Mechanical Properties Of Hybrid Fiber Concrete

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Abstract: ***Concrete is a substance, which has high strength in compression and less strength in tension, so far increasing the tensile strength of the concrete, reinforcements are added. In spite of this, cracks are formed on the surface due to many conditions like heavy loading, dry shrinkage etc. To increase the tensile strength and to prevent the growth of micro cracks of concrete to the macroscopic level, fibers can be added. In this paper, metallic and non-metallic fibers (i.e.), [hooked end steel fibers (HESF) and polypropylene fibers (PPF)] are combined and used as hybrid fibers. Their effects and mechanical properties are experimentally investigated. The mechanical property tests like compressive strength test split tensile test and flexural strength tests were carried out. HESF of length 30mm and diameter 0.5mm and PPF of length 6mm and diameter 0.01mm were used with water /cement ratio of 0.45. The concept of this experiment is to find the toughness properties of hybrid fibers (HESF &PPF) reinforced concrete of M30 grade with 0.7%, 0.75%, 0.8% of HESF & 0.3%, 0.25%, 0.3% of PP fiber by volume of cement. Each of 27 cubes, cylinder and beams were cast and tested after 7th, 14th and 28th days of curing. Results were found that 26% increase in the compressive strength and 87% increase in the flexural strength of concrete in 0.8% of HESF and 0.2% of PPF as compared other two and the conventional concrete.***

Index Terms: ***Hybrid Fiber, Hooked End Steel Fiber (HESF) and Polypropylene Fiber (PPF), Hybrid Fiber Reinforced Concrete (HFRC)***

I. INTRODUCTION

In today's world, the tasks civil engineer face is to develop environmental friendly and economically feasible structures. There is a requirement to find the new material to satisfy the above mentioned criteria. One such material is Fiber reinforced polymer (FRP). Fiber reinforced Concrete increases the structural integrity due to it containing fibrous materials which are short, discrete, uniformly distributed and randomly oriented. The various types of fibers include glass fiber, steel fiber, natural fibers and synthetic fibers. The main function of fibers is to prevent crack initiation and propagation. Hooked end steel fiber (HESF) is a type of metallic fiber which is produced from iron mineral. It has a physical property that provides the concrete with high tensile strength and increases the concrete's toughness.. It provides a strong bonding with concrete and increases structural integrity.

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Polypropylene is a type of natural fiber and recycled from carpet waste. It is widely used as concrete reinforcement.Polypropylene is a cheap polymer that is wide ly used because of its resistance to chemical reactions. Polypropylene filaments could be pragmatic for the strengthening of concrete, since it is shabby and effortlessly accessible and have a predictable quality. Impressive developments in strain limit, durability, affect resistant and break the control of cement. Polypropylene filaments are produced in various shapes and properties.

II. FIBER TYPES AND MATERIAL PROPERTIES

In this experiment, HESF and PPF are used and their properties are tabulated in Table No. 1, Figure 1 shows the HESF of length 30mm and 0.5 mm diameter & Figure 2 show the PPF of 6mm length and 0.01 mm diameter

Table 1: Material Properties of Hooked end steel fiber and Polypropylene fibers

Property	HESF	PPF
Length(l)(mm)	30	6
Diameter(d)(mm)	0.5	0.01
Density (Kg/m^3)	7850	946
Young's modulus(MPa)	2x10^5	3500
Aspect Ratio(l/d)	60	600

Fig. 1 HESF of 30mm length and 0.5mm diameter

Fig. 2 PPF of 6mm length and 0.01 mm diameter

III. EXPERIMENTAL TESTS ON HARDENED CONCRETE

A. Preparation of Test Specimens

Test specimens were prepared by using the designed mix proportion of 1.00: 1.48:2.69/ 0.45 to determine the physical properties of concrete with a combination of 0.8% of HESF & 0.2% of PPF, 0.75%.of HESF & 0.25% of PPF and 0.7%.of HESF & 0.3% of PPF. Thirty-Six concrete cubes of size 150x150x150mm were prepared using standard casting technique for compression tests. Three specimens of sizes 150mm diameter and 300mm high cylinders and 100x100x500mm prisms were cast for split tensile strength and flexural strength test, respectively. In hardened concrete at the age of 7th day, 14th day and 28 days, mechanical properties and quality of concrete were found by conducting the following tests

B. Compressive Strength of Hybrid Fiber Concrete

Compressive strength is generally the most frequently measured property for quality control. This test is done to evaluate the characteristics compressive strength of the concrete prepared. The tests were carried out on the concrete specimen of cube size 150mm. The cubes which are submerged in clean fresh water for curing was taken out after 7^{th} ,14^{th} & 28^{th} days for testing and kept in dry place for saturated surface dry condition before testing. Then the specimen was loaded in the Compressive Testing Machine (CTM) and the load is slowly increased until the specimen fails. The tests were conducted at the age of 7^{th} day, 14^{th} day and 28^{th} day as per the code IS 516-1959. The load at which the cube fails is noted and it is taken as the compressive load at which failure occurs.

Figure 3 and Figure 4 shows the compression test setup and failure mode of cube specimens. Table 2 represents the compressive strength of cubes tested at the ages of 7^{th}, 14^{th} & 28^{th} days. Figure 5 shows the Comparison of Compressive Strength of Hybrid Fiber Reinforced Concrete with Conventional concrete in which 0.8% of HESF & 0.2% of PPF shows the highest compression strength of 40.62 N/mm^2

Table 2: Compressive Strength Test Results

S.No	HESF	PPF	Compressive Test Of Cube (N/mm^2)		
			7 Days	14 Days	28 Days
1	0.8%	0.2%	36.27	38.62	40.62
2	0.75%	0.25%	28.81	31.4	36.87
3	0.7%	0.3%	32.2	33.78	37
4	Conventional		19.87	32.14	36.75

Fig .3 Compression test setup of cube

Fig.4 Failure mode of Cube specimen

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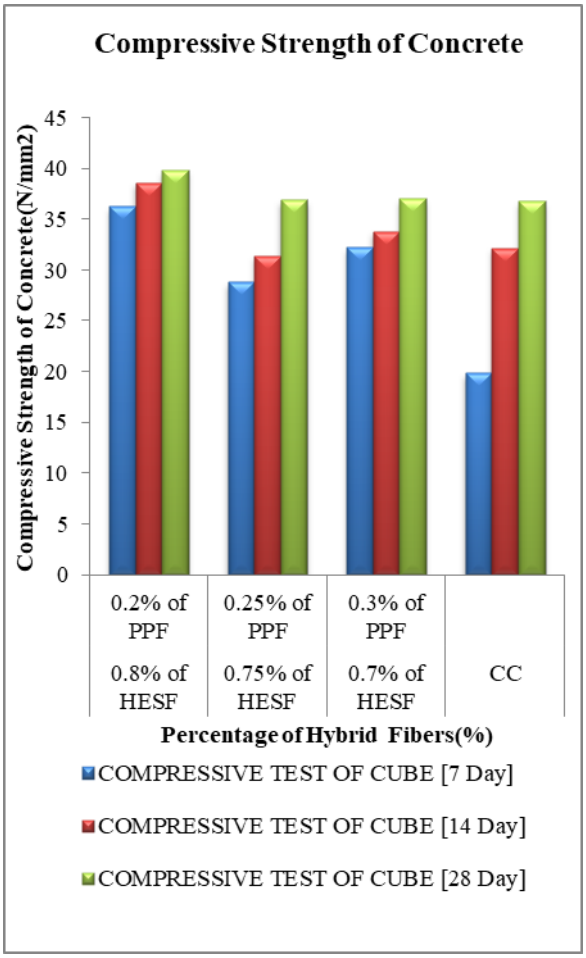

Fig.5 Comparison of Compressive Strength of HFRC with Conventional concrete

C. Split Tensile Strength Hybrid Fiber Concrete

Determining the tensile strength is essential to evaluate the load at which the specimens may initiate crack. The tests were conducted by keeping the cylindrical specimens horizontally between the compression test loading surfaces and the load was applied until the cylindrical fails by splitting along the vertical diameter, the test procedure is carried out in accordance with IS 5816:1999 guidelines. As a result of an elastic analysis due to compression loading, a good uniform tensile stress is achieved over nearly $2/3^{th}$ of the loaded diameter. For this test, 3 cylinders of diameter 150 mm and length 300 mm were cast and tested at 7^{th}, 14^{th} and 28^{th} days. The split tensile strength of cylinders is given in Table 3 and Figure 6 show the split tensile test. Figure 7 shows the comparison of the split tensile strength of HFRC with conventional concrete in which 0.75% of HESF & 0.25% of PPF shows the highest Split tensile strength of 3.09 N/mm2

Fig.6 Testing of Cylinder Specimen

Table 3 Split Tensile Strength Test Results

S.No	HESF	PPF	Split Tensile Strength of Concrete (N/mm^2)		
			7 Days	14 Days	28 Days
1	0.8%	0.2%	2.56	2.75	2.99
2	0.75%	0.25%	2.3	2.67	3.09
3	0.7%	0.3%	2.44	2.83	2.94
4	Conventional		2.26	2.59	2.73

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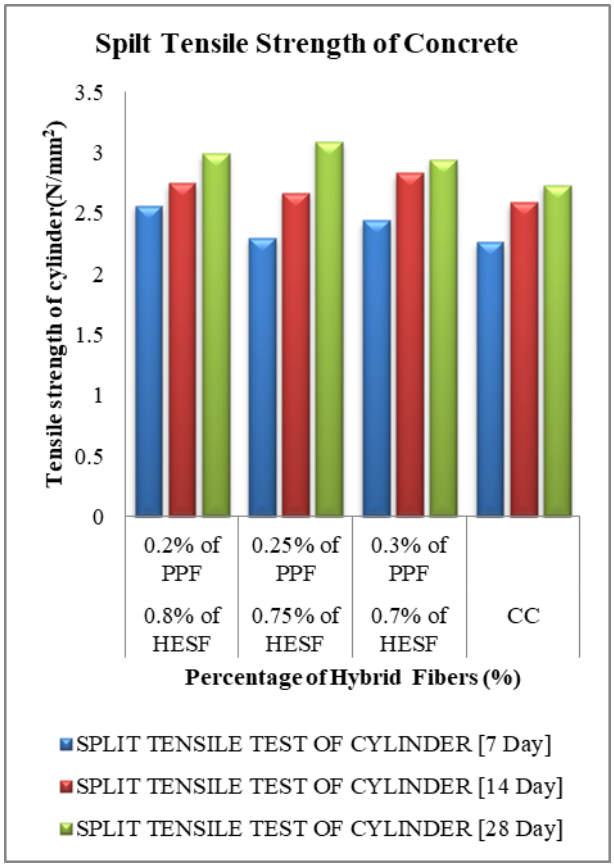

Fig.7 Comparison of Spilt Tensile strength of HFRC with Conventional Concrete

D.Effect of Hybrid Fiber in Flexural Strength of Concrete

Flexural strength testing is a mechanical parameter for fragile material, which has been defined as a material capable of resisting load deformation. For this study, four point load flexural tests were performed on test beams of length 500mm and width 0f 100mm. Beams were casted and tested on the 7th day, 14th day and 28th day. These beams were tested in Universal Testing Machine (UTM) under 4 point loading as per the code IS 516-1959.

Table 4 shows the results of the flexural strength test and Figure 8 shows the four - point beam bending test. Figure 9 shows the Comparison of Flexural strength of hybrid fiber reinforced concrete with conventional concrete in which 0.8% of HESF & 0.2% of PPF shows highest Flexural strength of 9.75 N/mm2

Fig.8 Flexural Test on Beam Specimen

Table 4 Flexural Strength Test Results

S.No	HESF	PPF	Flexural Strength of Concrete (N/mm²)		
			7 Day	14 Day	28 Day
1	0.8%	0.2%	4.2	5	9.75
2	0.75%	0.25%	4.83	6.38	9.23
3	0.7%	0.3%	4.68	6.32	8.98
4	Conventional		3.8	4.4	5.2

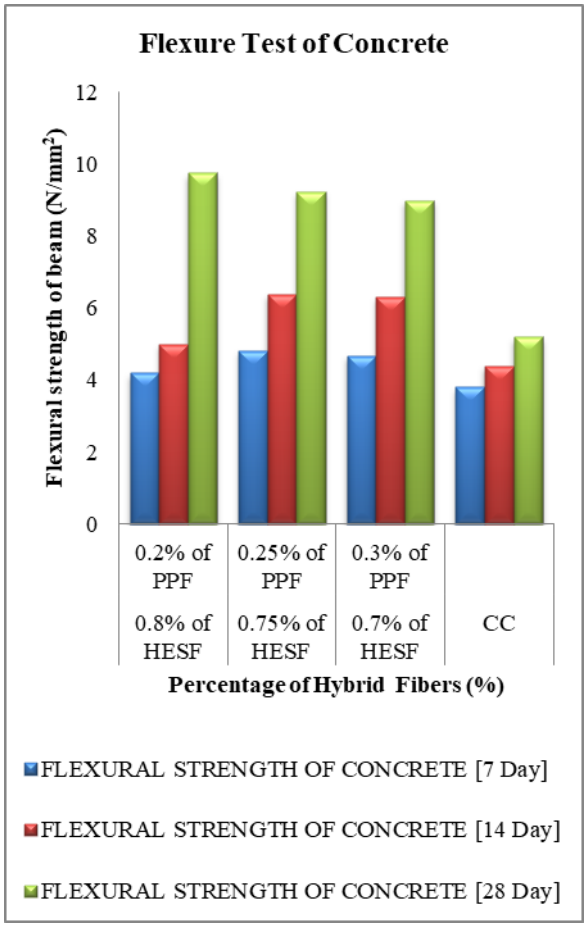

Fig.9 Comparison of Flexural strength of HFRC with Conventional Concrete

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IV. RESULT

Following results were found on mechanical properties of hybrid fibers.

• The compressive strength of concrete of hybrid fiber addition of ratio 0.8% of HESF and 0.2% PPF shows the maximum percentage increase of 26% of conventional concrete.

• Flexural strength of concrete of hybrid fiber addition of ratio 0.8% of HESF and 0.2% PPF shows the maximum percentage increase 87% and minimum increase of 72% of ratio 0.7% of HESF and 0.3% PPF in the flexural strength of the beam when compared with conventional concrete.

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