ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Special Issue
National Conference on Advances in Civil and Mechanical Engineering (NCACME 17)

Experimental Investigation on the Behavior of Steel Fiber and Polypropylene Fiber Reinforced High Strength Concrete

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Abstract:- **In the last few year's conventional fiber reinforced concrete (RC) has established and it is common practice to use FRC as construction material. FRC offers advantages over plain HSC and reinforced HSC such as in increase of tensile strength and mechanical load carrying capacity and an improvement of ductility and fire resistance as well. Fiber Reinforced Concrete (FRC) offers advantages over plain High Strength Concrete (HSC) and Reinforced High Strength Concrete (HSC) such as in increase of tensile strength and mechanical load carrying capacity and an improvement of ductility and fire resistance as well. One of the important properties of steel fibers reinforced concrete (SFRC) is its superior resistance to cracking and crack propagation. Polypropylene fibers cause mainly on the one hand for increasing ductility behavior and, on the other hand for improving the fire resistance.**

The present investigation was aimed carried out to determine the Compressive Strength, split tensile strength and also the resistance to cracking by determining the flexural strength of steel fiber (lathe waste) and polypropylene fiber reinforced high strength concrete of M60 grade 0%, 0.5%, 1%, 1.5% and 2% volume fractions of two types of fibers and 5% of cement is replaced by silica fume. Two types of fibers used are steel fibers with aspect ratio 25, 38 and polypropylene fiber with aspect ratio 1600.

Keywords:-- **Compressive Strength, Split Tensile Strength, Flexural Strength, Mix Proportion.**

I. INTRODUCTION

Concrete comprising a hydraulic cement, water, aggregates and discontinuous fibers is termed as Fiber Reinforced concrete. Fibers may be in the form of Steel fibers, natural fibers, synthetic fibers, glass fibers etc. The key function of fibers is to associate the cracks or fissures that progress in concrete and intensify the ductility of cement concrete elements. It improves the post-cracking behavior of concrete. It also controls plastic and drying shrinkage of concrete. Even though fiber reinforced concrete offers various benefits pertaining to mechanical properties of the concrete, it is somewhat brittle in nature and still remains as a handicap for seismic applications. Subsequently the ductility and strength properties exhibit a contrasting behavior, fiber reinforced concrete is significantly more brittle than common normal strength concretes. High strength concrete can be described as concrete, which achieves characteristic cube strength in the range between 60 and 100 N/mm2, even though higher strengths have been attained and cast-off. High-strength concrete is laid down where reduced weight is required and designed for architectural point of view. High-strength concrete decreases the overall quantity of material placed and decreases the overall budget of the structure by transmitting loads more effectively than normal-strength concrete. In addition to improvement in compressive strength of concrete, FRC also offers benefits such as fire resistance, increase in tensile strength and mechanical load capacity of the structure. As of today, high strength concrete is more imperative since the convectional concreting suffers from durability and reliability aspects after the construction.

II. OBJECTIVES OF THE STUDY

To conduct an experimental analysis of *Steel* and *Polypropylene* Fiber Reinforced High Strength Concrete (FRHSC) using 0%, 0.5%, 1.0%, and 2.0% volume fraction of two type of fibers and by replacing 5% cement with silica fume. The work is experimental oriented. The various parameters of strength characteristics studied are:

- Compressive Strength of Fiber Reinforced High Strength Concrete (FRHSC)
- Split Tensile Strength of Fiber Reinforced High Strength Concrete (FRHSC)
- Flexural Strength of Fiber Reinforced High Strength Concrete (FRHSC)

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III. SCOPE OF THE STUDY

In the modern era utilization of fiber reinforced concrete is more in the pavements, industrial flooring, marine structures, and in the field of repair and retrofitting. Due to heavy loading on these structures, there is a tendency of failure of structures. Thus, it is necessary to have a material, which is having high strength and good elastic property. Also the use of high strength concrete is gaining importance as a construction material in all type of structures. The present work gains importance in construction, retrofitting field of structural engineering.

Materials And Methodology

Cement, Fine aggregate and coarse aggregate are common in a concrete matrix. But nowadays due to the advancement in concrete technology, the usage of industrial debris in concrete such as fly ash, GGBS, silica fume, metakaolin and rice husk is very common and chemical admixtures such as water reducing agents, super plasticizers etc. are also employed in order to obtain improved performance.

Cement

Ordinary Portland cement of 53 grade was used. Tests were carried out on various physical properties of cement as per IS 12269:1987 and the results are shown in Table 4.1

Table 4.1 Physical Properties of Cement

Particulars	Experimental Result	As per Standard
1. Fineness	308m^2/kg.	268m^2/kg minimum
2. Soundness		
a) By Le-Chartelier mould	0.60 mm	10 mm max
b) By Autoclave	0.0948%	0.8% maximum
3. Setting Time		
a) Initial Set	150 min	30 min minimum
b) Final Set	198 min	600 minutes maximum
4. Compressive Strength		
a) 3 days	43.5	27 MPa
b) 7 days	52.8	37 MPa
c) 28 days	72.4	53 MPa

Fine Aggregate

Natural river sand was used as fine aggregate which conforms to Zone II of IS: 383 – 1970. The specific gravity of fine aggregate was observed to be 2.62.

Coarse Aggregate

Locally existing gravel was used as coarse aggregate with a maximum size of 12.5 mm and was conforming the standards as per IS 383: 1970. The specific gravity of coarse aggregate was found to be 2.92.

Silica Fume

5% of cement by its weight was replaced by silica fume in all the mixes. The specific gravity of silica fume was found to be 2.2. The chemical composition of silica fume is shown in Table 4.2

Table 4.2 Chemical Composition of Silica

Chemical Composition	Percentages
Silica (SiO_2)	89
Alumina (Al_2O_3)	0.50
Alkalies (Na_2+K_2O)	1.20
Iron oxide (Fe_2O_3)	2.50
Magnesium oxide (MgO)	0.60
Calcium oxide (CaO)	0.50

Water

Clean potable tap water available in the laboratory, which satisfies drinking standards, was used for the preparation of specimens and for the curing of specimens.

Superplasticizer

Conplast SP 430 superplasticizer manufactured by Fosroc Chemicals, Bangalore was used in this experimentation. Its use enhance the workability of the mix, helps in providing a better compaction and finishing. It also

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permits a reduction in water content upto 35%. A dosage of 0.4% by weight of cement was used.

Steel Fibers (SF)

Fig.4.1 Steel Fibers

The steel fibers used in the experimentation. The length of steel fibers (SF) used are 25 mm and 38 mm of thickness 1 mm leading to an aspect ratio of 38 and 25. The density of steel fiber was found to be 78500 N/m^3. The young's elastic modulus of steel fibers was found to be 2 x 10^5 MPa.

Polypropylene Fiber

The polypropylene fibers (PPF) were obtained from NINA INDUSTRIES, Mani Bhuvan 54, Hughas Road, Mumbai. The polypropylene fibers were having a length of 12 mm and their average thickness was found to be 7.5 μm leading to an aspect ratio of 1600. The young's elastic modulus of polypropylene fibers was found to be 5x10^3 MPa. The density of polypropylene fibers was found to be 9100 N/m^3.

Fig. 4.2 Polypropylene Fibers

Testing And Experimental Result

Compressive Strength

For finding the compressive strength of concrete, cube size of about 15cm*15cm*15cm were moulded. In saturated surface dried condition cubes were tested. Till the specimen reaches ultimate load, the loading was continued. Compressive strength at 7, 14, 28 days are tabulated in Table 5.1

Table 5.1 Over all result of Compressive Strength Test

Type of Concrete	% of Fibers	Compressive Strength (MPa)	% increase of compressive strength
Plain high strength concrete	0	60.15	----
HSC with steel fibers of 25mm	0.5%	62.52	3.94%
	1%	64.29	6.88%
	1.5%	66.22	10.09%
	2%	67.40	12.05%
HSC with steel fibers of length 38 mm	0.5%	62.81	4.42%
	1%	64.59	7.38%
	1.5%	66.96	11.80%
	2%	67.85	12.80%
HSC with polypropylene fibers	0.5%	61.77	2.69%
	1%	63.70	5.90%
	1.5%	64.89	7.88%
	2%	66.52	10.59%

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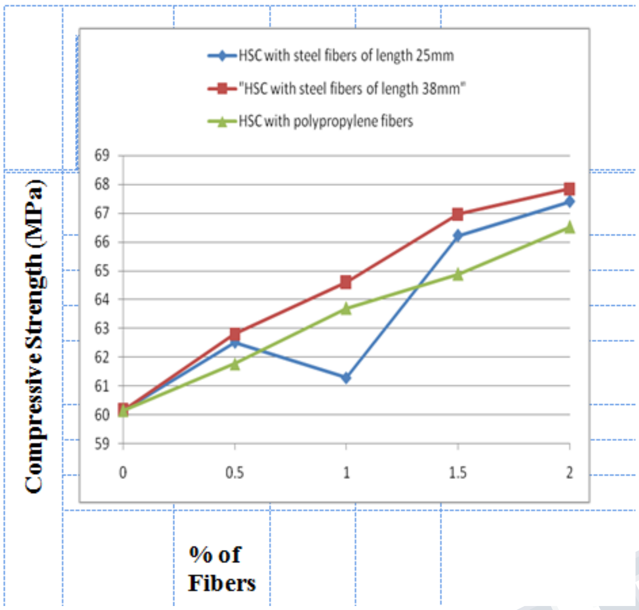

Fig.5.1 Variation of compressive strength with different percentage of steel fibers and polypropylene fibers reinforced high strength concrete

Splitting Tensile Strength Test

For the evaluating the tensile strength, cylindrical specimens of diameter 150 mm and length 300 mm were prepared. Split tension test was carried out on 2000 kN capacity compression testing machine as per IS 5816:1999.

Table 5.2 Overall result of Split Tensile Strength Test

Type of Concrete	% of Fibers	Tensile Strength (MPa)	% increase of Tensile strength (%)
Plain HSC	0	4.99	----
HSC with steel fibers of 25mm	0.5%	5.37	7.61%
	1%	5.89	18.06%
	1.5%	6.36	27.45%
	2%	6.46	29.45%
HSC with steel fibers of length 38 mm	0.5%	5.61	12.42%
	1%	6.03	20.84%
	1.5%	6.50	30.26%
	2%	6.69	34.06%
HSC with polypropylene fibers	0.5%	5.27	5.61%
	1%	5.70	14.23%
	1.5%	5.98	19.83%
	2%	6.31	26.45%

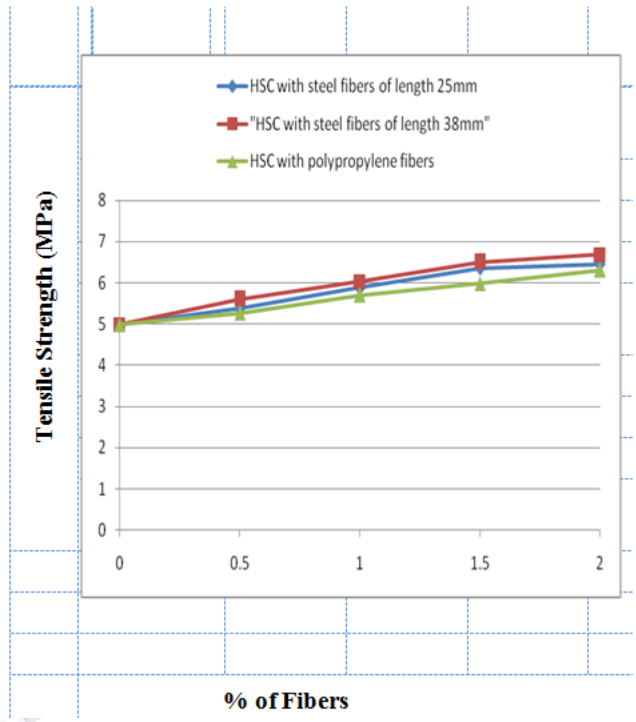

Fig.5.2 Variation of splitting tensile with different % of steel fibers and polypropylene fibers reinforced high strength concrete

Flexural Strength Test

For this test universal testing machine of 1000 KN (100 T) capacity was used. For evaluating the flexural strength, beam specimens of dimensions 100x100x500 mm were prepared. The two point loading were placed at a distance of 133 mm and bottom was placed at an effective span of 400 mm as per IS 516-1959. The load was applied without shock and increasing continuously at a rate of 1800N/min.

Table 5.3 Over all result of Flexural Strength Test

Type of Concrete	% of Fibers	Flexural Strength (MPa)	% increase of Flexural strength
Plain HSC	0	7.30	----
HSC with steel fibers of	0.5%	7.44	1.92%
	1%	7.61	4.24%
	1.5%	7.80	6.85%

25mm	2%	8.08	10.68%
HSC with steel fibers of length 38 mm	0.5%	7.47	2.33%
	1%	7.80	6.85%
	1.5%	7.93	8.63%
	2%	8.28	13.42%
HSC with polypropylene fibers	0.5%	7.40	1.37%
	1%	7.50	2.74%
	1.5%	7.52	3.01%
	2%	7.87	7.80%

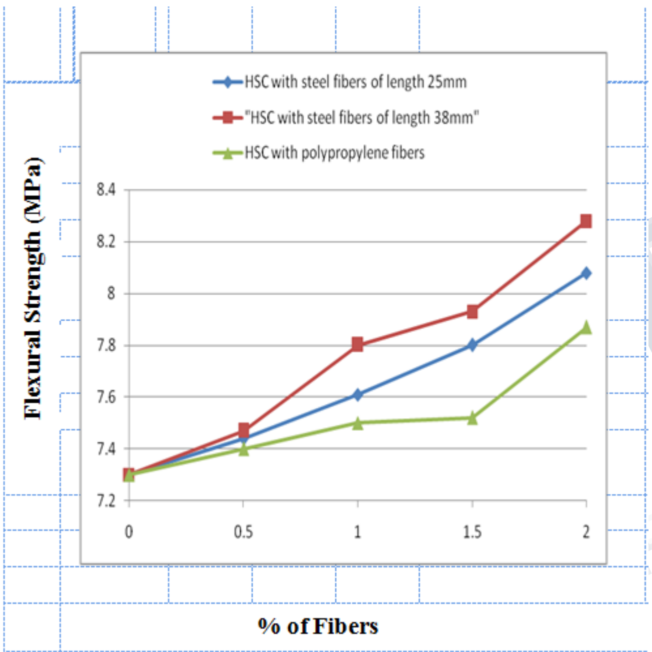

Fig.5.3 Variation of flexural strength with different % of steel fibers and polypropylene fibers reinforced high strength concrete

IV. CONCLUSION

1. By using 2% steel fiber of length 38 mm with aspect ratio 38, higher compressive strength can be obtained and 12.80% increase in compressive strength was found out when compared with the steel fiber of 25mm length.
2. By using 2% Polypropylene fibers of length 12 mm with aspect ratio 1600, higher compressive strength can be obtained and 10.59% increase in compressive strength was found.
3. The Fiber Reinforced High Strength Concrete with steel fiber of 2% and length 38 mm yields higher compressive strength than with steel fiber of length 25 mm and polypropylene fiber of length 12mm.
4. By using 2% steel fiber of length 38 mm with aspect ratio 38, higher splitting tensile strength can be obtained and 34.6% increase in tensile strength was found out when compared with the steel fiber of 25mm length.
5. By using 2% Polypropylene fibers of length 12 mm with aspect ratio 1600, higher splitting tensile strength can be obtained and 26.45% increase in tensile strength was found.
6. The Fiber Reinforced High Strength Concrete with steel fiber of 2% and length 38 mm yields higher splitting tensile strength than with steel fiber of length 25 mm and polypropylene fiber of length 12mm.
7. By using 2% steel fiber of length 38 mm with aspect ratio 38, higher compressive strength can be obtained and 13.42% increase in flexural strength was found out when compared with the steel fiber of 25mm length.
8. By using 2% Polypropylene fibers of length 12 mm with aspect ratio 1600, higher flexural strength can be obtained and 7.80% increase in flexural strength was found.
9. The Fiber Reinforced High Strength Concrete with steel fiber of 2% and length 38 mm yields higher flexural strength than with steel fiber of length 25 mm and polypropylene fiber of length 12mm.

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