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Strength Behavior Of Hybrid Fiber Reinforced Concrete

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Abstract

In this study Grade of concrete M20, Steel fiber reinforced concrete and Hybrid fiber (Composition of steel and Polyolefin) reinforced concrete strength properties were studied experimentally. The hooked end steel fibers were added into the concrete from 0.5% to 2.0% with increment of 0.5% volume fraction. The steel and polyolefin fibers were added with combination of 0.5 % (20% polyolefin + 80% steel fiber), 1% (30% polyolefin + 70% steel fiber), 1.5% (40% polyolefin + 60% steel fiber), and 2% (50% polyolefin + 50% steel fiber). The Flexural and Tensile Strength of the conventional, steel Fiber Reinforced Concrete (FRC) and Hybrid Fiber (polyolefin + steel fiber) Reinforced Concrete (HFRC) specimens experimental test results were compared.

Key words: FRC, HFRC, Strength, Concrete.

1 INTRODUCTION

Plain concrete is having a very low tensile strength, inadequate ductility and small resistance to cracking. The tensile strength of concrete can be improved by using conventional reinforced steel bars and also by applying restraining techniques. Although both these methods provide tensile strength to the concrete members, however, do not increase the tensile strength of concrete by itself. It has been recognized that the addition of uniformly discrete fibers to concrete would act as crack arrester and would substantially improve its properties [1]. This type of concrete is known as Fiber Reinforced concrete. The characteristics of the fibre reinforced concrete depend on the fibre material, amount, geometry, distribution, orientation, and densities of the fibres used. Steel fibers reinforce the concrete in its hardened stage,

thereby improving its strength and ductility [2]. Synthetic fibres give the increased durability and toughness of the concrete. The major difference between steel and synthetic fiber is their respective young's modulus and tensile strength. In this paper investigated the Splitting tensile strength and modulus of rupture of concrete with hooked steel fibers and Hybrid fibers with various volume fractions. The strength behavior of the steel fiber reinforced concrete and synthetic fiber reinforced concrete is compared with the values of conventional concrete.

2 EXPERIMENTAL PROGRAMS

2.1 Materials

The cement used in concrete mixes was ordinary Portland cement 53 grade as per IS 12269- 1987. The fine aggregate used was local river sand with specific gravity of 2.6. Size of Coarse aggregate 20 mm and the specific gravity was 2.65. The fibers used in the study were Hooked end steel of length 35mm , diameter 0.7 mm , polyolefin straight fiber of Length - 54mm, Thickness - 1.38 x 0.41 mm are shown in Figure 1.

(a) Steel Fibers

(b) Polyolefin Fibers

Figure1. Fibers Used

The M20 grade of concrete mix proportion was designed by using IS 10262 [3] as shown in Table 1. The super plasticizer Conplast - SP430 was added to the concrete for maintaining the workability of concrete when the fibers were added to it. The proportions of materials were maintained same for all specimens casting work, the volume fraction of fibers only vary and treated as study parameters.

Table -1. Concrete Mix Proportions for 1m^3 Concrete

Cement (kg)	Fine Aggregate (kg)	Coarse Aggregate(kg)	Water (kg)
407.65	574.78	1175.25	191.61

2.2 Preparation of specimens

To determine the compressive strength of concrete 150 mm size cube was used, for Splitting tensile strength 150 mm x 300 cylinders were used, and for flexural strength of concrete 100mm x 100 mm x 500 mm prisms were used. In the preparation of concrete, coarse aggregate, fine aggregate cement were initially mixed in dry state. Then the water, the super plasticizers Conplast SP 430 already mixed with 50 % of required quantity water was added into the mix then the well prepared mixed concrete added with the fibers manually and maintains uniform distribution by proper mixing operations. The well prepared mix of concrete, steel fiber reinforced concrete and hybrid fiber reinforced concrete specimens were cast with above moulds with proper compaction. Each mix three specimens were cast and the specimens were demoulded after 24 hours and then placed in a curing tank for 28 days.

2.3 Test procedure

The compressive strength of cube, Splitting tensile strength of cylinders and Flexural strength of prisms were tested using 200 T Compressive Strength Testing Machine. The compressive strength of cube specimens at 28 days from casting were conducted as per the Code provision of IS 516 – 1959 (reaffirmed 1999). The average value of the strength was 28.10 N/mm^2. The compressive strength of Cube load set up as shown Figure.2

Figure2. Compressive strength of cube

2.3.1 Splitting Tensile Strength

Each parameters three cylinders were tested and their average value is reported. The

Splitting tensile strength of concrete was determined in accordance with Indian Standards IS: 5816-1999[7]. The loading set up as shown in Figure.3. Splitting tensile strength was calculated as: Splitting Tensile strength (N/mm^2) = $2P / \pi DL$, P=failure load, D= diameter of cylinder, L=Length of cylinder.

Figure3. Splitting Tensile strength of Cylinder

2.3.2 Flexural Strength

The tests were carried out conforming to IS 516-1959[8] to obtain the flexural strength of Concrete. The loading set up as shown in Figure 4. Three standard prism specimens were cast for all parameters and tested under third-point loading. The load was applied without shock and increasing continuously at a rate such that the extreme fibre stress increases at approximately 0.7kg/sq cm/min that is, at a rate of 180kg/min . The load was increased until the specimen fails, and the maximum load applied to the specimen during the test was noted and Modulus of rupture ($f_{cr)}$ was calculated by using the following formula.

$$f_{cr} = PL/bd^2$$

P = Maximum applied load indicated by the testing machine, L = Effective Span, d = Average depth of the specimen, b = Average width of the specimen

Figure4. Flexural Strength test set up

3 Results and Discussion

Test results of all fiber concretes are shown in Table 2. The Splitting tensile strength of concrete is increased by adding of steel fiber up to 1.5% volume fraction, the strength effectiveness is 37.20% compare with normal strength concrete. In the hybrid form 2% volume fraction with S50%-P50% (HFRC2) combination gave more strength compare with the normal strength concrete, the strength effectiveness is 20.67% but the hybrid fiber combination of all fiber volume fractions increased the strength with increase of fiber volume compare with Normal Strength Concrete (NSC) shown in Figure 5.

Table-2. Test Results of Fiber Reinforced Concrete

S. No	Fiber Volume Fraction V_f (%)			Splitting Tensile Strength at 28 Days (N/mm^2)		Modulus of Rupture at 28 days ($N/mm^{2)}$	
	Steel	Polyolefin	Total	Measured value	Strength Effectiveness (%)	Measured value	Strength Effectiveness (%)
NSC	0	0	0	3.87	0	4.4	0
FRC0.5	0.5	0	0.5	4.03	4.13	4.8	9.09
HFRC0.5	0.3	0.2	0.5	3.96	2.32	6.4	45.55
FRC1	1	0	1	4.6	18.86	7.2	63.63
HFRC1	0.7	0.3	1	4.17	7.75	5.6	27.27
FRC1.5	1.5	0	1.5	5.3	36.95	8	81.8
HFRC1.5	0.9	0.6	1.5	4.31	11.37	4.8	9.09
FRC2	2	0	2	4.03	4.134	7.6	72.72
HFRC2	1	1	2	4.67	20.67	5.2	18.18

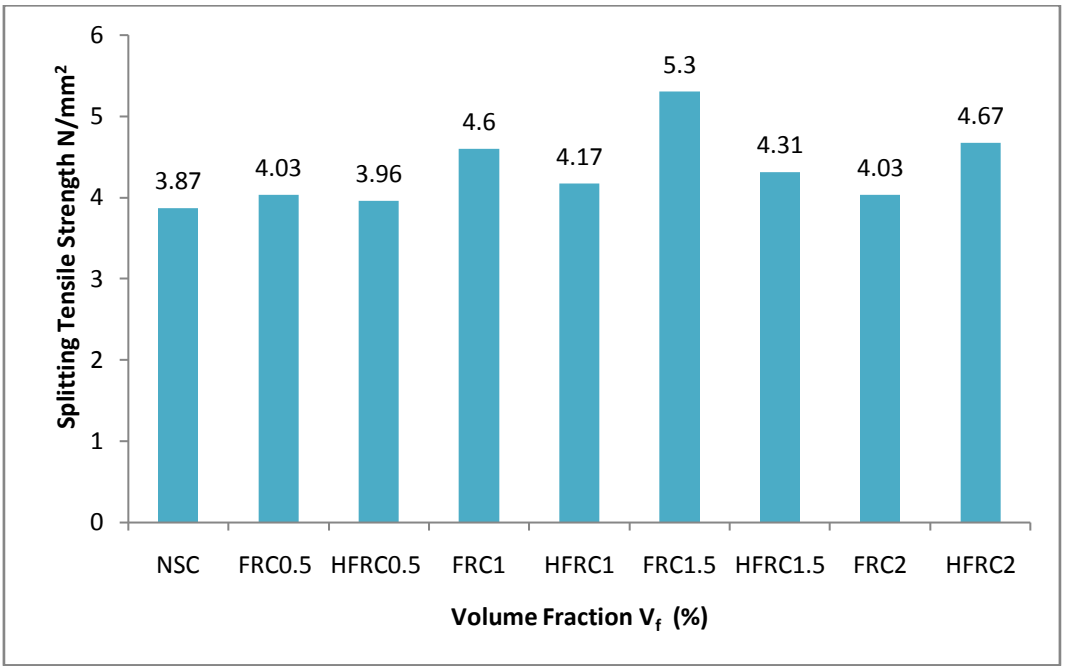

Figure5. Splitting Tensile Strength of NSC, FRC, and HFRC

The modulus of rupture of steel fiber reinforced concrete and hybrid fiber reinforced concrete test results are shown in Table 1. It shown that the 1.5% steel fiber reinforced concrete gave more strength, and strength effectiveness is 81.82% compare with the normal strength concrete. Hybrid fiber reinforced concrete 0.5% (S80-P20%) gave more strength compare with the normal strength concrete. The results are plotted as bar chart for comparison shown in Figure 6.

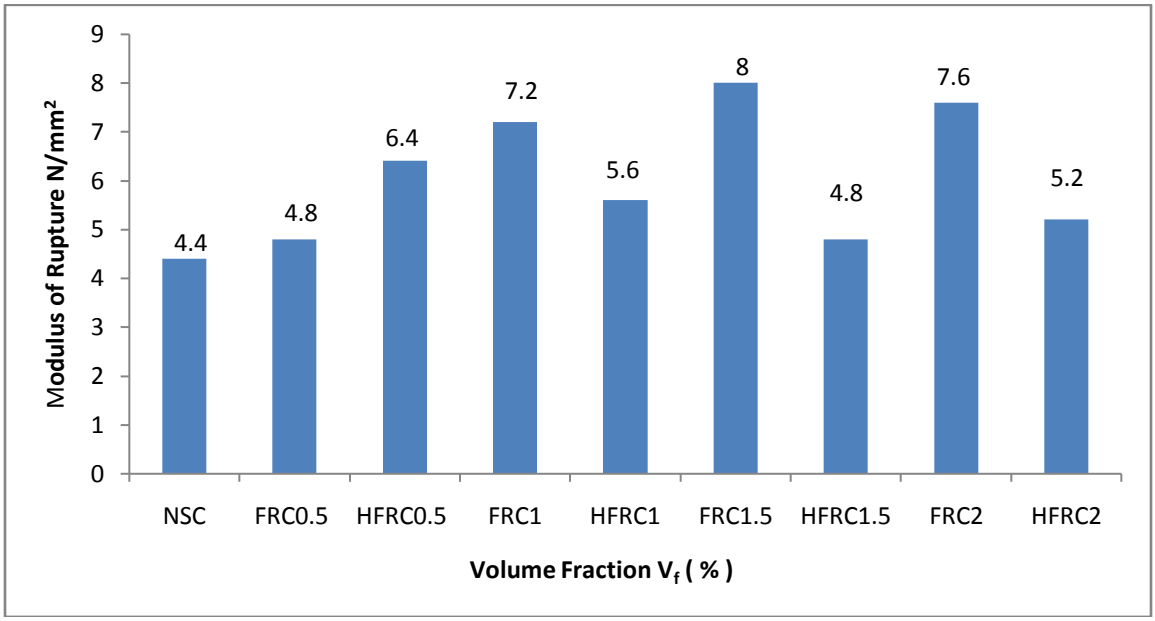

Figure6. Modulus of Rupture of NSC, FRC, and HFRC

4 Conclusions

The following conclusions were made from the experimental Investigation of normal strength concrete and steel fiber reinforced concrete and hybrid fiber reinforced concrete.

The Splitting tensile strength of steel fiber reinforced concrete was increase with increase of fiber volume fraction from 0.5% to 1.5% after that the value was reduced but it was more than the conventional concrete.

The Splitting tensile strength of Hybrid fiber reinforced concrete was increase with increase of fiber volume fraction compared with conventional and steel fiber reinforced concrete.

The flexural strength of steel fiber reinforced concrete was increased with increase of fiber volume fraction up to 2%, compare with conventional concrete.

The flexural strength of Hybrid fiber reinforced concrete was increased for all composition, the 0.5% (Steel 80%, Polyolefine20%) gave more strength compared with other composition and conventional concrete.

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