

STRUCTURAL PERFORMANCE OF FIBER REINFORCED SELF COMPACTING CONCRETE (SCC) BEAMS WITH OPENINGS

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ABSTRACT - In modern building construction, utility ducts and pipes are accommodated in the space above the false ceiling. There will be high stress concentration around the openings due to the implementation of transverse opening in the web. These results in reduction in beam stiffness. Therefore, while providing large openings, the behaviour of the beam must be properly accounted. Most of the cases the conventional concrete cannot completely fill the congested reinforcement around the opening. Hence Self-compacting concrete (SCC) can be used in these beams, as it can easily fill those congested reinforcement without any vibration. It also prevents the local cracks around openings. The use of fibres extends its possibilities.

The study mainly involves the experimental investigation of compressive strength of cubes to obtain M 30 grade mix. The compressive strength of cubes by varying the percentage of Recron 3s fiber was investigated to obtain the optimum fiber content. The beams were tested by applying point load at one third points under the loading frame, which has a capacity of 50 tons .The first crack load, ultimate load and deflection of the specimens are tested. It was observed that the ultimate capacity was increased up to 11 % for flexure and 10.5% for shear when fiber was added. Also the ductility factor was increased up to 11.58% for flexure and 17.5% for shear when fiber was added.

The main objectives included are to obtain a SCC mix corresponding to M30 grade concrete; to study the flexural and shear behaviour of fiber (Recron 3s) reinforced SCC beams with and without openings.

Key Words: SCC, Recron 3S, ductility ratio, stiffness, stress-concentration.

1. INTRODUCTION

Self compacting concrete (SCC) or self levelling concrete or self consolidating concrete is a mix of a concrete with very low yield stress, good segregation resistance, high deformability and also moderate viscosity. External compaction is not provided for this type of concrete.

SCC is less labour-intensive compared to the conventional concrete mixes and in terms of its setting time and gaining strength it is similar to standard concrete. SCC mix is obtained by limiting the coarse aggregate content and its maximum size and to use lower water-powder ratios together with super plasticizers. The main disadvantages of SCC are its cost, associated with the use of chemical admixtures and use of high volumes of Portland cement. One of the best methods to reduce the cost is the use of mineral additives such as limestone powder, natural pozzolanas, fly ash and slag.

Recron 3 s is a type of polypropylene monofilament short fiber, which is used in concrete for the purpose of control and arrest cracks. This fiber reduces rebound splattering of concrete .also it reduces wastage of mortar and speeds up the space of work. They also have the capacity to increase the tensile strength. Its importance increases when plastering is in progress at higher floors, ceilings and outside surfaces of the buildings. Many researchers have worked on fresh properties of self compacting concrete.

2. MATERIAL CHARACTERISTICS

(a) Cement: In this research Portland Pozzolona cement (ultra tech cement) was used and its properties are shown below in table 1

Table -1: Properties of cement

	Test for	Observed value
Cement	Specific gravity	3.125
	Consistency	33 %
	Initial setting time	45 min
	Final setting time	6 hrs

(b) Fine aggregate: For the present study M sand is used .the sieve analysis of FA has been carried out as per IS 383-1970 and from that it is confirmed to grading zone-1 and its specific gravity is 2.67.

(c) Coarse aggregate: Maximum nominal size of aggregate chosen was 12 mm and other properties are given –

Table -2: Properties of coarse aggregate

Coarse aggregate	Test for	Observed values
	Bulk density	1.5 g/m ³
	Specific gravity	2.68

(d) Fly ash: Fly ash is a by-product obtained during the process of combustion of pulverized coal in electric power generating plants. Fly ash produced from thermal power plant Pandalam, was used as partial addition for cement and its specific gravity is 2.2.

(e) Super plasticizer : Aura mix 300 plus super plasticising admixture procured from Fosroc Chemicals India Pvt. Ltd.is used and its properties are shown below.

Table- 3: Properties of Auramix 300 plus

Auramix 300 plus	Test for	Observed value
	Colour	Light yellow
	Density	1.05 Kg/l
	Alkali content	Less than 1.5 Kg/l

(f) Fiber : Recron 3s fiber, modified polyester fibers, optimum percentage was found at 1.5 %.



Fig-1 Recron 3s fiber

3. EXPERIMENTAL INVESTIGATION

[A] General outline of experimental investigation:

The aim of the present investigation is to study the load carrying capacity, deflection, of the self compacting concrete beams. In this study the flexural and shear behaviour of beams with rectangular openings is considered. The size

of the openings provided was 80 x 100 mm. For the testing of the same, various properties of the materials used for concreting were also studied. The basic test on cement and aggregates were done.

[B] Workability test for fresh concrete (trial mix proportions):

The mix design for SCC were followed from the EFNARC (May 2005) guidelines. The recommended range for W/P ratio by volume is 0.85 to 1.1 and that for coarse aggregate is less than or equal to 50% of total aggregate.

The main properties of Self- Compacting Concrete are its filling ability, passing ability and resistance to segregation. Many methods have been developed to characterize the properties of SCC.

Table -4: The recommended limits for different properties according to EFNARC are:

TEST	PROPERTY	LIMITS
Slump flow	Filling ability	650-800mm
V-funnel	Segregation resistance	6-12 sec
L-box	Passing ability	0.8-1

The slump flow test is carried out to find the horizontal free flow of SCC mix in the absence of obstructions. The concrete mix flows, on lifting the slump cone, which is filled with concrete. The average diameter of the concrete circle is measured from two perpendicular directions, which is a measure of filling ability of concrete.



Fig-2 Slump flow test

The viscosity and filling ability of self-compacting concrete is found out by v funnel test. The time taken by the concrete to flow out of the funnel after filling the v shaped funnel is measured and recorded as the v-funnel flow time.



Fig-3 V funnel test

The L box test is used to test the passing ability of the SCC mix, by allowing the horizontal flow of fresh concrete through the gaps between vertical, smooth reinforcing bars of L box and height of the concrete beyond the reinforcement is measured.



Fig-4 L box test

From this works, concluded that, fly ash percentage that is used to replace cement is 28%.the cement used is 500 kg/m³ and water cement ratio was fixed at 0.38.The optimum percentage of fiber was 1.5 % by volume of concrete. With these, SCC trials have been done and are given below.

Table -5:-SCC Trials

Fin e %	Coars e%	Slump (mm)	V-Funn el	L-bo x	Comp. strengt h (MPa)	Remar ks
50	50	890	4	1.5	-	N
52	48	750	4.3	1.3	-	N
54	46	724	6	0.9	22.1	Y
56	44	685	6.2	0.8	21.15	Y
58	42	655	13	0.7	-	N
60	40	600	15	0.5	-	N
53	47	730	4.7	0.7	-	N
55	45	690	9	0.9	22.68	Y
57	43	680	11	0.8	20.89	Y

[C] Design of reinforcement

The reinforcement details of beams were obtained from IS 456 – 2000, and they are:-

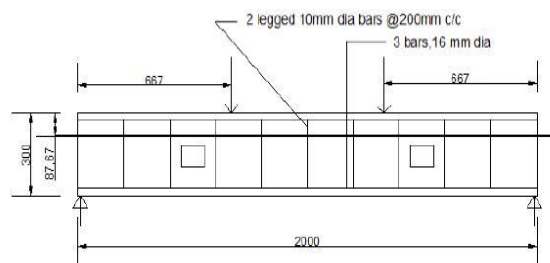


Fig- 5: Longitudinal section of beam with openings for flexural failure

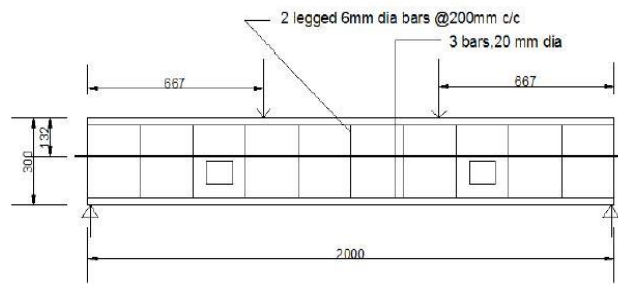


Fig- 6: Longitudinal section of beam with openings for shear failure

[D] Preparation of test specimen

The mould of the beam was casted by using wood.. The concrete mix contains cement, sand, aggregate, fly ash, water and super plasticiser were weighted accurately. The mixing was done till uniform mix was obtained. The concrete mix was then placed into the mould immediately after mixing. Compaction was avoided in this case, as it is SCC mix. At the end of 7 days of casting the test specimen were remoulded. They were cured in water for 28 days. After 28 days of curing the specimen was dried in air.



Fig- 7: Arrangement of reinforcement for beams with openings

[E] Experimental setup

The beams was tested in a 50 tons capacity loading frame and they were mounted as simply supported beams. Two dial gauges were placed, one at the mid span under the loading point and other at one third span. Demecs were placed at the centre of the beam and at right, towards tension zone to get maximum deflection. The load was applied at increment of one ton. While testing, the first cracking load and ultimate load was observed and cracks patterns were marked. Strains were noted by strain gauge. All beams were loaded till its failure.



Fig- 8: Test set up for beams with opening in loading frame

4. TEST RESULTS AND DISCUSSIONS

[A] Load-Deflection curves

After the testing, the Load deflection curves were obtained for both flexural and shear SCC beams. It was observed that as load increased the deflection of the beam also increased. The maximum deflection was observed for beams with openings and minimum deflection was observed for beams with openings incorporating fibers.

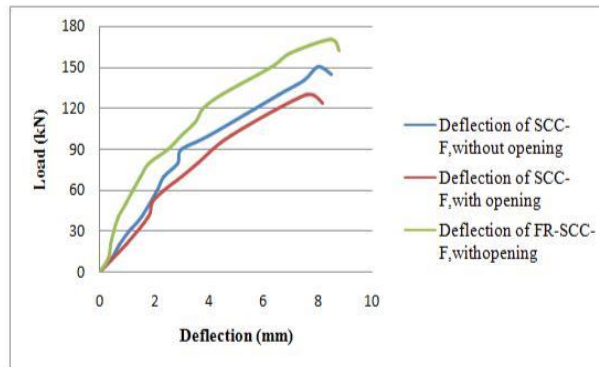


Chart-1: Load deflection curve of SCC beam for flexure at mid span

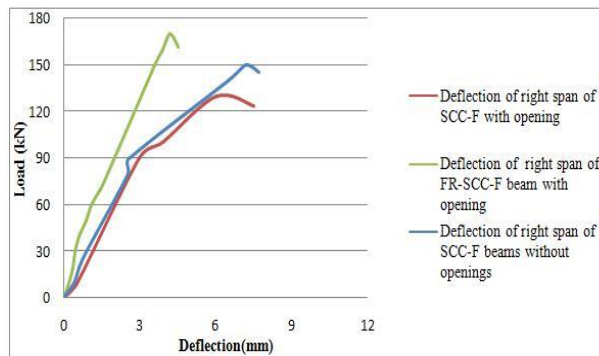


Chart-2: Load deflection curve of SCC beam for flexure at right span

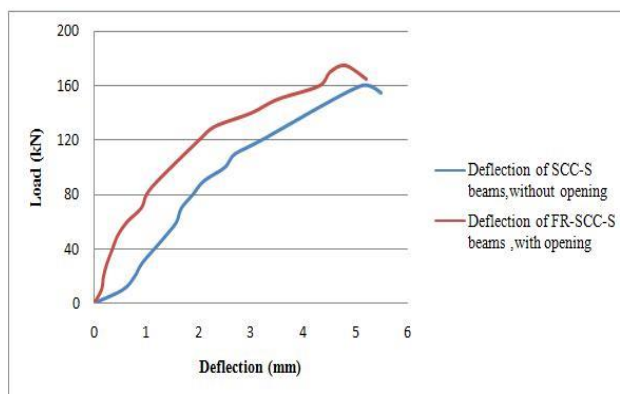


Chart-3: Load deflection curve of SCC beam for shear at mid span

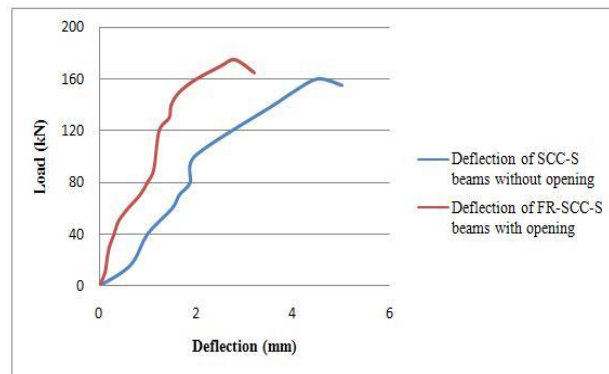


Chart-4: Load deflection curve of SCC beam for shear at right span

[B] Load carrying capacity of beams

The ultimate and the first cracking load taken by each of the beam were observed. It was observed that beyond the ultimate load the beam takes no load and further failure occurs. The load at which the first crack occurs is the first cracking load.

Table-6: Ultimate and first cracking load of different beams

Beam Notations	Specimen details	First crack load (kN)	Ultimate load (kN)
SCC-F	Self-compacting concrete beams for flexure without opening	80	150
SCC-F, openings	Self-compacting concrete beams for flexure with opening	60	130
FR-SCC-F	Fiber reinforced Self compacting concrete beams for flexure with opening	90	160
SCC-S	Self-compacting concrete beams without openings for shear	80	160
FR-SCC-S	Fiber reinforced Self compacting concrete beams with opening for shear	90	175

The above table-6 shows that when openings were provided in the normal SCC beams it adversely affected the ultimate load carrying capacity of the beams. The ultimate load carrying capacity was reduced to about 12.6 % compared to normal beam, and when Recron 3s was used in beams, which act as secondary reinforcement in beams, enhanced the load carrying capacity of beams and around the openings. The percentage of increase of ultimate load carrying capacity was about 23.4% in flexural beams and 10.5 % for shear beams.

[C] Comparison of Ductility factor in beams

Table -7: Ductility factor in beams

Beam Name	Ultimate deflection(mm)	Yielding deflection (mm)	Ductility factor
SCC-F,without opening & fiber	8	2.99	2.6
SCC-F,with openings	7.6	3	2.5
FR-SCC-F,with openings & fiber	8.5	2.9	2.9
SCC-S,without opening & fiber	5.1	2.1	2.4
SCC-S,with opening & fiber	4.8	1.7	2.82

From the above table ,it was observed that when openings was provided in beams the ductility factor of beams for both flexure and shear was reduced. On addition of fibers, the ductility factor increased. The ductility factor increased to 11.58 % in flexure beams .For flexural beams it was increased up to 17.5 %.

5. CONCLUSIONS

The presence of openings in the beams reduces the beams load carrying capacity and its overall behaviour. Use of SCC mix, reduced the efforts of vibration and addition of fiber in beams with openings, enhanced the beam capacity. From the experimental study it was concluded that, the first crack load was reduced to 25 % when openings were provided in beams for flexure. On addition of Recron 3s fibers enhanced the capacity up to 33% in beams, when compared with beams without fiber.

The ultimate load carrying capacity was reduced to 12.6 % in beams for flexure, when openings were provided.

On addition of Recron 3s fibers enhanced the capacity up to 30.7%, when compared with beams without fiber.

Ductility factor was increased up to 11.58% when fiber was added for flexure.

The first crack load was increased to 11% when fibers were provided in beams with openings for shear.

The ultimate load carrying capacity was increased to 10.5 % in beams for shear, when fibers were provided.

Ductility factor was increased up to 17.5% when fiber was added for shear.

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