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Experimental Study on Hybrid Fiber Reinforced Concrete

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Abstract—*Hybrid fiber-reinforced concrete is a type of fibre-reinforced concrete characterized by its composition. It contains at least two or more types of fibres of different sizes, shapes or origins. Considering that, fibres of different types have different effects on the properties of fresh and hardened concrete. The suitable combinations of two types of fibers in the FRC has not yet been classified. The research has been going on to study about the mechanical properties of the HFRC all over the world. But the research on the combinations of fibers in the HFRC are still scanty. In this study, an attempt is made to study the HFRC by using steel and polypropylene fibers. With the volume of fraction of 1% in different proportions of steel-polypropylene fibers such as 100-0%, 75-25%, 50-50%, 25-75% and 0-100% were used. The HFRC showed improved result.*
HFRC – Hybrid fiber-reinforced concrete

1. INTRODUCTION

In India, most of the construction activities are made with concrete as it is easily available. It is known that concrete being a brittle material has low tensile strength as a result; the mechanical behavior of concrete is critically influenced by crack propagation. Concrete in service may exhibit failure through cracks. Recent development in concrete shows interest in the fiber hybridization. To improve the properties of concrete, developments going on fiber hybridization. A macro-crack propagates at a stable rate until it attains conditions of unstable propagation and a rapid fracture is precipitated. Addition of small closely spaced and uniformly dispersed fibers to concrete would act as crack arrester and would substantially improve its static and dynamic properties. The fiber reinforcement may be used in the form of three dimensionally randomly distributed fibers throughout the structural member when the added advantages of the fiber to shear resistance and crack control can be further utilized.

Research in the HFRC was done recently. The characteristic feature of these concretes is that they contain less than one volume percentage of fibers of varying shape, length and origin. The hybrid fibers are used in the concrete mixture, the same properties of concrete can be obtained as those exhibited by conventional FRC but with the addition of a smaller amount of fibers.

2. EXPERIMENTAL PROGRAMME

2.1 Materials

2.1.1Steel fibre

In this experimentation, Hook end Steel fibers (L=30 mm, diameter=0.5 mm) were used.

2.1.2 Polypropylene

Fibrillated 20 mm cut length fibers were used.

2.1.3 Fine Aggregate

The sand used for the experimental program was locally procured and conformed to grading zone II as per IS: 383-1970 having specific gravity 2.67 and fineness modulus of 2.48.

2.1.4 Coarse Aggregate

Locally available coarse aggregate having the size of 20mm were used in the present work. Testing of coarse aggregates was done as per IS: 383-1970 having specific gravity 2.75and fineness modulus of 2.68.

2.1.5 Ordinary Portland cement

OPC 53 grade cement is used for this whole experimental study. The physical test results on OPC are as follows.

1) Normal consistency = 22%
2) Initial Setting time = 30 min.
3) Final Setting Time = 10 hrs.
4) Specific Gravity = 3.15

2.2 Concrete

An M30 mix is designed as per guidelines in IS 10262, 1982 based on the preliminary studies conducted in the constituent materials.

The properties of concrete were shown in Table 1

Table 1: Properties of concrete

S. No	Tests conducted on cement	Values obtained
1	Slump test	65mm
2	Vee-bee test	15 sec
3	Compaction factor	0.95
4.	Flow test	79%

2.2.1Mixture Proportioning of M_{30} concrete

Concrete for M30 grade were prepared as per (I.S.10262:2009 with w/c 0.55. Mix proportion for M30 grade concrete were shown in table 2.

Table 2: Mix proportion of M30 grade concrete

w/c ratio	Cement	Fine aggregate	Coarse aggregate
191.6 lit	425.78 Kg	673.85 Kg	1157.75 Kg
0.45	1	1.58	2.72

2.2.2 Mixture proportioning of fibre

Different proportions of steel and polypropylene fibers are shown in table3.

Table 3: Different proportions of fibers

Notation	Steel Fibers by Volume of Concrete (%)	Polypropylene Fibers by Weight of Cement (%)
HFRC S0-0%	0	0
HFRC S0-P100%	0	1
HFRC S25-P75%	0.25	0.75
HFRC S50-P50%	0.50	0.50
HFRC S75-P25%	0.75	0.25
HFRC S100-P0%	1	0

2.3 Testing methods

Testing is done as per following IS code. The testing done for compressive strength of cubes were measured 7, 14, 28 days as per (IS : 516 – 1959) ,the testing done for flexural strength of beam were measured 7,14, 28 days as (per IS : 5816 - 1999) and the testing done for split tensile strength of cylinder were measured 7,14,28 days as per (IS : 516 – 1959). To know the properties of HFRC on mortar, we performed different tests.

3. RESULTS AND DISCUSSIONS

Compressive Strength Results of Compressive strength for M-30 grade of concrete on cube specimen with 0%, 0% 100-0%, 75-25%, 50-50%, 25-75% and 0-100% are shown in table4 and Fig. 1:

Table 4: Compressive strength for M_{30} grade concrete after 7, 14, 28, days

Sl. No	Percentage (s- p fiber)	Compressive strength (N/mm2)		
		7-Days	14-Days	28-Days
1.	0-0%	21.4	23.5	31.7
2.	100-0%,	23.65	25.58	34.2
3.	75-25%,	24.33	25.92	36.5
4.	50-50%,	24.16	27.13	39.7
5.	25-75%,	25.57	27.36	41.2
6.	0-100%	24.54	25.42	39.5

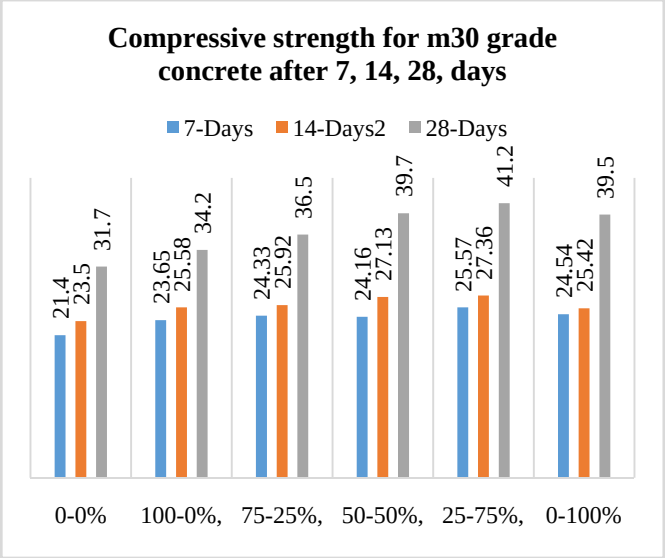

Fig. 1: Compressive strength for M30 grade concrete after 7,14,28 days

B Tensile strength Results of splitting tensile strength for M-30 grade of concrete with 0% 0%, 0% 100-0%, 75-25%, 50-50%, 25-75% and 0-100% fibers are shown in table5 and Fig. 2

Table 5: Split tensile strength for m_{30} grade concrete after after 7, 14, 28, days

Sl. No	Percentage (s- p fiber)	Split tensile strength (N/mm2)		
		7-Days	14-Days	28-Days
1.	0-0%	2.37	2.642	3.17
2.	100-0%,	3.19	3.317	4.74
3.	75-25%,	3.228	3.463	4.42
4.	50-50%,	3.04	3.402	3.81
5.	25-75%,	3.007	3.878	4.25
6.	0-100%	2.92	3.716	3.833

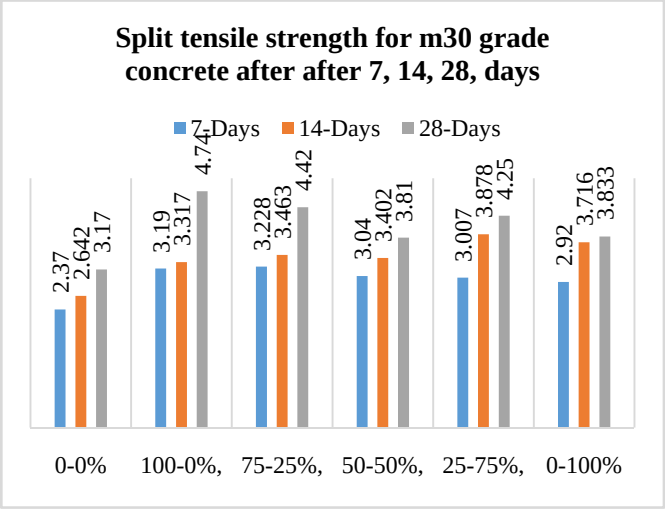

Fig. 2: Split tensile strength for M30 grade concrete after 7,14,28 days

C Flexural strength Results of Flexural tensile strength for M-30 grade of concrete with 0% 0%, 0% 100-0%, 75-25%, 50-50%, 25-75% and 0-100% fibers are shown in table6 and Fig. 3

Table 6: Flexural strength for m_{30} grade concrete after 7, 14, 28, days Table 6

Sl. No	Percentage (s- p fiber)	Flexural strength (N/mm2)		
		7-Days	14-Days	28-Days
1.	0-0%	2.659	3.55	3.87
2.	100-0%,	3.905	4.25	4.21
3.	75-25%,	3.998	4.671	4.63
4.	50-50%,	4.042	4.768	4.96
5.	25-75%,	3.68	4.622	5.49
6.	0-100%	3.36	4.167	4.33

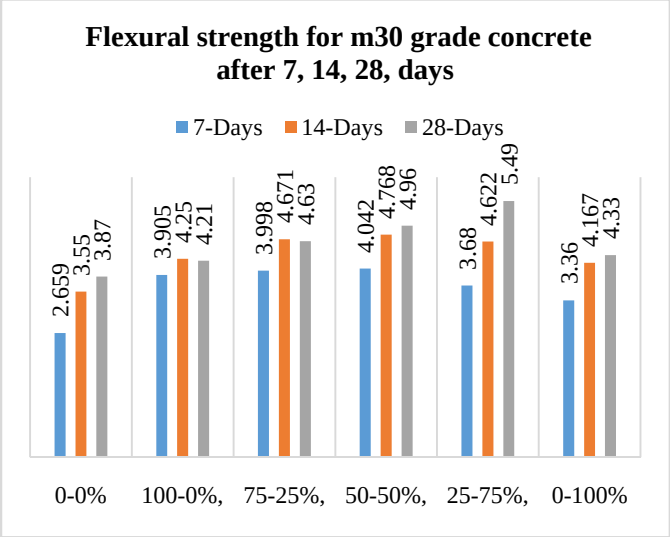

Fig. 3: Flexural strength for M30 grade concrete after 7,14,28 days

4. CONCLUSIONS

The hybrid fiber reinforced concrete, indicated that a combination of steel and polypropylene fibers can be effectively used to optimize the behavior of concrete in fresh and hardened states. On the basis of the investigations conducted, Addition of fibers in concrete proves to give the desired strength in concrete.

The addition of fibers 100-0%,75-25%,50-50%,25-75%,0-100%(steel- polypropylene fiber in concrete, with reference to the test results it was found that, for M_{30} concrete the compressive strength increased with addition up to 25-75%and then started to decrease, hence the inclusion of steel fiber should be limited up to the specified percentage.

It was found that, for M_{30} concrete the tensile strength increased with addition up to 75-25% and then decreased, but not less than the conventional ones.

It was found that, for M_{30} concrete the flexural strength increased with addition up to 50-50%, and then decreased, but not less than the conventional ones.

The study on the effect of hybrid fibers with different proportions can still be a promising work as there is always a need to overcome the problem of brittleness of concrete.

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