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Flexural Behavior of Hybrid Fibre Reinforced Self Compacting Concrete Incorporating Rice Husk Ash

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Abstract: *Now a day's usage of cement is increasing day by day which has to be reduced since production of cement emits approximately equal quantity of co2. For environmental purpose it is our responsibility to find a supplement for cement. The material such as silica fume, ggbs, fly ash, rice husk ash etc can used as a supplement for cement. Rice husk ash is a waste product which is obtained from the burning of rice husk. It has been employed as an additive in many materials, including refractory brick, light weight concrete. The ash which produced under certain temperature consist of ninety percent silica and five percent alumina It's highly porous, light weight and has a high specific area. It contains 90% of amorphous silica and 5% alumina which make its highly pozzolanic. Use of rice husk ash improves the durability of concrete, economical and eco-friendly. And also addition of fibers in concrete which increases the duration of generating initial crack and reduces the initial shrinkage. The main aim of the project is with addition of steel fiber as 0.75% and polypropylene as 0.25% incorporating rice husk ash as a partial replacement for cement in varying percentages up to 30% with increment of 5%. The main objective is to study the flexural behavior of hybrid fiber reinforced self-compacting concrete incorporating rice husk ash.*

Keywords*- hybrid fibre, flexural behaviour, Rice husk ash, SCC.*

I. INTRODUCTION

Rice husk ash (RHA) is an agricultural waste obtained from burning of the husk under controlled temperature. The process produces about 25% ash containing 85% to 90% amorphous silica plus about 5% alumina, which makes it highly pozzolanic. There is an increasing importance to preserve the environment in the present day world. Their utilization not only improves properties and durability of concrete, but also makes it cost effective and environment-friendly. Due to the pozzolanic reactivity, rice husk ash (RHA) is used as supplementary cementing material in mortar and concrete and has demonstrated significant influence in improving the mechanical and durability properties of mortar and concrete. Proper consumption of these RHA contributes in solving environmental pollution and production of cost-effective concrete it can also play a vital role for the production of sustainable concrete. About self-compacting concrete it is easily placed in thin-walled elements or elements with limited access it results in high-performance concrete its ease of placement can result in cost savings through reduced equipment and labor requirements. The increased flow ability and consolidation of SCC can also improve appearance and enhance the durability of the finished element. Recently the idea of making simultaneous use of different type of fibres with different geometry or material is gaining acceptance. This improves the tensile strength and ductility of the material. When compared to ordinary concrete flexural members, SCC beams exhibited early initial cracking and higher deflection at later stages. Steel fibres as additional reinforcement in beams allows substantial increase in flexural and shear strength and ductility. The hybrid fibres of steel and polypropylene used is stronger and stiffer. It improves first crack stress and ultimate strength. Steel fibre which is more flexible and ductile leads to improved toughness and strain capacity in post cracking zone. Also the onset of cracking is delayed and fibre addition allows multiple cracking with lesser crack widths. Thus my project aims at producing Sustainable, Green, Self Compacting Concrete with better Crack Resistance and Deflection Properties employing the combined advantages of SCC, RHA and HFRC.

II. EXPERIMENTAL INVESTIGATIONS:

2.1 MATERIAL PROPERTIES:

The material properties for preparation of concrete are cement, fine aggregate, coarse aggregate, rice husk ash, super plasticizer, hybrid fiber is explained below.

Cement:

Ordinary Portland cement 53 grade cement is used confirming to various specifications as perIS 4031-1998. Results showed that specific gravity is 3.15 and standard consistency is 32.

Fine aggregate:

River sand confirming to IS 4031-1998. Results showed that the specific gravity is 2.6, fineness modulus 3.07 which is confirms to grading zone II.

Coarse aggregate:

Crushed coarse aggregate of 10mm down size is used which is confirming to IS 4031-1998. Results showed that specific gravity 2.7, fineness modulus 7.30.

Reinforcing steel

HYSD (Fe 415) bars conforming to IS 1786:2008 specifications was used to cast the test specimen.8 mm and 10mm dia rods are used as top and bottom reinforcement and 6mm stirrups rod respectively.

Super plasticizer:

Master glenium sky 8650 is an admixture of new generation based on modify polycarboxylic ether. The product has been primarily developed for application in high performance concrete where the highest durability and performance is required. Master glenium sky 8650 is free of chloride and low alkali.

Steel fibre (Novocon-XR):

Steel fibre obtained from jeetmulljaichandlalpvt.ltd Chennai, the shape of fibres are crimpled of length 9mm.

Polypropylene fibre:

An ENDURO 600Polypropylene fiber is obtained from jeetmulljaichandlalpvt.ltd Chennai.

Water: potable water is used.

Rice husk ash (hyper-2000) :

Obtained from Kccontechpvt.ltd Chennai, having specific gravity of 2.06

2.2 DETAILS OF DESIGNED MIXES

The mix proportions of SCC, rice husk ash are replaced in the cement by the way of increasing the percentage of RHA content (0%, 5%, 10%, 15%, 20%, 25% and 30%).

The variation for specimen details are tabulated and explained below.

Table 1: Details of specimen

Specimen	Replacement of RHA
T1	5%
T2	10%
T3	15%
T4	20%
T5	25%
T6	30%

Table 2: Trial mix proportion

Mix	Cement Kg/m^3	Rice husk ash Kg/m^3	F.A Kg/m^3	C.A Kg/m^3	Water lit/m^3	SP Kg/m^3	Steel fiber (g)	Pp fiber (g)
T1	522.5	27.5	785	735	290.9	3.85	600	10.125
T2	495	55	785	735	290.9	4.5	600	10.125
T3	467..5	82.5	785	735	290.9	4.95	600	10.125
T4	440	110	785	735	290.9	5.5	600	10.125
T5	412.5	137.5	785	735	290.9	6.05	600	10.125
T6	385	165	785	735	290.9	6.6	600	10.125

III. EXPERIMENTAL PROCEDURES:

3.1 Mix design:

Mix proportion for SCC is obtained and the ratio is 1:1.427:1.33 with water cement ratio of 0.45. Indian standard method is used for study of mix design. The design involves in the calculation of amount of cement, fine aggregate, coarse aggregate and other related parameters dependent on the properties of constituent material.

3.2 Batching, mixing:

Batching, mixing and casting operations were done carefully. The mixture of concrete was prepared by hand mixing on a water tight platform. The coarse and fine aggregate were weighed first and cement added with needed quantity of rice husk ash. After that steel and polypropylene were added and mixed thoroughly. During mixing fiber is added by sprinkling for proper mix. The moulds were filled with concrete. The top surfaces of the specimen was leveled and finished. After 24 hours the specimens were demoulded and transferred to curing tank. They were allowed to cure for 7 & 28 days. The entire specimens were tested in laboratory.

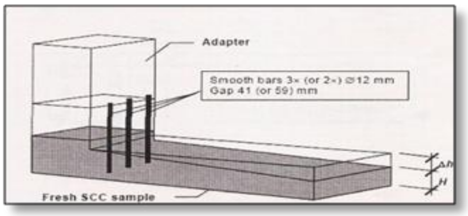
3.2.a Replacement of RHA

3.2.b Addition of hybrid fiber

3.3 Tests carried out for SCC:

3.3.1 L-box test:

Set the apparatus level on firm ground, ensure that the sliding gate can open freely and then close it. Moisten the inside surfaces of the apparatus, remove any surplus water. The concrete is filled on to the vertical leg of L box and allowed to flow into the horizontal leg by opening a lid located at the bottom of the vertical leg. When the concrete stops flowing, the distance H1 and H2 are measured. Calculate H1/H2, the blocking ratio. The whole test has to be performed within 5minutes.

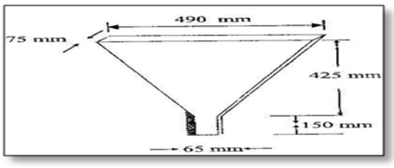


3.3.1. a L-box apparatus

3.3.2. b L-box test

3.3.2 V-funnel test:

Wet the inner surface of the funnel. Keep the trap door open to allow any surplus water to drain. Close the trap door and place a bucket underneath. The concrete is poured into the V-Funnel and completely filled. Fill the apparatus completely with concrete without compacting or tamping; simply strike of the concrete on the top with the trowel. Open within 10sec after filling the trap door and allow the concrete to flow out under gravity. Start the stop watch when the trap door is opened, and record the time for the discharge to complete.

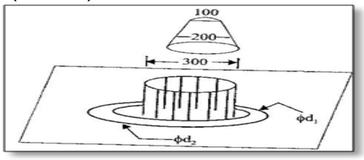


3.3.3.a V-funnel apparatus

3.3.3.b V-funnel test

3.3.3 J-ring test:

Place the base plate and slump cone on a leveled surface after greasing it. . Place the j-ring centrally on the base plate and the slump-cone centrally inside it and hold down firmly. Fill the cone till the top of the cone with the help of trowel. Remove any surplus concrete Raise the cone vertically and allow the concrete to fall in perpendicular directions. Calculate the average of the two measured diameter (In mm).Measure the difference in between the concrete just inside the bars and that just outside the bars. Calculate the average of distance at four locations (In mm).



3.3.4.a J-ring apparatus

3.3.3. b J-ring test

3.4 Casting and curing of specimen:

After finished SCC tests and all the concrete is poured into a mould to cast a specimen. The diagram for casting and curing of specimen is mentioned below.

3.4a Casting of a specimen

3.4b Curing

3.4c Specimen after curing

3.5 Compressive strength test:

The compressive strength of concrete is one of the most important properties of concrete. For compressive strength test the cube specimens of dimensions 150×150×150 mm were casted for M30 grade of self-compacting concrete. After curing these cubes were tested on compression testing machine. The failure load was noted. In each category three cubes were tested and their average value is reported. The compressive strength was calculated as follows,

Compressive strength (MPa) = Failure load / cross sectional area.

IV. PRELIMINARY INVESTIGATIONS FOR SCC

The effect of hybrid fibers on the properties of SCC was studied by adding varying percentage of hybrid fiber totally 1% by volume of concrete 0.9 mm diameter steel fibers with aspect ratio 30 to the designed mixes. The variation in workability due to hybrid fiber addition on M30 mix was tabulated in table 3. The flow ability properties decreased and the hardened properties such as cube compressive strength, strength and increased with addition of fibers. Since the primary objective of fiber addition was improvement in tensile behavior, optimum performance was observed for SCC with 0.75% of steel fiber addition and 0.25% polypropylene addition. The macro fiber addition showed similar improvement for M30 mix.

Table 5 workability test results for M30 grade SCC mix.

Trial mix	Slump flow(mm)	T50 sec	V funnel (sec)	V funnel @ T5min	L box	J ring (mm)
T1	540	8	25	80sec	0.4	18
T2	560	6	20	60sec	0.5	15
T3	585	7	18	50sec	0.5	12.5
T4	650	4	10	12sec	0.7	9
T5	680	2	8	10sec	0.9	8
T6	685	3	10	10sec	0.85	8

V. TEST RESULTS AND DISCUSSION

The compressive strength results for the specimen are tabulated and test images are included as follows.

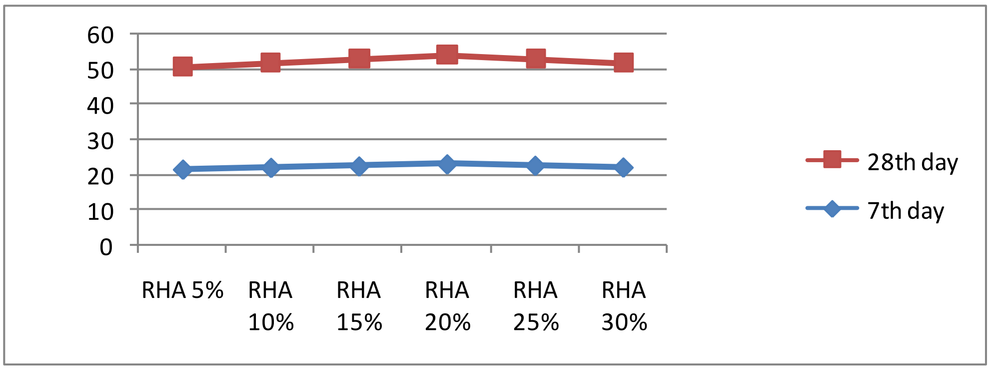
5.a Testing of specimen

5. b Failure of specimen

Table 6 Compressive strength result for 7th and 28th day

Specimen	7th day	28th day
T1	21.4	29.4
T2	21.9	29.9
T3	22.3	30.8
T4	22.9	31.23
T5	22.5	30.7
T6	22	29.96

5.1 GRAPHICAL REPRESENTATION OF 7TH AND 28TH DAY COMPRESSIVE STRENGTH RESULT



5.2 MIX OPTIMIZATION:

From the above results we have optimized mix proportion for casting an element. The mix proportion for casting is tabulated below.

Mix	Cement kg/m3	Fine agg kg/m3	Coarse agg kg/m3	Water lt/m3	Steel fiber grams	Pp fiber grams
T4	550	785	735	2900	600	10.125

VI. DETAILS OF ELEMENT: (BEAM)

The experimental program consists of two types of specimens, namely, CS and HFRSCC-RHA. Specimen CS represented a control specimen, detailed as per IS 13920 recommendation. The test specimen was reduced to 1/5th scale to suit the loading arrangement and test facilities. For experimental model, the dimension of beam was 150 X 180 mm without slab thickness and beam length of 1200mm.

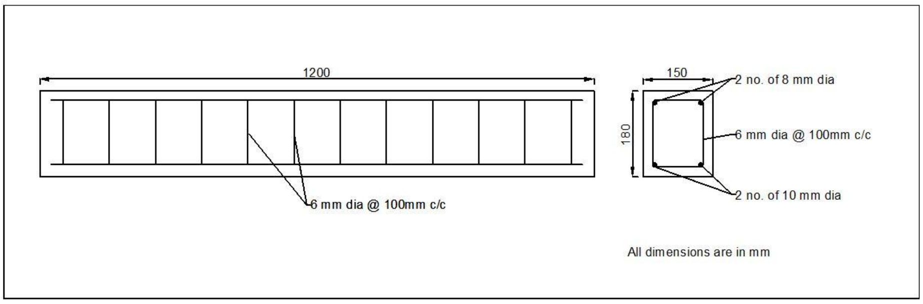
6.1 DETAILS OF SPECIMEN:
RHA-T - Rice husk ash without fiber
RHA-T4 - Rice husk ash with fiber

6.2DESCRIPTION OF THE FORMWORK

To cast the specimens, wooden moulds were fabricated and using 25mm thick plywood sheet made to suit the dimension of the model. The size of the beam was mm 1200mm x 150 mm x 180 mm for specimens.

6.3 REINFORCEMENT DETAILS:

The reinforcement details of beam specimens are shown in figure 4.7.two numbers of 8mm diameter are used for top reinforcement and two numbers of 10mm diameter are used for bottom reinforcement of beam. Shear reinforcement consist of 6mm diameter at 110 mm c/c. The reinforcement detail for the beam is shown below.



6.2a Reinforcement details as per IS13920

6.4 CASTING AND CURING OF BEAM

The mould is arranged properly and placed over a smooth surface. The sides of the mould exposed to concrete were oiled well to prevent the side walls of the mould from absorbing water from concrete and to facilitate easy removal of the specimen. The reinforcement cages were placed in the moulds and cover between cage and form provided was 20 mm. Concrete mixes designed for SCC and water cement ratio is 0.5. Cement mortar block pieces were used as cover blocks. The concrete contents such as cement, sand, aggregate and water were weighed accurately and mixed. The mixing was done till uniform mix was obtained. The concrete was placed into the mould immediately after mixing. The test specimens were de-moulded at the end of 48 hours of casting and marked identifications on the specimen. They are cured in water for 28 days.

6.3a Casted specimen

6.3b Demoulded specimen

6.4a Curing of beam

6.5 TEST SET UP FOR BEAM:

The beam of dimension 1200*150*180 was casted and cured. After that transferring of beam was carried out and kept in a open surface to get dry .two point loading is applied to the beam to find the deflection. The test set up for beam is shown below.

6.5a Test set up for a beam

6.6 TESTING OF BEAM:

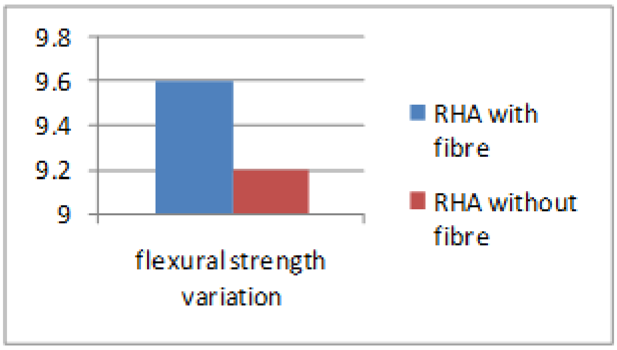
The following images will give clear information in cracking of control specimen with experimental specimen.

6.6a crack pattern

Table 8. Flexural strength results

Specimen details	Initial crack (KN)	Ultimate strength (KN)
RHA-T	90	120
RHA-T4	130	170

6.8 Graphical representation of results



VII. CONCLUSION:

From this study it can be known that SCC has more flexural strength than compared to conventional concrete. By the addition of fibers the formation of initial crack is delayed and strength is more. Water cement ratio is increased by the addition of rice husk ash. The optimum level of replacement of rice husk ash in concrete is 15-20% further addition of RHA decreases the compressive strength**.**

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