Effect of Hybrid Fibers on Mechanical Properties and Flexure-Deficient R.C. Beams

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Abstract— Investigation carried out on M40 grade of concrete having mix proportion of 1:1.81:2.08[1] with water-cement ratio of 0.44 to study the performance of hybrid fiber reinforced concrete. Hybrid fiber reinforced concrete is obtained by mixing of steel and polypropylene fibers. Steel fibers are kept at constant i.e. at 0.9% volume fraction and polypropylene fibers are at 900 g, 1050 g, and 1200 g per cubic meter of concrete. Performance of hybrid fiber reinforced concrete done by studying the behavior in terms of compressive strength, split tensile strength, maximum load carrying capacity of flexure deficient beams.

Key words: Hybrid Fiber Reinforced Concrete, Compressive Strength, Split Tensile Strength, Load Carrying Capacity of Beams

I. INTRODUCTION

Mechanical properties of fibers that we are going to use in concrete are very important, as they are used to improve the performance of concrete. The combination of two or more types of fibers is more common, with optimizing the overall behavior. Hybrid fiber reinforced concrete attained by mixing of steel fibers and polypropylene fibers in suitable proportions. Fibers are added to the concrete by dispersed them randomly while mixing of concrete. The micro-cracks in plain concrete members may leads to weakness of those members. The weakness can be removed by the addition of fibers to the plain concrete. Fibers help to resist the load that transfer to the cracks.

II. MATERIALS USED

Materials that are used in the experimental investigation are cement, fine aggregate, coarse aggregate, steel fibers, polypropylene fibers, water.

- Cement: Ordinary Portland cement of 53 grade of single lot is used throughout the investigation. Properties of cement have been compared with IS: 12269:2013. [2, 3]
- Fine aggregate: Locally available river sand has been used in the present investigation. Based on the particle size fine aggregate comes under Zone-II of IS: 383-1970. [4]
- Coarse aggregate: Locally available coarse aggregate of 10mm size has been used in the present investigation with fineness modulus of 6.26. [4]
- Steel fibers: Dura flex hooked end steel fibers are used in this present investigation. These fibers are imported from Kasturi metal Composite pvt.ltd, Maharashtra.
- Polypropylene fibers: Blended polypropylene fibers of 24mm and 40mm.These fibers are imported from the Waltar enterprises.
- Water: Water is used for both casting and curing of specimens and make sure that water is free from deleterious material.

III. EXPERIMENTAL PROGRAM

Experimental investigation has been carried out by casting cubes, cylinders, and beams by using the moulds. Mould sizes are as follows:

Specimen type	size of mould
Cube	150mm × 150mm× 150mm
Cylinder	(15cm ϕ× 30cm length)
Beam	120mm×210mm×1500mm

Table 1: Specimen details

For casting of these specimens all the materials i.e. cement, fine aggregate, coarse aggregate, steel and polypropylene fibers are kept ready. All these materials are mixed properly till uniform mix obtained. Then water is added to the dry mix and mix that mortar for 2 to 3 minutes. Pour this mix in the moulds and compacting by using table vibrator for cube and cylinder specimens and for beam specimen needle vibrator is used. Before pouring mortar all these moulds are applied with shutter release oil. All the flexure deficient beam specimens are designed as singly reinforced. These beams are fails in flexure. Reinforcement details for casting the beam specimens are as follows:

Steel reinforcement		Stirrups spacing
Tension zone	compression zone	
2-6 ϕ	2-12 ϕ	70mm

Table 2: Reinforcement details [5]

Fiber percentage		Number of specimens		
Steel fibers (V_f) %	Polypropylene fibers	cylinders	cubes	Beams
0	0	3	3	1
0.9	900 g	3	3	1
0.9	1050 g	3	3	1
0.9	1200 g	3	3	1

Table 3: Number of specimens casted

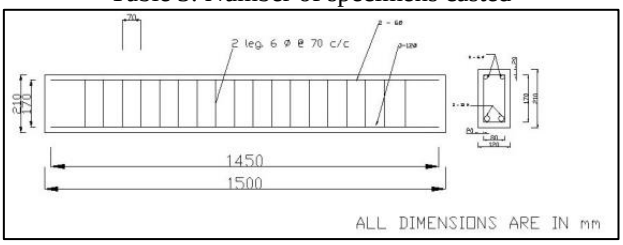

Fig. 1: Reinforcement details for flexure deficient beams

IV. TESTING PROCEDURE

A. Compressive Strength

Cubes are tested under the compressive testing machine according to IS: 516-1959. Load was applied at the rate of 5kN/sec. and the testing setup is shown in figure below: [6]

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Fig. 2: Testing of cube in CTM

B. Split-Tensile Test

Fig. 3: Split-tensile test for cylinder in CTM

To know the tensile strength of concrete, split-tensile test was conducted as per IS: 5816-1959. Standard cylinder of size 15cm Ø X 30cm length is used for testing the split-tensile strength. The cylinder is placed in the CTM as shown in figure below. The rate of loading used is 2.3kN/s. The maximum load at which cylinder is fail is noted.

As per the IS: 5816-1959 the split-tensile strength is calculated using following formula [7]

Split-tensile strength $T = \frac{2P}{\pi DL}$

Where, P = Maximum load taken by the cylinder at failure

D = Diameter of the specimen,

L = Length of the specimen.

C. Load Carrying Capacity

All the beam specimens are tested with the help of loading frame of 1000 kN capacity. Load taken by the beam was recorded by using the Proving ring, having a least count of 0.361kN. Entire testing of beam set up is shown in figure below:

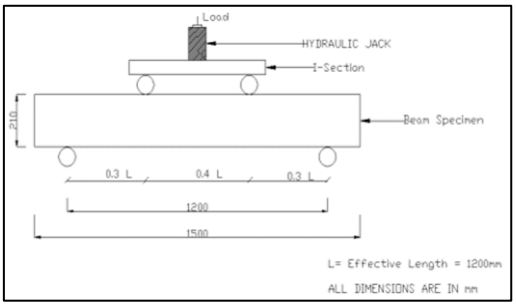

Fig. 4: Schematic representation for testing of beam specimens

V. RESULTS AND DISCUSSIONS

A. Compressive Strength

Compressive strength increases with increasing the polypropylene fibers in concrete, for cubes up to with the fiber combination of 0.9% steel fibers along with the polypropylene content of 1050 g per meter cube of concrete and there is decrement in compressive strength for cubes with fiber combination of 0.9% steel fibers along with the polypropylene content of 1200 g per meter cube of concrete. The variation in compressive strength shown in figure below:

fiber ratio		Cube Specimen Notation	Average compressive strength (Mpa)
Steel fiber (%Vf)	Polypropylene fiber (g/m3)		
0	0	0-SF-0-PPF	41.33
0.9	900	0.9-SF-900-PPF	42.07
0.9	1050	0.9-SF-1050-PPF	42.57
0.9	1200	0.9-SF-1200-PPF	33.67

Table 4: Compressive strengths for various cubes

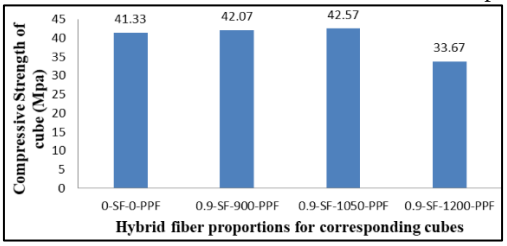

Fig. 5: Compressive strengths for different hybrid proportions

B. Split-Tensile Test

Split-tensile strength increases with increasing the polypropylene fibers in concrete, when compared with the cylinder with zero fibers. The variation in Split-tensile strength shown in figure below:

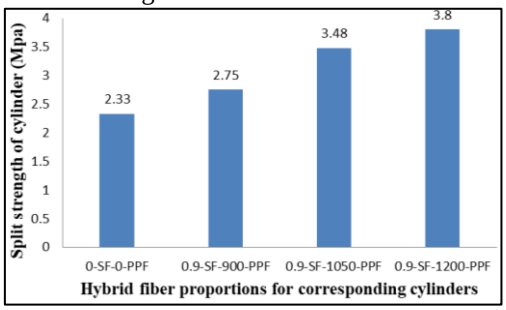

Fig. 6: Split-tensile strengths for different hybrid proportions

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fiber ratio		Cylinder Specimen Notation	Average Split tensile Strength (Mpa)
Steel fiber (%Vf)	Polypropylene fiber (g/m3)		
0	0	0-SF-0-PPF	2.33
0.9	900	0.9-SF-900-PPF	2.75
0.9	1050	0.9-SF-1050-PPF	3.48
0.9	1200	0.9-SF-1200-PPF	3.8

Table 5: Split-tensile strengths for various cylinders

C. Load carrying capacity for Flexure deficient beams

Load carrying capacity increases with increase the polypropylene fiber content, when compared with the beam with no fibers i.e. beam F. The variations in Load carrying capacity shown in figure below:

Fiber Ratio		Beam notation	Load carrying capacity
Steel fiber (%Vf)	Polypropylene fiber (g/m^3)		
0	0	F	119.83
0.9	900	F1	127.19
0.9	1050	F2	134.76
0.9	1200	F3	158.87

Table 6: Recorded data for Load carrying capacity

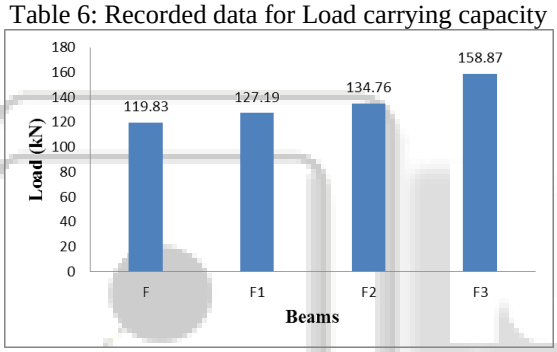

Fig. 7: Comparison of Load carrying capacity for all beams

Fig. 8: Cylinders after testing

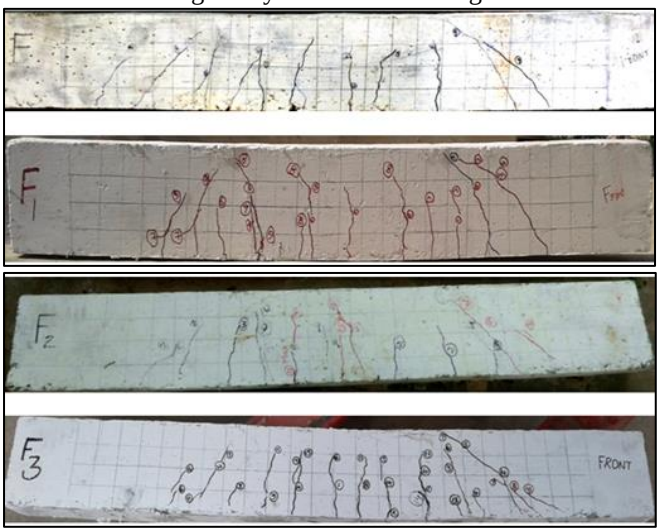

Fig. 9: Flexure deficient beams after testing

VI. CONCLUSIONS

1) Compressive strength of the concrete is increased by 4.45 % for hybrid fiber combination at 0.9-SF-1050-PPF. And there is decrement in compressive strengths for hybrid fiber combination at 0.9-SF-1200-PPF; it is because of improper distribution of fibers.
2) Split tensile strength of concrete is observed to be improved as maximum as 63.90% with increase in the polypropylene fiber at 0.9-SF-1200-PPF.
3) Maximum load carrying capacity is increased by 32.57% for the beam with addition of hybrid fibers in concrete.
4) Workability of concrete decreases by increase in fiber content in the volume of concrete. Thus some water reducing admixtures are recommended to use to increase the workability of concrete.

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