ability to solve the problems of concrete mix. To achieve the SCC mix, it is required to reduce the aggregate content and increase the cement amount as well as the addition of agricultural wastes known to possess pozzolanic properties. Rice husk ash (RSH) was used to replace cement in stepped concentration of 0 %, 5%, 10%, 15%, 20% and the compressive strength of different concrete mix (1:2:4, 1:3:6, 1:4:8) cured in fresh water for different ages (7days, 14days, 21days and 28days) were determined. The result of the compressive strength tests showed that for all the curing periods the peak values (aside the control of 0% RHA) were recorded at 10% RHA replacement for 1:2:4 mix ratios). All the values recorded for the replacement mixes were in excess of 90% of the control values. Giving the expected (long-time) strength gain of the pozzolanas, the 10% replacement of RHA could be used for a lean concrete at 1:2:4 mix.

Keywords: Compressive Strength, Concrete Mix, Pozzolana, Rice Husk Ash, Self Compacting Concrete.

1. Introduction

Concrete is the most widely used man-made construction material in the world (Mehta, 2007). It is obtained by mixing cementitious materials, water, aggregate and sometimes admixtures in required proportions. Fresh concrete or plastic concrete is freshly mixed material which can be moulded into any shape. This hardens up into a rock-like mass known as concrete which is a result of the chemical reaction between water and cement, which continues for long period leading in increased strength with age. (Ahmdi, 2007).

Self-compacting concrete (SCC) is a new kind of high performance concrete (HPC) developed in Japan in 1986. The development of SCC has made casting of dense reinforcement and mass concrete convenient. Fresh self-compacting concrete SCC flows into formwork and around obstructions under its own weight to fill it completely and self-compact (without any need for vibration), without any segregation and blocking. The elimination of the need for compaction leads to better quality concrete and substantial improvement of working conditions. SCC mixes generally have a much higher content of fine fillers, including cement, and produce excessively high compressive strength concrete, which restricts its field of application to special concrete only. To use SCC, mixes in general concrete construction practice requires low cost materials to make inexpensive concrete. (Mehta, 2007)

Self-compacting concrete is featured in its fresh state by high workability and rheological stability. SCC has excellent applicability for elements with complicated shapes and congested reinforcement. In concrete materials, most of the previous works studied the effects of pozzolanic materials on physical and mechanical properties of normal concrete (Webb and Hamdi, 2007).

As a result of increased industrial and agricultural processes across the globe, there has been significant increase in industrial and agricultural wastes which most often have negative impact on the environment. Most research efforts in recent times (Mohammedbhai and Baguant, 1990; Osinubi, 1998a, b; Osinubi and Medubi, 1997; Medjo and Riskowiski, 2004; Osinubi et al., 2009; 2011) were geared towards possible ways of recycling these wastes for re-use, to keep the environment clean and safe. The transportation, construction, and environmental industries have the greatest potential for re-use because they use large quantities of earthen materials annually and also this phenomenon enhances reduction in the cost of the cement to be used for a particular proposed project when the quantity of the cement needed is to be supplemented by these wastes instead of disposing them and thereby alleviating environmental pollution (Basha et al, 2002).

2. Materials

Rice Husk Ash

The rice husk ash used for the study were sourced from Bida in Niger State and they were completelety burnt in an electric furnace at 600^0c for 2 hours at the forgery and molding workshop of Mechanical Engineering Department, Federal Polytechnic Offa, Kwara State. These were later made to pass through sieve no 200

Fig. 1: Rice Husk Ash

3. Concrete Materials

The ordinary Portland cement, fine and course aggregates used for the study were purchased from dealers at an open market in Offa. The size of the mould used for the study was 50 x 50 x 50 mm

The oxide composition of the ash was determined at the Centre for Energy Research and Training (CERT), A.B.U, Zaria, by method of Energy Dispersive X-Ray Flourescence.

Table 1: Oxide Composition of RHA and Typical OPC

Oxide	**RHA (%)**	***OPC (%)**
CaO	1.08	63
SiO_2	55.38	20
Al_2O_3	14.93	6
Fe_2O_3	0.278	3
MnO	0.09	-
Na_2O	0.18	1
K_2O	2.00	-
SO_3		2
P_2O_5	0.23	-
Loss on Ignition	10.63	2

*After Czernin, 1962

4. Sample Preparation

Batching by weight was adopted using consistent weighing balance for measuring the granular materials. The ordinary Portland cement was partially replaced with rice husk ash by weight at 5%, 10%, 15% and 20% respectively. The batching was done for three different mix ratios of 1:2:4, 1:3:6 and 1:4:8. The cement and the rice husk ash were taken in turns at appropriate proportion of and the aggregates were added and thoroughly mixed manually with water until a uniform material was formed. The concrete were allowed to self compact in the mould after placing and left to set for 24 hours. After casting and setting of the concretes the cubes were removed from the mould and were completely immersed in a curing tank. The curing was done for 7, 14, 21 and 28 days.

After the required age of curing the concrete cubes were removed from the curing tank and allowed to surface dry after which they were weighed on a balance to obtain the weight of each cube. The weighed cubes were carefully placed in the universal testing machine with the smooth face in contact with the plates of the machine. The load was applied without shock and increased continuously at a rate within the range of 0.2 to 0.4N/mm square per sec until no greater load can be sustained and the maximum load applied to the cubes were recorded. The compressive strength is measure by breaking the specimen cube of concrete in the machine. The compressive strength is calculated by the failure load divided by the cross-sectional area of the cube resisting the load. The tests were permormed in accordance to ASTM C39.

TABLE 2: BATCHING FOR COMPRESSIVE STRENGTH MIX RATIO 1:2:4

% REPLACEMENT	**POZZONLAN (g)**	**CEMENT (g)**	**SAND (g)**	**GRANITE (g)**
0%	0	128.5	257	515
5%	6.4	122.1	257	515
10%	12.8	115	257	515
15%	19.3	109	257	515
20%	25.7	102	257	515

TABLE 3: BATCHING FOR COMPRESSIVE STRENGTH MIX RATIO 1:3:6

% REPLACEMENT	**POZZONLAN (g)**	**CEMENT (g)**	**SAND (g)**	**GRANITE (g)**
0%	0	90	270	540
5%	4.5	85.5	270	540
10%	9	81	270	540
15%	13.5	76.5	270	540
20%	18	72	270	540

TABLE 4: BATCHING FOR COMPRESSIVE STRENGTH MIX RATIO 1:4:8

% REPLACEMENT	**POZZONLAN (g)**	**CEMENT (g)**	**SAND (g)**	**GRANITE (g)**
0%	0	69	276	552
5%	3.5	65.5	276	552
10%	6.9	62.1	276	552
15%	10.4	58.6	276	552
20%	13.8	55.2	276	552

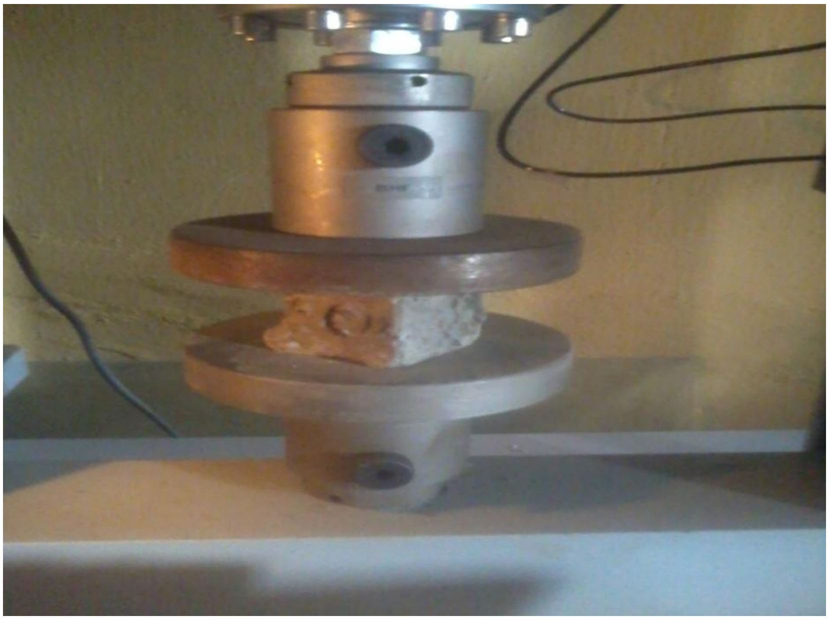

Fig. 2: The Placement of Cube in the Universal Testing Machine

5. Results and Discussions

The results of the compressive strenth tests are given in the tables below

TABLE 4: COMPRESSIVE STRENGTH TEST VALUE OF DIFFERENT MIX RATIO AND PERCENTAGE FOR 7DAYS

MIX Ratio	**COMPRESSIVE STRENGTH**				
	0%	5%	10%	15%	20%
1:2:4	3.659	2.523	3.523	3.212	2.249
1:3:6	1.938	2.687	2.334	2.429	2.170
1:4:8	1.475	1.421	1.498	1.621	1.172

TABLE 5: COMPRESSIVE STRENGTH TEST VALUE OF DIFFERENT MIX RATIO AND PERCENTAGE FOR 14DAYS

MIX Ratio	**COMPRESSIVE STRENGTH**				
	0%	5%	10%	15%	20%
1:2:4	7.695	4.391	5.132	5.940	4.349
1:3:6	5.009	2.209	2.028	1.771	1.896
1:4:8	4.414	3.370	2.551	2.509	4.414

TABLE 6: COMPRESSIVE STRENGTH TEST VALUES OF DIFFERENT MIX RATIO AND PERCENTAGE FOR 21DAYS

MIX Ratio	**COMPRESSIVE STRENGTH**				
	0%	5%	10%	15%	20%
1:2:4	12.560	12.396	12.405	8.119	8.132
1:3:6	11.807	9.396	9.943	9.167	4.634
1:4:8	6.038	10.048	9.041	10.989	7.368

TABLE 7: COMPRESSIVE STRENGTH TEST VALUES OF DIFFERENT MIX RATIO AND PERCENTAGE FOR 28DAYS

MIX Ratio	**COMPRESSIVE STRENGTH**				
	0%	5%	10%	15%	20%
1:2:4	15.476	12.517	14.125	8.568	8.513
1:3:6	12.652	10.089	10.989	7.683	6.038
1:4:8	10.368	9.971	8.528	4.818	5.571

From the results, the maximum compressive strengths were recorded at 0% RHA content, as expected, for all the mixes and curing age. For the 7-day curing, the maximum compressive strength of 3.659N/mm^2 recorded at mix ratio 1:2:4 at 0% RHA and was followed closely by 3.52 N/mm^2 value recorded at 10% RHA content at the same mix. For the 14-day curing, the maximum compressive strength was 7.695N/mm^2 at mix ratio 1:2:4 at 0% RHA while 5.13 N/mm^2 was recorded at thesame mix for 10% RHA.

The maximum compressive strength of 12.56N/mm^2 was recorded at mix ratio 1:2:4 for 0% RHA and that of 10% RHA was 12.40N/mm^2 (also) at mix ratio 1:2:4. For the 28-day curing, the maximum compressive strength was 15.476N/mm^2 at mix ratio 1:2:4 at 0% RHA and a value of 14.13N/mm^2 was recorded at mix ratio 1:2:4 at 10% pozzonlana content.

All the 10% RHA values recorded were in excess of 90% values of the control (of 0% RHA) at 1:2:4 mix ratio for all the curing ages.

6. Conclusion and Recommendation

From the result obtained from the work, it was noticed that the compressive strength of self-compacting concrete increased as ages of curing increases except for concrete mix 1:4:8 at 28days which decreases at 20% RHA replacement. The values of 10% RHA at 1:2:4 mix ratio are also very close to the peak 0% values for all the mixes.

Giving the long-term strenght gain tendency of pozzolanas, the use of rice husk ash at 10% partial replacement of cement is hereby recommended for lean concrete with 1:2:4 mix ratio.

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