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ORIGINAL RESEARCH
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Effect of partial replacement of cement with rice husk ash on concrete properties

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ABSTRACT

This research work is related to the study of effects on properties of concrete having rice husk ash as cementitious supplementary materials. Total four mixes of concrete were done with varying percentages of rice husk as 6%, 12% and 18%. The tensile, flexural and compressive strengths that contain rice husk ash were determined by testing cubes, cylinders and beams. There was a replacement of 6%, 12% and 18% of rice husk ash in all mixes except the control mix. The concrete's flexural strength with rice husk ash increases at the beginning and at the later age (i.e., 28 days) similar to control mix; however, variation in compressive and splitting tensile strength is negligible. The optimum results are achieved with 6% replacement of cement with rice husk ash. Therefore, it was inferred that rice husk ash could be used as partial replacement of cement in concrete to produce economic concrete.

KEYWORDS

concrete, rice husk ash, compressive strength, splitting tensile strength

1. INTRODUCTION

Millions of tons of cement are consumed yearly for the construction of building, highways, etc. The production of cement requires a lot of energy and it also generates harmful gases that affect the environment. The cement consumption can be decreased by including supplementary cementitious materials in concrete production and also in granular materials [1]. Concrete is mostly used in the construction of highways, dams, residential buildings and industrial structures. Concrete in its simplest form consists of cement, water, coarse and fine aggregate. The supplementary materials can be added to concrete, to get desired properties economically [2]. The supplementary materials like fly ash, silica fume, Rice Husk Ash (RHA), metakaolin etc., can be added in designed quantity during cement production or during concrete production. The skeleton of the rice grain is siliceous in nature. Rice grains are covered by hard covering named as rice husk and the milling process is used to separate rice husk from rice grains. Rice husk ash is produced from burning of rice hulls. The burning of rice husk results in ash with rich silica content. Pozzolan is a siliceous material, which possesses little reactivity. Rice husk ash is finer than cement; once completely burnt has a Blaine number of 3600, higher than that of cement (around 2800). Fine pozzolan forms a compound with cementing properties upon exposure to moisture. Rice husk ash is used in concrete as supplementary cementitious materials by the researchers [3]. The use of byproducts like rice husk results in significant energy and cost-saving. Rice husk in millions of tones is produced each year. Researchers have revealed that RHA has good pozzolanic and reactivity properties when used in the concrete [4]. The construction industry is in a race to produce economical concrete with better durability [5]. Rice husk and rice husk ash used is found beneficial in the ceramic industry as a potential source of silica [6]. RHA is also used as a soil improvement agent with cement. The experiment on use of rice husk ash as a partial

Table 2. Concrete mix design

Sr.#	Mix designation	Cement (kg)	RHA (kg)	Coarse Aggregate (kg)	Fine Aggregate (kg)	Water (kg)
1	CM	43.00	0	126.42	93.31	21.5
2	C94R6	40.42	2.58	126.42	93.31	21.5
3	C88R12	37.84	5.16	126.42	93.31	21.5
4	C82R18	35.21	7.74	126.42	93.31	21.5

*CM is control mix, C is cement, R is RHA

Table 3. Test-specimen details

Test	Specimens (mm)	Age (days)		Total specimens for each mix	Total for 4 mixes
		7	28		
Compressive Strength	Cylinder (150 × 300)	3	3	6	24
Splitting Tensile	Cylinder (150 × 300)	3	3	6	24
Flexural Strength	Beam (100 × 100 × 500)	3	3	6	24

2.3.2. Compression test. The cylindrical specimens of 150 mm in diameter were tested. The compression test was performed [15] for curing age of 7 and 28 days by 1000 kN capacity machine. The purpose of these tests was to determine the compressional behavior of the test specimens at specified ages.

2.3.3. Splitting tensile test. The cylindrical specimens of 150 mm in diameter were tested. The splitting tensile test [16] was performed for curing age of concrete at 7 and 28 days.

2.3.4. Flexural test. The test specimen was of size 100 × 100 × 500 mm. Modulus of rupture [17] of concrete was determined by testing concrete beams at different curing periods.

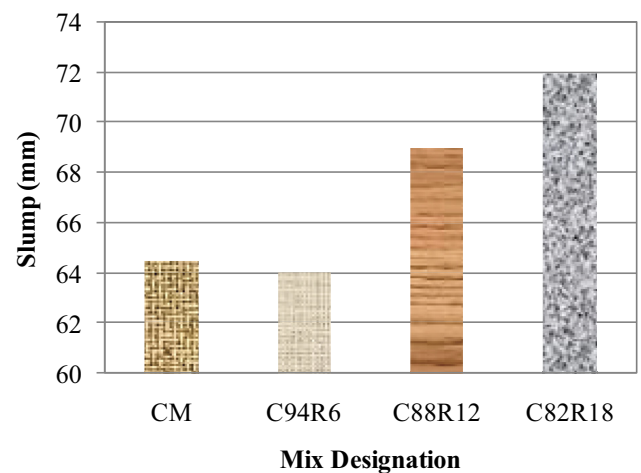


Fig. 3. Slump test results

3. TEST RESULT AND DISCUSSION

3.1. Workability

The workability of control mix and RHA mixed concrete was measured according to ASTM Standard [13]. At different levels of replacement of RHA, the workability of concrete is illustrated in Fig. 3. It is clearly depicted from the results that the control mix has a lower slump value as compared to RHA concrete blends. The slump value of C82R18 mix is about 72 mm. The coefficient of variation is 5.66%.

3.2. Compressive strength

The uniaxial compressive test results are depicted in Fig. 4. It is observed that the compressive strengths were increased for all mixes at curing age of 7 and 28 days. The trend is similar to that of control mix. The maximum compressive strength achieved by C94R6 mix at 7 and 28 days is about 10.2 and

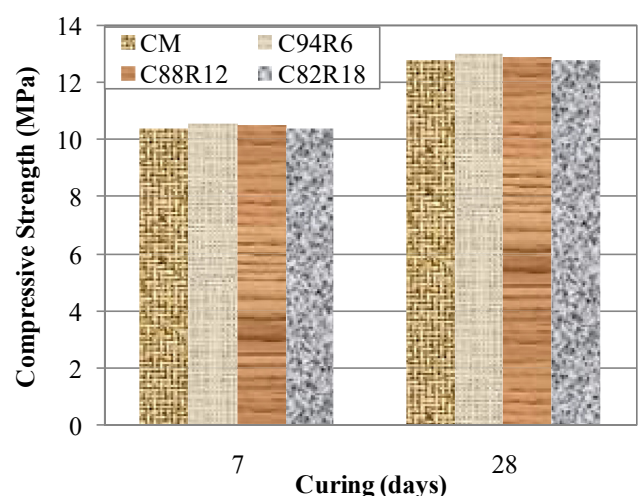


Fig. 4. Compressive strength results

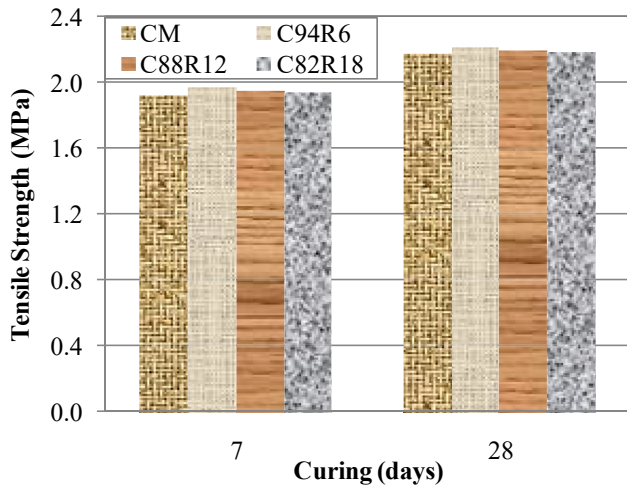


Fig. 5. Splitting tensile strength

13 MPa respectively. The coefficient of variation is 0.91 and 0.74% for 7 and 28 days respectively.

3.3. Splitting tensile strength

It can be seen in Fig. 5 that the splitting tensile strength is improved as similar to CM for all mixes at age of 7 and 28 days. The trend of increase in splitting strength with the replacement of RHA is comparable in behavior to compressive strength. The maximum splitting tensile strength achieved by C94R6 mix at 7 and 28 days is about 1.9 and 2.3 MPa respectively. The coefficient of variation is 1.07 and 0.78% for 7 and 28 days respectively.

3.4. Flexural strength

The flexural test results are shown in Fig. 6. The three-point loading test [16] was performed to find out the modulus rupture of the concrete. The maximum flexural strength is shown by C94R6 blend. The trend is similar to tensile and

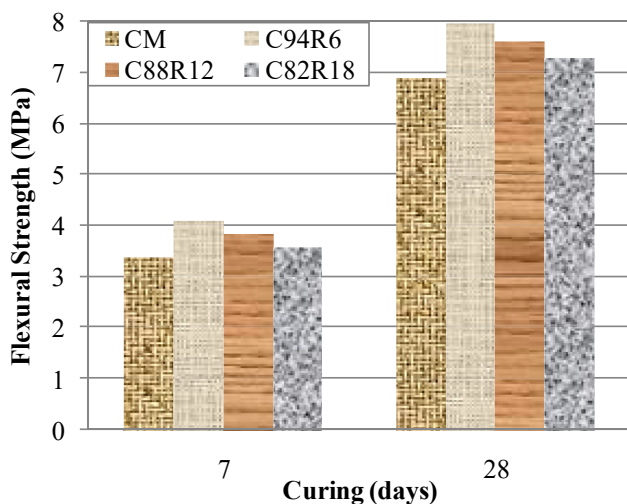


Fig. 6. Flexural strength

compressive strength results. The maximum flexural strength achieved by C94R6 mix at 7 and 28 days is about 4 and 8 MPa respectively. The coefficient of variation is 8.47 and 6.13% for 7 and 28 days respectively.

4. CONCLUSIONS

The workability, compressive, tensile and flexural properties of concrete were investigated using RHA. Following results are deduced from the experiments:

- Slump value of concrete shows increasing trend with the increase in replacement level of rice husk ash. The maximum slump value is observed for C82R18 mix;
- The variation in compressive strength of mix with replacement percentage of RHA upto 18% and that of control specimen is negligible;
- The variation in splitting strength of mix with replacement percentage of 18% and that of control specimen is negligible. The trend is similar to that of uniaxial compressive behavior;
- The variation in flexural strength of control specimen and mix with replacement percentage of RHA upto 18% is observed. Highest flexural strength of concrete is achieved with 6% replacement of RHA. The flexural strength of concrete decreased with further increase in RHA percentage, i.e., >6%.
- The use of RHA as supplementary cementitious material in concrete, results in an economical and environmental friendly mix.

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