An Experimental Study on Properties of Hybrid Fiber Reinforced Concrete

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Abstract— Hybrid Fiber Reinforced Concrete (Hy-FRC) is formed from a combination of two or more different types of fibres, which differ in material properties, remain bonded together when added in concrete and retain their identities and properties. The combining of fibers, often called hybridization, is investigated for a M20 grade concrete at a fraction of 0.5% in this paper. Control and three different hybrid fiber ratios were cast using different fiber proportions of polypropylene and coir fibers at the ratio of 70 % and 30 %. Compressive strength, split tensile strength and flexural strength test were performed and results were analyzed to associate with above fiber combinations. Based on experimental studies, the paper identifies fiber combinations that demonstrate maximum compressive, split tensile and flexural strength of concrete. To evaluate the strength parameters different tests are conducted and results are tabulated. Hybrid ratio 0.5 % gives maximum results in all the strength parameters compare to other different hybrid ratios, that the strength was observed as increased up to 45 % while adding 0.5 % hybrid fibers.

Key words: Polypropylene Fiber, Coir Fiber, Hybrid Fiber, Hybridization

I. INTRODUCTION

Concrete is an ancient material of construction, first used during the Roman Empire. It is a composite material composed of water, coarse granular material (the fine and coarse aggregate or filler) embedded in a hard matrix of material (the cement or binder) that fills the space among the aggregate particles and glues them together. It is characterized by the quasi-brittle failure, the loss of load bearing capacity once the failure of the concrete is initiated. This character limits the application of the concrete and it can be overcome by introducing the short randomly distributed fibers to remedy the weakness of concrete, such as high shrinkage cracking, low durability, etc. The usage of fiber in concrete results in the improved strength and durability of the concrete and also the fiber alters the behavior of the concrete because of fiber matrix. While adding two different types of fibers into the concrete, the composite structure gives the maximum strength.

The objective of this project is to study the strength parameter which includes the compressive strength, split tensile and flexural strength of the hybrid fiber reinforced concrete with different proportions of fiber composites for M20 grade concrete and to determine the optimum percentage of the addition of fiber composite by comparing the strength of the hybrid fiber reinforced concrete with the conventional concrete.

II. MATERIALS AND METHODS

A. Materials

1) Cement

Ordinary Portland Cement (OPC) 53 grade confirming to IS 12269 -1987 is available in the local market and was used in the present studies.

Specific Gravity	3.02
Soundness of cement	5 mm
Consistency	32%
Initial Setting Time	39
Final Setting Time	296

Table 1: Test result on cement

2) Fine Aggregate

Locally available river sand passing through 4.75 mm confirming to IS 383 – 978 is used as fine aggregate for this study.

3) Coarse Aggregate

Locally available aggregates those are 20mm down size coarse aggregates were used for this study. Properties are tabulated below.

Property	Fine aggregate	Coarse aggregate
Specific Gravity	2.38	2.76
Water Absorption	0.75 %	0.5 %
Fineness Modulus	3.27	5.88
Shape of aggregate	-	Angular

Table 2: Test result on aggregates

4) Water

Portable water confirming to IS 456-2000 was used for casting and as well as for curing.

5) Polypropylene Fibres

In present study, the polypropylene fibres (PPF) with 12mm cut length having the tensile strength of 350–550 mpa is used.

6) Coir Fibres

In this study, the coir fiber with 12mm cut length is used.

Property	PPF	Coir fiber
Specific Gravity	0.90	1.00
Length	12 mm	12 – 16 mm
Diameter	30 to 35 micron	0.29 to 0.83 mm
Aspect ratio	350	75

Table 3: Properties of fiber used

B. Mix Proportion

Mix of concrete	% of Fibers to the weight of cement (%)	Polypropylene Fiber to the percentage of fiber required (%)	Coir Fiber to the percentage of fiber required (%)
M 1	0	0	0
M 2	0.5 %	70 %	30 %

M 3	1.0 %	70 %	30 %
M 4	1.5 %	70 %	30 %

Table 4: Mix proportion of specimens

III. RESULT AND DISCUSSION

A. *Fresh Concrete Test Results*

Mix	M 1	M 2	M 3	M 4
Slump (mm)	60	60	55	50
Vee bee (sec)	8.5	9	10	10.5
Compaction Factor	0.92	0.91	0.90	0.88

Table 5: Test results of fresh concrete

B. *Hardened Concrete Test Results*

1) *Compressive Strength Test*

Mix	Average compressive strength (N/mm^2)			
	M 1	M 2	M 3	M 4
7 days	13.63	19.7	18.22	16.74
14 days	17.11	23.41	21.33	19.26
28 days	20.89	28.58	24.89	23.52

Table 6: Compressive strength of specimen

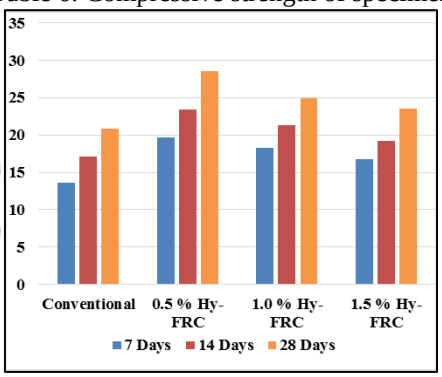

Fig. 1: Compressive strength of specimens

2) *Split Tensile Strength Test*

Mix	Average split tensile strength (N/mm^2)			
	1	M 2	M 3	M 4
7 days	1.34	2.45	18.22	2.36
14 days	2.36	3.35	21.33	3.01
28 days	2.74	3.86	3.56	3.42

Table 7: Split tensile strength of specimen

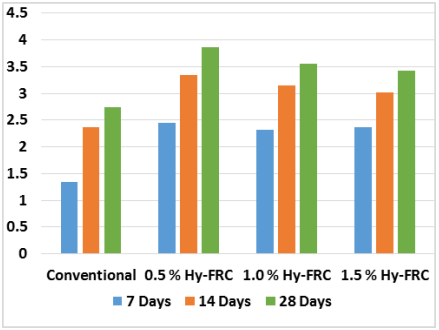

Fig 2: Split tensile strength of specimens

3) *Flexural Strength Test*

Mix	Average flexural strength (N/mm^2)			
	M 1	M 2	M 3	M 4
7 days	4.75	7.83	6.75	5.5
14 days	6.37	10.75	9.25	8.83
28 days	9.5	14.75	11.5	10.5

Table 8: Flexural strength of specimen

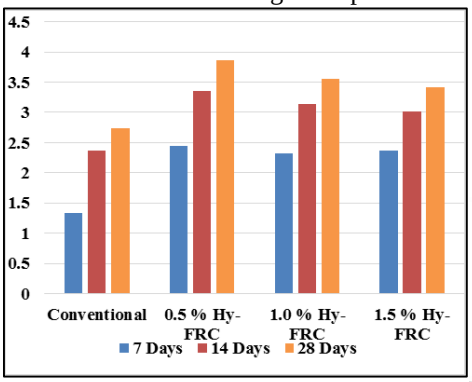

Fig. 3: Flexural strength of specimens

C. *Variation in Strength*

The variation of strength of mix proportions were tabulated below. The strength obtained for each proportions were compared with the strength obtained from the conventional specimen at respective days of testing.

Fiber Added (% to the weight of cement)	Variation in strength compared to Conventional Specimens (%)			
	Strength Parameter	Day of testing		
		7 days	14 days	28 days
0.5 %	Compressive Strength	+ 45	+ 41	+ 65
	Split Tensile Strength	+ 37	+ 42	+ 69
	Flexural Strength	+ 37	+ 41	+ 55
1.0 %	Compressive Strength	+ 34	+ 33	+ 42
	Split Tensile Strength	+ 25	+ 33	+ 45
	Flexural Strength	+ 19	+ 30	+ 55
1.5 %	Compressive Strength	+ 23	+ 30	+ 16
	Split Tensile Strength	+ 13	+ 28	+ 39
	Flexural Strength	+ 13	+ 25	+ 11

Table 9: Strength variation obtained on various mix

IV. CONCLUSION

The study on the hybrid fiber reinforced concrete is a promising work as there is always a need to overcome the problem of brittleness of concrete. The maximum compressive strength reaches in the hybrid fiber fraction 0.5% consists of 70% polypropylene fiber and 30% coir fiber. The strength is obtained as an average of 63% more by adding 0.5% of the hybrid fibers to the weight of cement. The increasing of fiber composites in the concrete reduces the strength and also affects the workability of concrete and it was clearly seen from slump values obtained for each mix.

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