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Evaluation of properties of Self-Compacting Concrete specimenshaving Rice Husk Ash and Shell Lime Powderas fillers

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Abstract: - *Self-CompactingConcrete (SCC) isthe one thatcanbeplaced in the form and compactedunderitsownweightwithlittle or no vibration effectwithsuitable bond to behandledwithoutsegregation or bleeding. The highlyfluid nature of SCC makesitsuitable for placing in difficult conditions and in sections withcongestedreinforcement.SCCusuallyrequireshighpowder content and lesscoarseaggregates. This studyhighlights the initial results of a researchprojectaimedatproducing and comparing SCCincorporatingRiceHuskAsh (RHA) and Shell Lime Powder (SL), bothlocallyavailablemineraladmixtures,as an additionalcementingmaterial, in terms of itspropertieslike Compressive strength, Split Tensilestrength and FlexuralStrength. The freshSCCsweretested for fillingability (Slump flow), passing ability (L box) and segregationresistance.*

Keywords: - *Self-Compacting Concrete, Rice Husk Ash, Shell Lime Powder, Split Tensile strength, Compressive strength, Flexural Strength, Locally available mineral admixtures, Modified Nan Su method*

I. INTRODUCTION

Self-Compacting Concrete (SCC) was developed in Japan during the later part of the 1980s to be mainly used for highly congested reinforced structures in seismic regions. The main characteristics of SCC are the properties in the fresh state. The mix design is focused on the ability to flow under its own weight without vibration, the ability to flow through heavily congested reinforcement, and the ability to retain homogeneity without any segregation.

SCC consists of the same materials as of the conventional concrete, i.e., cement, fine aggregates, coarse aggregates, and water. But it also contains additional materials of chemical and mineral admixtures. SCC contains less coarse aggregates so as to minimize the blockage of passing through spaces between steel bars. This results in higher cement content which is expensive and causes temperature rise due to heat of hydration. Therefore, cement should be replaced by high volume of mineral admixture like Rice Husk Ash and Shell Lime Powder.

Rice husk ash (RHA)has been used as a highly reactive pozzolanic material to improve the microstructure of the interfacial transition zone between the cement paste and the aggregate in SCC. Research shows that the utilization of rice husk ash in SCC mix produced desired results, reduced cost, and also provided an environment friendly disposal of the otherwise agro-industry waste product [1].

Before cement was developed, lime was used asbinding material in the casting of lime concrete. This was obtained from naturally occurring lime stone deposits in the earth's crust. The naturally occurring resource is depleting fast and hence for sustainable development it needs to be conserved. Naturally occurring mollusks like shell fish in the oceans have protective shells that contain $CaCO_3$ or lime. This resource can be tapped, as an alternative for the limestone deposits [2].

II. EXPERIMENTAL PROCEDURE

2.1 Materials

2.1.1 Cement: Ordinary Portland cement of 43 grade is used in this experiment, Table 1 shows the test results on cement.

Table 1: Test results on cement

Test	Results
Normal Consistency	30%
Specific Gravity	3.15
28-days Compressive Strength (MPa)	45.79
Setting Time (minutes)	
1. Initial	58
2. Final	185

2.1.2 Rice Husk Ash (RHA): Rice husk ash is produced by incinerating the husks of rice paddy at a temperature range of 500° to 800°C. It has 90% to 95% of amorphous silica, which is the reason why it has excellent pozzolanic properties. Specific gravity and normal consistency values are 2.13 and 36% respectively. Rice Husk is available in abundance locally inManipal, the coastal region of Karnataka, India [1].

2.1.3 Shell Lime (SL): Shell Lime powder is obtained by incinerating a combination of shell lime and coal in a furnace. It blends in the mix easily and forms a very good cohesive mix and also acts as a good viscosity modifier for fresh concrete paste. It is obtained from naturally occurringmollusks like shell fish in the oceans which have protective shells that contain $CaCO_3$. Specific gravity and normal consistency values are 3.09 and 49% respectively. Shell Lime is also locally available in abundance [2].

2.1.4 Aggregates: Gravels were used as coarse aggregates of uniform quality with respect to shape and grading having 12mm downsize. River bed sand of size less than 125 micron were used as fine aggregate [3], Table 2 shows the test results on aggregates.

Table 2: Test results on aggregates

Property	Results	
	Coarse Aggregate	**Fine Aggregate**
Bulk density (kg/m^3)	1402	1502
Specific Gravity	2.64	2.63

2.1.5 Super plasticizer (SP): It is a chemical compound used for increasing the workability of concrete mix without adding additional water. Cera Hyper plasticizer HRW 40 was used in the experiment.

2.1.6 Water: Water should be potable and free from alkalinity.

2.2 Mix Proportioning

The mixture proportion is one of the important aspects in SCC. So far the proper mix design procedure to get the proportion of all the ingredients in the SCC is not standardized. No method specifies the grade of concrete in SCC except the Nan Su method. The limitation of Nan Su method is, that it gives the required mix proportions for the grades which are not less than M50, this was observed during experimental work on normal grade of concrete in SCC (grade less than M50). An attempt has been made to modify the Nan Su method and obtain a mix design in normal grades with two admixtures (Rice Husk Ash & Shell Lime Powder). With all the two mineral admixtures incorporated, the compressive strength and flow properties of the SCC were studied [4], Table 3 shows the contents of all materials used in kg/m^3.

Table 3: Mix proportion in kg/m^3 of SCC.

Mix	Cement	RHA	SL	Coarse aggregate	Fine aggregate	Water	SP
SL based SCC	360.71	-	147.24	744	961	221.77	9.14
RHA based SCC	360.71	111.2	-	744	961	190.04	8.49

2.3 Tests Conducted

2.3.1 Fresh concrete tests: Rheological properties of the fresh concrete mixes were tested using theSlump flow apparatus, V-funnel, L- box and U-box, as per the EFNARC guidelines [5].

Slump flow test is done to assess the horizontal flow of concrete in the absence of obstructions. This also indicates the resistance to segregation. The higher the flow value, the greater is the ability to fill formwork under its own weight.

V-funnel test is conducted to determine the filling ability (flowability) of the concrete with a maximum size of aggregate being 20mm.

L-box test assesses the flow of concrete and also the extent to which the concrete is subjected to blocking by reinforcement.

U-box test is used to measure the filling ability of SCC.

Table 4 shows the rheological properties of the mixes, against the acceptance criteria of the tests as laid down by EFNARC [5].

The SCC mixes prepared were tested for filling ability (Slump flow and V-funnel) and passing ability (L-box and U-box). The test results satisfied the criteria laid down by EFNARC as seen from Table 4.

Table 4: SCC Acceptance Criteria& Rheological Properties of the mixes

Test	Unit	Acceptable Range of values	RHA based SCC	SL based SCC	Remarks
Slump flow	mm	650-800	710	670	Acceptable
V-funnel	sec	6-12	6.2	6.1	Acceptable
L-box	h_2/h_1	0.8-1.0	0.92	0.89	Acceptable
U-box (h_2-h_1)	mm	0-30	16	23	Acceptable

2.3.2 Hardened concrete tests:Compressive strength (cube size: 150mm side), Split Tensile strength (cylinder size: length 300mm and diameter 150mm), and Flexural strength (prism size: 100x100x500mm) were the tests included for both SCC mixes for a period of 7, 14, and 28 days of curing. The tests were carried out as per the relevant IS Codes [6, 7]. Table 5 shows the hardened concrete test results. Fig. 1 through Fig. 3 show the strength relation between SL based SCC and RHA based SCC in graphical form.

III. RESULTS AND DISCUSSIONS

Table 5: Test results on hardened SCC mixes

Strength (MPa)	Age in Days	SL based SCC	RHA based SCC
Compressive Strength	7	12.25	21.27
	14	20.06	28.34
	28	28.78	30.52
Split Tensile Strength	7	1.944	1.568
	14	1.89	1.797
	28	2.51	2.53
FlexuralStrength	7	1.48	3.92
	14	4.16	4.28
	28	4.87	4.31

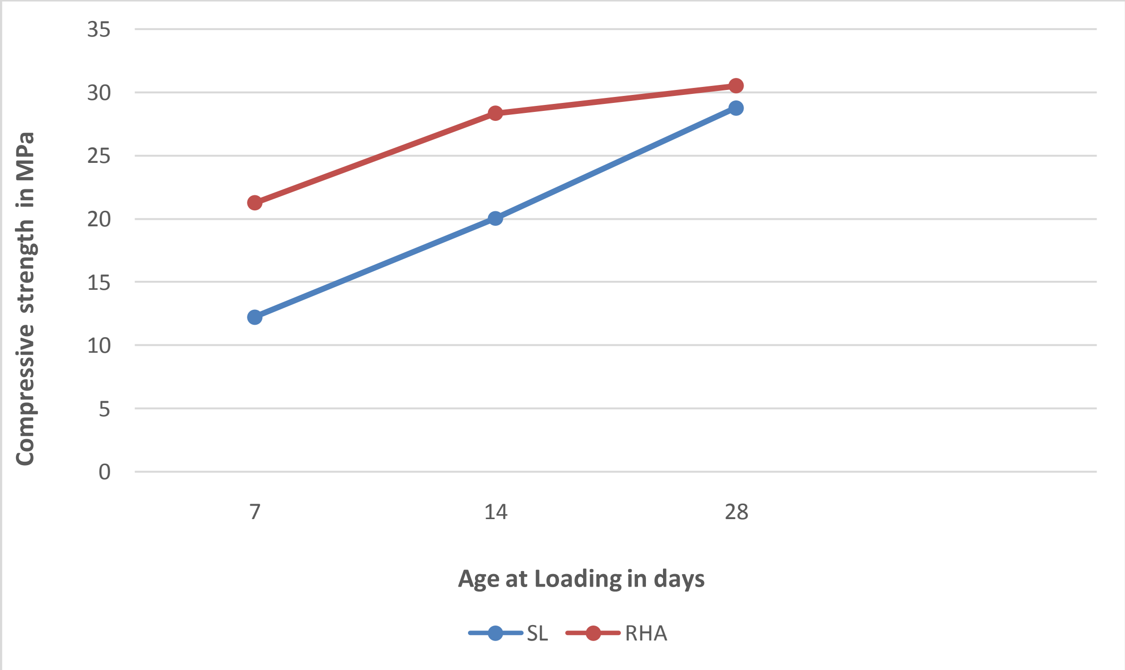

Fig.1. Compressive Strength v/s Age at loading

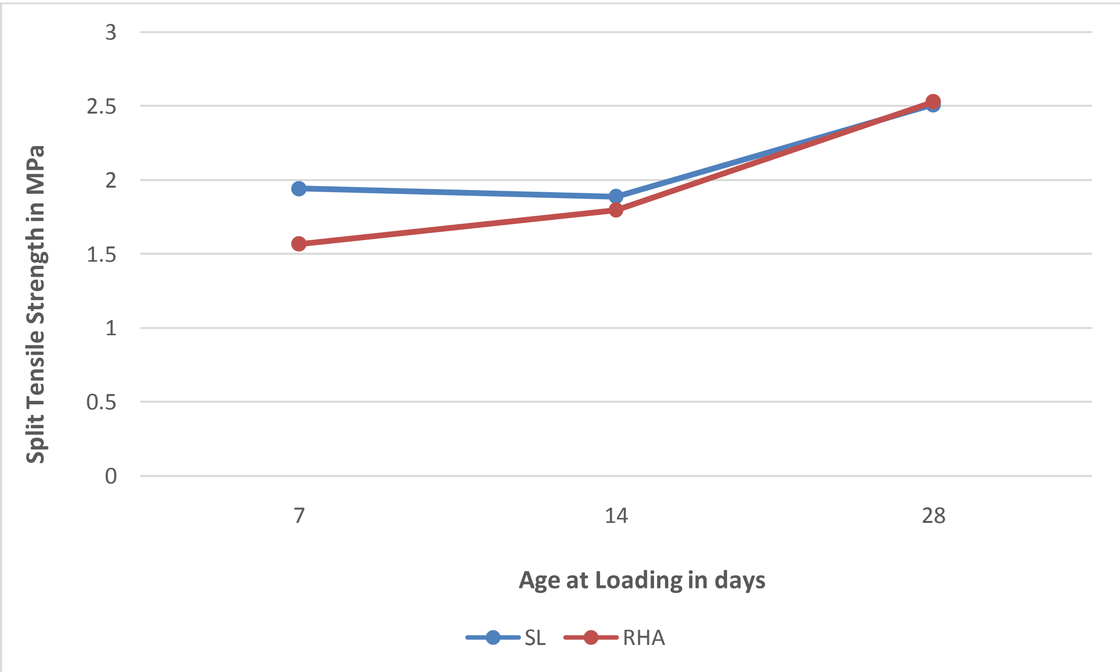

Fig.2. Split Tensile Strength v/s Age at loading

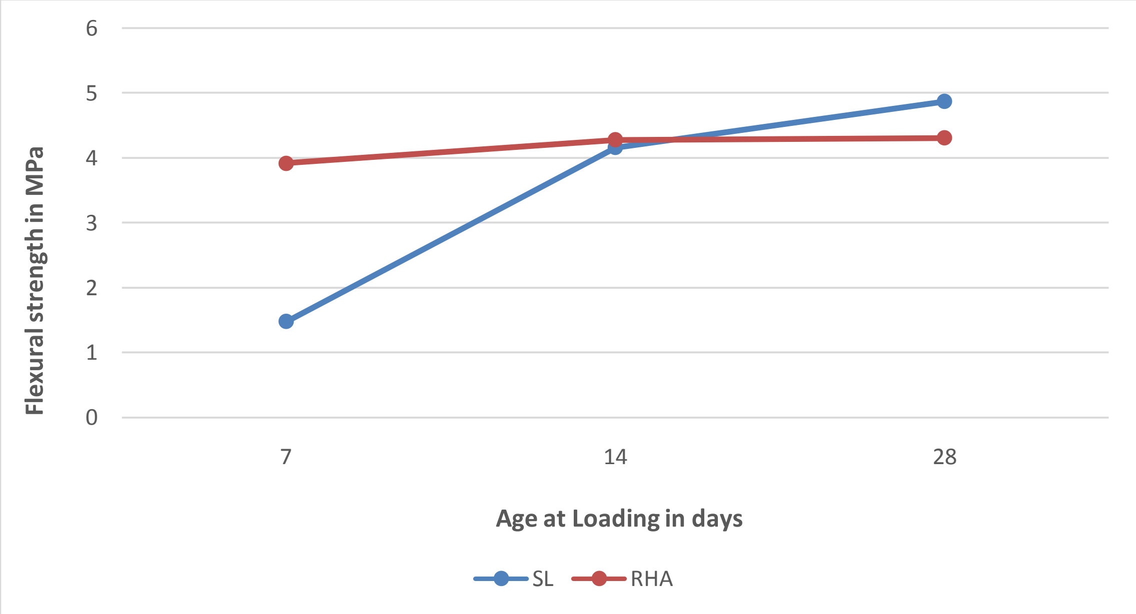

Fig.3. Flexural Strength v/s Age at loading

Compressive strength of RHA when compared to SL gave a higher strength by 73.6% for 7 days of curing. For 14 days of curing, the strength of RHA was 41.27% higher than that of SL. For 28 days of curing, the strength of RHA was 6.04% higher than that of SL.
Split Tensile strength of SL when compared to RHA gave a higher strength by 23.98% for 7 days of curing. For 14 days of curing, the strength of SL was 5.2% higher than that of RHA. For 28 days of curing, the strength of RHA was 0.8% higher than that of SL.
Flexural strength of RHA when compared to SL gave a higher strength by 164.8% for 7 days of curing. For 14 days of curing, the strength of SL was 2.88% higher than that of RHA. For 28 days of curing, the strength of SL was 13% higher than that of RHA.

IV. CONCLUSION

Based on EFNARC criteria for SCC, fresh and hardened concrete tests were conducted on both the specimens and satisfactory results were obtained. The Compressive strength of curing period of 28 days was found to be 6.04% higher in RHA when compared toSL.Split Tensile strength of RHA when compared to SL was higher by 0.8% for 28 days curing. Flexural strength though was higher by 13% in SL when compared to RHA for 28 days curing; it was observed that RHA had a much better strength when compared to that of SL as a whole.
Since RHA contains silica contents and SL contains calcite contents, the silica contents react better with cement compared to that of calcite contents, as cement contains lime, which in turn consist of calcite contents. Thus, this probably explains the higher strength in RHA when compared to SL.

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