EXPERIMENTAL STUDY ON PROPERTIES OF POLYPROPYLENE AND STEEL FIBRE REINFORCED CONCRETE

Bharath.S [1], Ashok Kumar [2], Meghana.G.S [3], Rakshitha.V [4], Prof.Shashikumara.S.R [5]

[1,2,3,4] UG-Students, [5] Assistant professor Department of Civil Engineering
JSS Academy of Technical Education, Bengaluru 560060, Karnataka, India

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Abstract - *Present experimental study was conducted to determine the optimum dosage of polypropylene and steel fibers. The mechanical properties of fiber reinforced concrete were investigated by including polypropylene and steel fibers. The standard cube test specimen, cylinder test specimen and prism test specimen were casted, cured and tested for 7, 14, & 28 days as per Indian standard guidelines. In this experimental study it was found that the optimum dosage of Poly Propylene Fibre was 0.05% by volume of concrete and that of Steel Fibre was 0.75% by volume of concrete. Both PFRC and SFRC exhibited convincing behavior compared to HPC (conventional concrete) at the specified optimum dosage. Also the test results showed that use of steel fibre reinforced concrete improves compressive strength and tensile strength compared to conventional concrete (HPC).*

Key Words: **PFRC- Polypropylene fibre reinforced concrete, SFRC- steel fibre reinforced concrete, HPC- High performance Concrete (conventional concrete).**

1. INTRODUCTION

It is well known that conventional concrete designed on the basis of compressive strength. Hence problems like Shrinkage, creep, thermal expansion, etc. are faced. To meet functional and durability requirements such as impermeability, resistance to frost, thermal cracking adequately it is required to go for HPC (high performance concrete). High performance concrete is a special concrete designed to provide several benefits in the construction of concrete structures that cannot always be achieved routinely using conventional ingredients, normal mixing and curing practices. In this study HPC is developed based on the packing density method. The low tensile strength of concrete is improved in several ways by providing steel reinforcement and also by pre stressing methods etc. Though these methods provide tensile strength to the concrete they do not increase the intrinsic tensile strength of the concrete. Further to improve the tensile property of conventional concrete, different fibres like steel fibres, polypropylene fibres, glass fibres and many natural fibres are added to it. The fibre in the concrete matrix acts as crack arresters which restricts the growth of flaws in the matrix preventing these from enlarging under load, into cracks, which eventually cause failure.

2. OBJECTIVE

- To study the fresh and hardened properties of polypropylene and steel fibers.
- To study the synchronized effect of both fiber at fresh and hardened stage.
- To determine the optimum dosage of polypropylene and steel fibers.

3. LITRATURE SURVEY

The relevant literature available in this area of mix proportioning of fiber reinforced concrete, has been critically studied. The work carried out by different researchers in the area of concrete mix proportioning using particle size distribution concept and packing models are critically reviewed.

[1] Conducted experimental study on concrete mix design by packing density method Results obtained by packing density method are compared with IS code method. The optimum bulk density was obtained at proportion of 42% coarse aggregates (20mm downsize), 18% coarse aggregates (12.5mm downsize) and 40% fine aggregates.

[2] worked on improvements in fly ash based concrete strength in compression and flexural strength. The compressive and flexure strength of concrete for various mixture proportions of concrete containing the inclusions of different percentage of polypropylene fibers from 0% to 0.3% and fly ash replacement levels at 25% , 50% of fly ash were investigated.

[3] Studied the influence of polypropylene fibers in different proportioning and fiber length to improve the performance characteristics of the lightweight cement composites. Fibers were used in two different lengths (6mm

and 12mm) and fiber proportions (0.15% and 0.35%) by cement weight in the mixture design. Hardened concrete properties such as: 7-day and 28-day compressive strength, splitting tensile strength, flexural strength, water absorption, and shrinkage were evaluated.

[4] In their investigation studied the properties of steel fiber reinforced concrete like flexure and compressive strength. They conducted tests to study the flexural and compressive strength of steel fibre reinforced concrete with varying aspect and varying percentage of fibre. In the experiments conducted four aspect ratio were selected i.e. 40,50,60,70 and percentage of steel in each case varied from 0.5% to 2.5% at interval of 0.5%.

4. MATERIAL CHARACTERIZATION

4.1 Cement

Ordinary Portland cement of 53 grade available in local market is used in the investigation. The cement used has been tested for various properties as per IS: 4031and found to be confirming to various specifications of IS: 12269. The specific gravity of cement was 3.15

4.2 Fine aggregate

Locally available manufactured sand confirming to Zone II of IS 383-1970 is used in the present study. The specific gravity of fine aggregate was 2.62

4.3 Coarse aggregate

Crushed angular granite metal of 20 mm & 12.5mm single size confirming to IS: 383-1970, From a local source was used as coarse aggregate. The specific gravity of 2.70

4.4 Micro silica

The Micro silica obtained from the M/s ELKEM Pvt Ltd, Bombay confirming to ASTM C1240 is used for this study.

4.5 Water

Edible water confirming the requirement of IS 456-2000 used in concrete mix preparation.

4.6 Chemical admixtures

Master Gelanium SKY 8233 conforming to IS: 9103:1999 is used as superplasticiser.

4.7 Fibres

Polypropylene fibres having diameter 0.036mm, cut length 12mm and aspect ratio 334 and Round end hooked steel fibres having 0.6 mm diameter, 30mm length and aspect ratio 50 is used.

Fig -1: Polypropylene Fibre

Fig -2: Steel Fibre

5. EXPERIMENTAL PROGRAMME

The experimental programme consists of preparation of fibre reinforced concrete with different percentage (by volume of concrete) of fibres. The details of the mix proportioning of materials as per packing density method are shown in the table 1.

Table -1: Mix design of HPC as per PD method

Mix Design Table			
Materials		Mix Weights (Kg/M^3)	Mix Proportions
Cement		378.79	0.80
Micro Silica		94.69	0.20
Fine aggregate		724.53	1.53
Coarse aggregate	20 mm	652.07	2.29
	12.5 mm	434.72	
Water		160.98	0.34
Superplasticiser		5.20*	-
yield		2451	-

* 1.1 % by weight of cementitious material

Four sets of test specimen with different dosage say as 0.025%, 0.05%, 0.075%, & 0.100 % by volume of concrete is considered for PFRC sets of specimen and 0.25%, 0.50%, 0.75%, & 1.0 % by volume of concrete is considered for SFRC sets of specimen. Fresh state tests like slump test & Vee-bee consistency test were carried out and that of in hardened state Compressive, split tensile and Flexural strength of concrete are studied to find optimum dosage of fibre to be added to concrete. The details of different proportions of fibre reinforced concrete test specimens are as shown in table-2

Table -2: Different Sets of FRC Test Specimen

Type of specimen	Sets of Test specimen	Percentage of fibre	Weight (Kg/m^3)
Polypropylene fibre reinforced concrete	PFRC 1	0.025 %	0.61
	PFRC 2	0.050 %	1.23
	PFRC 3	0.075 %	1.84
	PFRC 4	0.100 %	2.45
Steel fibre reinforced concrete	SFRC 1	0.25 %	6.13
	SFRC 2	0.50 %	12.26
	SFRC 3	0.75 %	18.38
	SFRC 4	1.00 %	24.51

The number of test specimen with different percentage of fibres casted for the conduction of test as prescribed in the experimental programme are shown in table-3

Table -3: number of FRC Test Specimen

Type of specimen	Sets of Test specimen	% of fibre	Test specimens		
			cube	cylinder	prism
Polypropylene fibre reinforced concrete	PFRC 1	0.025 %	9	9	9
	PFRC 2	0.050 %	9	9	9
	PFRC 3	0.075 %	9	9	9
	PFRC 4	0.100 %	9	9	9
Steel fibre reinforced concrete	SFRC 1	0.25 %	9	9	9
	SFRC 2	0.50 %	9	9	9
	SFRC 3	0.75 %	9	9	9
	SFRC 4	1.00 %	9	9	9

6. RESULT AND DISCUSSION

6.1 FRESH STATE TESTS

(i) Slump Test:

The slump test is the most commonly used method because of its easy adoptability. This test can be used for FRC only when slump values exceed 40 to 50 mm.
The slump test was conducted as per IS 1199 -1959 guidelines. The test results are as shown in Chart -1

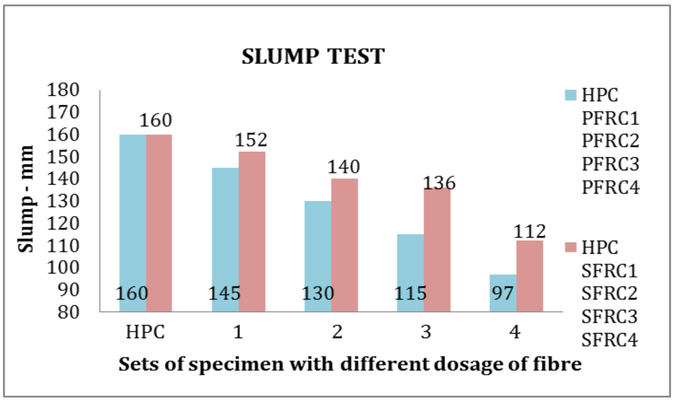

Chart -1: Graphical Representation of Slump Test Results

(ii) Vee-Bee Consistency Test:

The measure of workability by consistmeter is prime important since the concrete is fibrous, in this test the concrete is subjected to external vibration. The consistency of the mix is determined by time, in second. The vee-bee consistency test was conducted as per IS 1199 -1959 guidelines. The test results are as shown in Chart –2

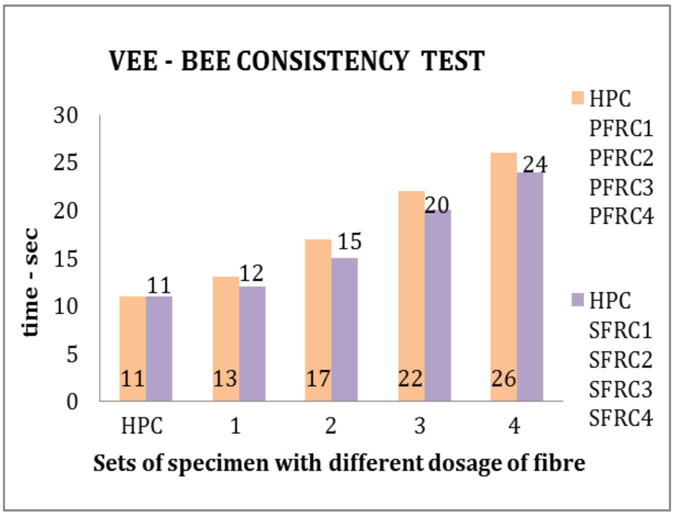

Chart -2: Graphical Representation of Vee-Bee Consistency Test Results

6.2 HARDENED STATE TESTS

(i) Compression Test:

For compressive strength test, cube specimens of dimensions 150 mm × 150 mm × 150 mm were casted; the top surface of the specimen was leveled and finished. After 24 hours, the specimens were demoulded and transferred to curing tank wherein they were allowed to cure for 7 days, 14 days, and 28 days after which were tested on digital compression testing machine as per IS:516-1959 guidelines.

Fig -3: cube specimen tested for compression strength

The compressive strength was calculated as follows: Compressive strength (MPa) = Failure load / Cross sectional area Results of compressive strength of test specimen reinforced with fibres (i.e., PFRC & SFRC) was compared with conventional concrete test specimen (HPC). The compression test results are shown in Chart -3

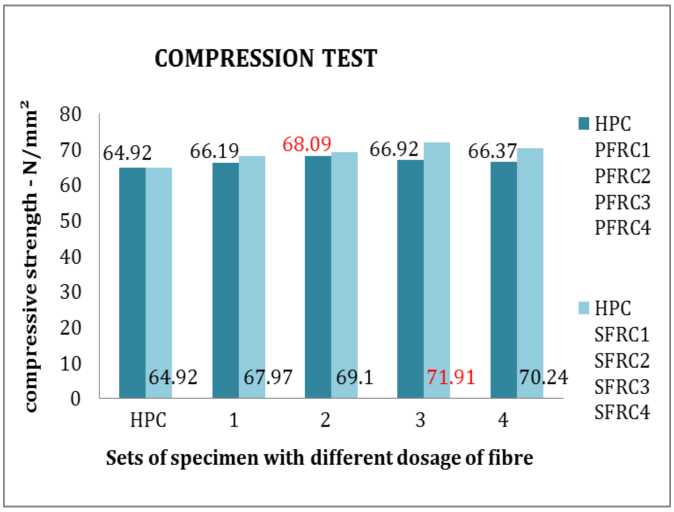

Chart -3: Graphical Representation Of Compression Test Result At 28 Day

(ii) Split Tensile Test:

Specimens of cylindrical shape of diameter 150 mm and length 300 mm were tested under a Compression Testing Machine, under a compressive load across the diameter along its length till the cylinder splits.

Fig -4: cylinder specimen tested for split tensile strength

The tension develops in a direction at right angles to the line of action of the applied load. The Split Tensile strength was calculated as follows:

Split Tensile Strength (MPa) = 2P / π DL

Where, P = Failure load,

L = Length of cylinder, and

D = Diameter of cylinder.

Results of tested cylinder specimens are shown in Chart -4

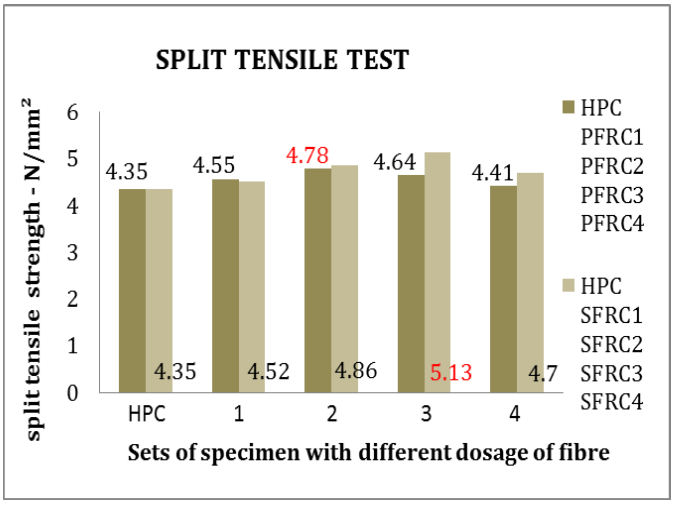

Chart -4: Graphical Representation Of Split Tensile Test Result At 28 Days

(iii) Flexure Test:

For flexural test, prism specimens of dimensions 150 mm × 150 mm × 750 mm were casted & tested on flexure testing machine as per IS:516-1959 guidelines.

Fig -5: prism specimen tested for flexural strength

The flexural strength was calculated as follows:
flexural Strength (MPa) = $3P\,a/\,bd^2$
Where, P = Failure load,
b = breadth of specimen
d = depth of specimen
a = distance from centre of support to the failure point
Results of tested cylinder specimens are shown in Chart -5

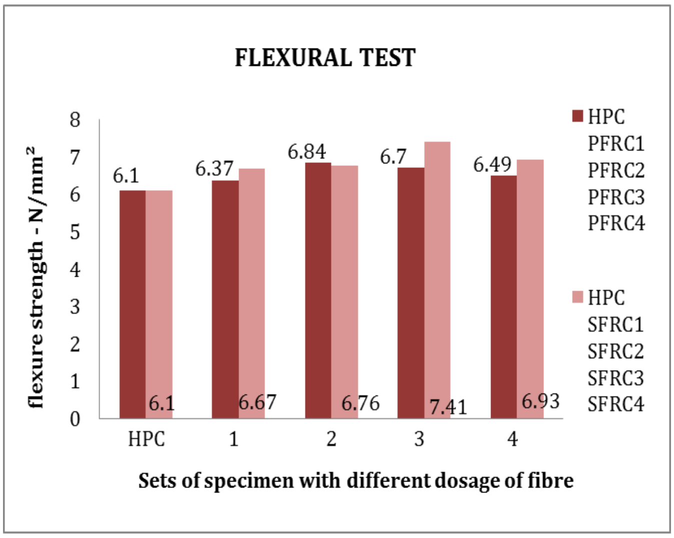

Chart -5: graphical representation of flexural test result at 28 days

7. CONCLUSION

From the present experimental study and the results obtained, the following conclusions may be drawn:

- The workability reduced with addition of fibers. Since the surface area of polypropylene fibre is more, the PFRC exhibit more reduction compared to SFRC.
- The experimental study indicated the concrete with **0.05%** of polypropylene fiber and **0.75%** of steel fiber by volume of concrete exhibit convincing behavior under compression and flexure hence can be concluded as optimum dosage of polypropylene fibre and steel fibre.
- Only Marginal enhancement in compression strength recorded due to fibre inclusion the maximum percentage of improvement in compressive strength by incorporating the polypropylene fibre and steel fibre was **4.88%** & **10.77%** respectively compared to HPC (conventional concrete).
- Also from the split tensile test it was noted that maximum percentage of improvement in tensile strength by incorporating the polypropylene fibre and steel fibre was **9.84%** & **18.04%** respectively compared to HPC (conventional concrete).
- Considerable amount of improvement in tensile strength was found by the flexural strength test the maximum percentage of improvement in tension by incorporating the polypropylene fibre and steel fibre was **12.14%** & **21.36%** respectively compared to HPC (conventional concrete).
- The toughness of the FRC specimen was increased since the fibre performed as crack resisters. It was observed that the specimens of PFRC & SFRC did not split into two halves as in case of conventional concrete.
- An increase in ductility of the specimens by the introduction of fibers was observed in this investigation. The specimens of PFRC & SFRC did not yield to sudden breakage as observed in case of conventional concrete.

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AUTHOR BIOGRAPHIES

	**Mr. BHARATH.S** Completed Diploma In Civil Engineering (DCE) during 2014 from PVP Polytechnic bengaluru-56, Karnataka-India. Presently pursuing B.E. (CIVIL), JSS academy of technical education, bengaluru-60, Karnataka-India. Currently working on project "Experimental Study On Optimization Of Hybrid Fibre Reinforced Concrete".
	**Mr. ASHOK KUMAR** Student pursuing B.E. (CIVIL), JSS academy of technical education, bengaluru-60, Karnataka-India. Currently working on project "Experimental Study On Optimization Of Hybrid Fibre Reinforced Concrete"
	**Ms. MEGHANA.G.S** Student pursuing B.E. (CIVIL), JSS academy of technical education, bengaluru-60, Karnataka-India. Currently working on project "Experimental Study On Optimization Of Hybrid Fibre Reinforced Concrete"

	**Ms. RAKSHITHA.V** Student pursuing B.E. (CIVIL), JSS academy of technical education, bengaluru-60, Karnataka-India. Currently working on project "Experimental Study On Optimization Of Hybrid Fibre Reinforced Concrete"
	**Prof. SHASHIKUMARA.S.R** He has obtained his Bachelor of Engineering in Civil during 2003 from VTU belagavi and M.E in Construction technology from Bangalore University, Bengaluru, India during 2007. prof. Shashikumara.S.R is currently working as Assistant Professor in Department of civil engineering, JSS academy of technical education, Bengaluru-60. He has 10 years of teaching experience in the field of Civil engineering; and also has 04 years of industry experience working as site engineer and senior engineer in various companies.