Self-Compacting Concrete Cement is Partially Replaced by Rice Husk Ash for M60 Grade Concrete Beams

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Abstract- We investigated experimental behavior of self-compacting concrete(SCC) with rice husk ash (RHA) as partial replacement of cement, due to the high increase in construction which has brought a heavy demand for ingredients of concrete such as cement and sand, and this materials are costly and scarce. The cost of cement is also steadily increasing with ever-increasing environmental problems because of industrial waste product comes a great needs to use these products in a appropriate manner to reduce health and environmental problems. RHA is a waste material its used in the production of concrete may prove to be advantageous in an agriculture driven economy like India.

Rice husk ash has been used as a highly reactive pozzolonic material to improve the microstructure of the interfacial transition zone(ITZ) with in the cement paste and aggregates in self-compacting concrete. Mechanical experiment of rice husk ash blended Portland cement concretes reveal that in addition to the poozolonic reactivity of RHA, the particle grading of cement and rice husk ash mixtures also exerted significant influences on the blending efficiency.

The basic objective of the research is to understand the rheological and strength characteristics of the self-compaction mixes with different composition of rice husk ash. Different replacement % of rice husk ash with cement and different water simultaneous material ratio are determined for both normal concrete beams and self-compacting concrete beams.

1. INTRODUCTION

1.1 Self Compacting Concrete:

Self-Compacting Concrete (SCC) was developed in Japan during the latter part of the 1980's to be mainly used for highly congested reinforced structures in seismic regions. Recently, this concrete has gained wide use in many countries for different applications and structural configurations. The use of SCC has many advantages, such ash reducing the construction time and labor cost, eliminating the need for vibration, reducing the noise pollution, and also improving the filling capacity of highly congested structural members. SCC consists of the same components as conventionally vibrated concrete, which are cement, aggregates and water, with the addition of chemical and mineral admixtures in different proportions.

The first point to be considered when designing SCC is to restrict the volume of the coarse aggregate so as to avoid the possibility of blockage on passing through spaces between steel bars. This reduction necessitates the use of a higher volume of cement which increases the cost besides resulting in temperature rise. So cement should be replaced by high volume of mineral admixture like fly ash or rice husk ash.

1.2 Lightweight concrete (LWC):

LWC generally has a density of less than 2000 kg/m3 and compressive strength of more than 20 MPa. it is known as structural LWC. The challenge in making LWC is in decreasing the density while maintaining strength and without adversely affecting cost. Introducing different types of lighter aggregates into the matrix is a common way to lower a concrete's density. The crushed stone and sand are the components that are usually replaced with lightweight aggregate (LWA) to produce LWC. LWC has been used as a building material for many decades throughout e (LWA) to produce LWC.

LWC has been used as a building material for many decades throughout the world. It has gained its popularity due to its lower density and Superior thermal insulation properties. Structural LWC offers design flexibility and substantial cost savings by providing less dead load, improved seismic structural response, lower foundation costs etc…..

1.3 Scope of the work:

The aim of this study is to assess the utility and efficacy of RHA as a cement as an alternative to natural aggregate in concrete. RHA has not been tried as cement in structural concrete. The properties of RHA have to be known before it can be used as a cement in concrete. This research focuses on properties of RHA first, and then as a structural material.

2. Materials

2.1 Cement:

Ordinary Portland cement of C53 grade conforming to both the requirements of IS: 12269 and ASTM C 642-82 type-I was used. We are conducting different types of tests on cement, those are Normal Consistency, Initial and Final setting times, Compressive strength of cement, Specific Gravity and Fineness of cement. From the test results obtained the conventional concrete can be designed according to IS10262-82(MIX DESIGN CODE). Finally M30 Grade concrete is designed.

2.2 Coarse Aggregate

Normal aggregate that is crushed blue granite of maximum size 20 mm was used as coarse aggregate. We are conducting tests on coarse aggregate are Water Absorption Capacity, Specific Gravity and Fineness Modulus of coarse aggregate.

2.3 Fine Aggregate

Well graded river sand passing through 4.75 mm was used as fine aggregate. The sand was air-dried and sieved to remove any foreign particles prior to mixing. We are conducting tests on fine aggregate are Water Absorption Capacity, Specific Gravity and Fineness Modulus of fine aggregate

2.4 Rice Husk Ash

The husk was collected from paddy field in Kuala Selangor, Malaysia, it was then burned in the laboratory by using a ferro-cement furnace[8]. This furnace (Figure 1) can hold up to 60 kg of rice husks; it has three small openings through which fire is ignited. They too allow ventilation. A fire source was maintained under the furnace for around 10 minutes, after which the husks slowly burned for more than one day. The ash was left inside the furnace to cool down before it was collected.

Rice husk ash, obtained by burning rice husk in the controlled manner without causing environmental pollution. When properly burnt with ash sio_2 content and can be used as a admixture. Rice husk ash exhibits high pozzolonic characteristics and contributes to high strength and high impermeability of concrete. Rice husk ash essentially consist of amorphous silica (90%), 5% carbon, and 2% K_2O. the specific surface of RHA is between 40-100 m^2/g.

2.5 Super Plasticizer:

The super plasticizer used in conplast SP 430, manufactured by FOSROC, india. conplast SP 430 is based on sulphonated Naphthalene polymers and is supplied as a brown liquid instantly dispersible in water. It gives water reductions up to 25% without loss of workability to produce high quality concrete of reduced permeability.

2.1 Table shows Properties of Materials:

PROPERTIES OF MATERIALS	RESULTS
Normal consistency of cement	31%
Initial setting time Final setting time	33 minutes 635 min
Compressive Strength of cement 3 days 7 days 28 days	 27.2 38.36 54.46
Specific Gravity of cement	3.15
Fineness of cement	10%
Specific Gravity C.A F.A	 2.65 2.6
Fineness modulus C.A F A	 6.2 2.72
Normal consistency of RHA	27.86%
Specific gravity of RHA	2.18

3.1 Table showing that different quantities of concrete Mixes

TRAIL NO	CEMENT (KG)	WATER (LT)	W/C RATIO	F.A(KG)	C.A (KG)	MIX PROPORTION
1.	423	197	0.28	601.8	786.7	1: 1.63:2.19
2.	423.6	197	0.28	642.8	792.2	1: 1.42: 2
3.	419	197	0.28	590.5	810.6	1: 1.46:2.1
4.	420	193	0.28	733.5	904.5	1:1.51: 1.93

3.1 Testing SCC in Fresh State:

Once a satisfactory mix is arrived at, it is tested in the lab for properties like flowing ability, passing ability high resistance to segregation, Appropriate plastic viscosity and sufficient deformability. The characteristics are fully described by the following properties.

Filling Ability :Ability to completely fill all the spaces.

Passing Ability :Ability to flow through tight places and around reinforcement.

Segregation resistance :Ability for SCC to remain homogeneous during transportation & placing

The following tests were conducted in the laboratory on fresh SCC to find filling ability , passing ability , segregation resistance. The prescribed limits of the tests are

3.2 Slump Flow Test & T 50 CM Test

The slump flow test is used to assess the horizontal free flow of SCC in the absence of obstructions, and it Vindicatesthe resistance to segregation, and filling ability of concrete. On lifting the slump cone filled with concrete the average diameter of spread of the concrete is measured. Also T50 time is taken in seconds from the instant the cone is lifted to the instant when the horizontal diameter of the flowreaches 500mm.

Fig.No3.1 Slump Flow Test

3.3 V. Funnel T 5 Min Test

The flow ability of the fresh concrete can be tested with the V-funnel test, whereby the flow time is measured. The funnel is filled with about 12 litres of concrete and the time taken for it to flow through the apparatus is measured. Shorter flow time indicates greater flow ability.

Fig.No3.2 V-Funnel Apparatus

3.4 L-Box Test:

L-box test assesses filling and passing ability of SCC, and serious lack of stability (segregation) can be detected visually. The vertical section of the L-

Box is filled with concrete, and then the gate is lifted to let the concrete flow into the horizontal section. Blocking ratio, i.e. ratio of the height of the concrete at the end of the horizontal section (H2) to height of concrete at beginning of horizontal section (H1) is determined.

Fig.No3.3 L-box apparatus

3.5 U-Box Test:

U-box test is used to measure the filling and passing ability of SCC. The apparatus consists of a U shape vessel that is divided by a middle wall into two compartments. The U-box test indicates the degree of compactability in terms of filling height i.e. H1-H2, the difference of height of concrete attained in the two compartments of U-box.

Fig.No3.3 U-box apparatus

3.5 Compressive Strength Test:

The compression test is simply the opposite of the tension test with respect to the direction of loading. In some materials such as brittle and fibrous ones, the tensile strength is considerably different from compressive strength. Therefore, it is necessary to test them under tension and compression separately. Compression tests results in mechanical properties that include the compressive yield strength, compressive ultimate strength, and compressive modulus of elasticity in compression, % reduction in length etc. The compressive loading tests on concretes were conducted on a compression testing machine of capacity 2000 kN. For the compressive strength test, a loading rate of 2.5 kN/s was applied as per IS: 516–1959. The test was conducted on 150mm cube specimens at 3, 7 and 28 days. Each sample was weighed before putting into the crushing machine to ascertain it density. The compression strength of each sample was determined as follows

$$\text{Compressive strength} = \frac{\text{Crushing Load (kN)}}{\text{Effective Area (mm}^2\text{)}}$$

Fig no: 3.4 compression testing machine

3.6 Split Tensile Strength Test:

The test is carried out by using the cube specimens. The cube specimens were placed with the cast faces at right angles to that as cast in the compression testing machines. In order to apply the magnitude of high compressive stress near the point of application of load,2 narrow packing wooden sticks of 200mm long was used. So exactly at center of the cube the splitting takes place. According to standard specifications the load on the specimens was applied at constant rate up to the failure of the specimen and the ultimate loads are noted. Split tensile strength for all the specimens tested and results were noted.

Fig no: **3.5 Split tensile testing machine**

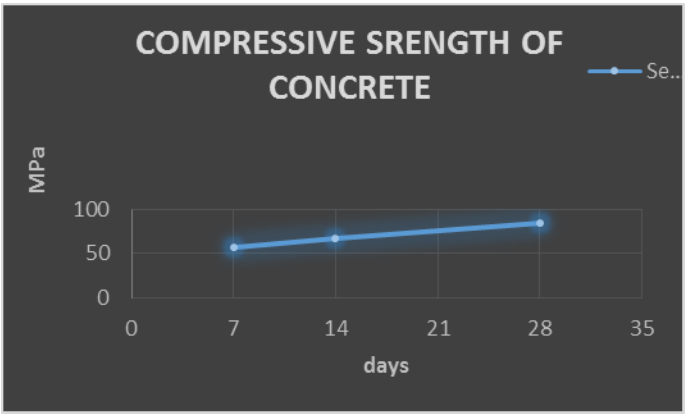
4. Results and Discussions:

Table -4.1.The results of slump flow, L-Box, U-Box, V-funnel tests are given

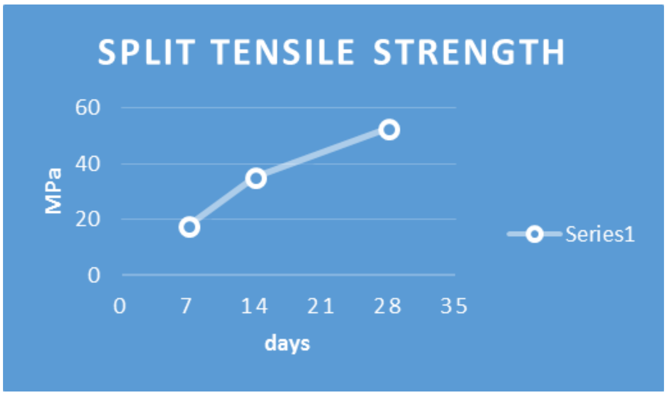
TEST	UNIT	RANGE	RHA(SCC)	REMARKS
SLUMP FLOW	mm	650-800	710	ACCEPT
T50 SLUMP FLOW		2—5	2.5	ACCEPT
L-BOX (H2/H1)	sec	0.8-1.0	2.5	ACCEPT
U-BOX(H1-H2)	mm	0-30	21	ACCEPT
V-FUNNEL	sec	6—12	9	ACCEPT

4.1 Hardened Concrete Test Results: Table No:4.2 Compression ,split tensile and flexural strength of concrete

STRENGTH (Mpa)	(DAYS)	RHA BASED SCC
COMPRESSIVE STRENGTH	7	56.46
	14	67.65
	28	84.23
SPLIT TENSILE STRENGTH	7	17.54
	14	35.08
	28	52.62



Graph No.4.1 The variation in Compressive Strength with Age at loading



Graph No 4.2 the variation in Split Tensie Strength with age at loading

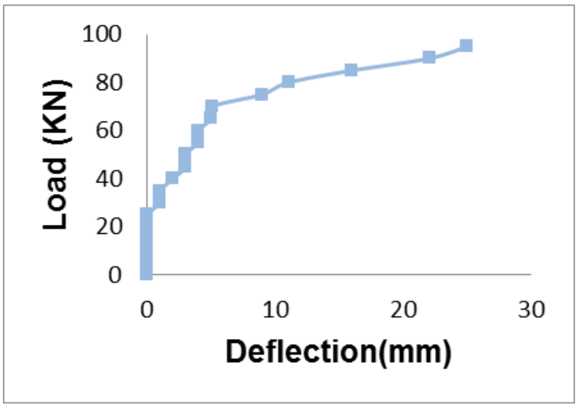
4.2 Cracking:

In general, a high degree of variability was exhibited by the specimens tested. The location of the crack had a large effect on the cracking load and the post-cracked peak load. The closer the crack was to the mid-span of the specimen, the higher the cracking and peak loads in the bending condition. Representative crack patterns for the specimens tested are presented in Figure. As expected, the plain concrete test set CNBM exhibited brittle behavior, failing immediately after the prism cracked. As with the dogbanes, the addition of RHA to the mix controlled the abrupt opening of the failure crack. In all cases, the RHA replaced concrete specimens exhibited an ability to carry residual flexural loads after first cracking and the load- carrying capacity decreased steadily and gradually as the crack continued to open. The load-deflection curves for the test sets are presented in Figure.

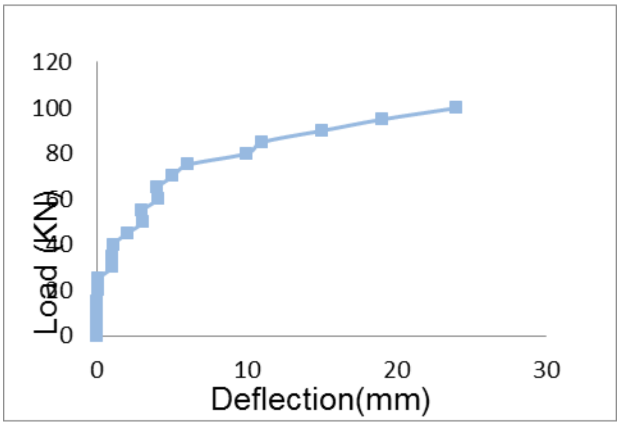
Fig-3.6 CNBM Beam Crackings.

4.3 Load-Deflection Behaviour of Beams

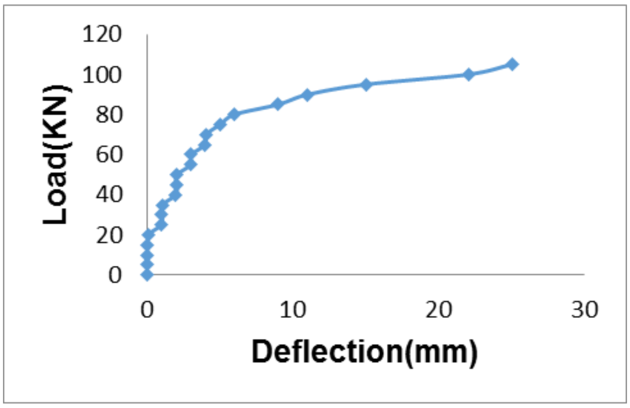
Curve of the load-deflection relation at mid points of each beam are shown in Figure. These figures shows the comparison of HSC beams with steel – polyolefin combine, with 80% -20% at each volume fraction and plain concrete beam. With the addition of Rice husk ASH , HSC beam show a steeper slope in the ascending part of the load-deflection curve, which means the HYFRC beam possess higher shear strength. Compared to the ascending part of the load, deflection curve of RHASCC beams are steeper than that of normal plain HSC beams.



Graph.No.3.2: Load-Deflection behaviour of high strength normal reinforced concrete beam.



Graph.No.3.2 (a): Load-Deflection behaviour of high strength self-compacting concrete beams at 15% rice husk ash volume.



Graph.No.3.2 (b) Load-Deflection behaviour of high strength self-compacting concrete beams at 20% rice husk ash volume.

4.4 Effect on Deflections

The deflections at ultimate load and at yield loadare presented in below Table. The deformation characteristics of high-strength concrete beams improved significantly with the addition of RHA. The deflection increased with increase in loads. These influences were more pronounced for SCCB beams and larger deflections occur after yield stage and before failure. From Figs, it is observed that the SCC with RHA beams exhibit increase in deflection with increase of RHA content at ultimate load when compared to reference beam.

Table-4.3 Experimental data of test beams.

BEAM	Yield point			Ultimate point		
	Yield load	deflection	Crack width(mm)	Ultimate load	deflection	Crack width(mm)
CNBM	70	5.079	5.98	90	25.002	6.12
SCCB-1	75	6.028	4.25	100	24.05	4.69
SCCB-2	80	6.01	4.42	105	22.086	4.82

5. Conclusion:

- The SCC mixes containing rice husk ash as filler materials were tested for their fresh properties as per EFNARC guidelines.
- Both SCC mixes have satisfied all the acceptance criteria laid down by EFNARC.
- The hardened properties like compressive strength, split tensile strength and flexural strength were checked and found that not all the test results were satisfactory.
- But comparative study of the test result shows that SCC containing RHA has better compressive strength, split tensile strength and flexural strength.

- it is observed that the SCC with RHA beams exhibit increase in deflection with increase of RHA content at ultimate load when compared to reference beam.
- Past research has shown that the optimum level of cement replacement with RHA for normal concrete is30%.
- The low strength of rice husk ash based SCC may be due to the high amount of rice husk ash (62.35% of total powder).
- It is also observed from the results that the calculated cement content (200kg/m3) as per the Nan Su et al. method was not adequate to give the required strength to the mix.
- The quantity of cement content calculated was possibly not sufficient to bind all the ingredients in the mix. As a consequence, more trials with higher percentage of cement are required to attain the target strength.

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