

Experimental Investigation on Hybrid Fiber Reinforced Concrete

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ABSTRACT: Plain cement concrete is good at providing reasonable compressive strength but it tends to be brittle in nature and is weak in tensile strength, and minimum resistance to cracking, poor toughness. To overcome the deficiencies of concrete, fibers are added to enhance the performance of concrete. In the present study hybrid fibers consists of two different types of fiber combinations i.e. glass and polypropylene fibers are used with conventional concrete. The fiber proportions of 0%, 0.25%, 0.5%, 0.75%, 1% and 1.25% by weight of cement is used. Strength parameters are compressive strength and split tensile strength will be tested and results were analyzed.

KEYWORDS: Hybrid fiber, glass and polypropylene fibers, Compressive Strength, Tensile strength.

I. INTRODUCTION

In civil engineering construction, concrete is a major construction material used in all over the world. These construction materials have inherently brittle in nature and have some of the dramatic demerits are overcomes such as poor deformability of concrete and weak crack resisting properties. Is also weak in tensile strength parameter and flexural strength is relatively low as compared to their compressive strength. Fibers are added to improve these factors. Basically hybrid concrete containing, two or more different types of fibres are rationally combined to produce a composite that derives benefits from each of the individual fibres and exhibits a synergistic response in concrete. And also its increases the structural integrity of concrete .Basically fibers can be divided into following two types (a).High elastic modulus of fibers for example: nylon, cellulose fiber, and polypropylene fiber etc.(b).Lower modulus of elasticity of fibres for example: steel, glass fiber, etc. Fibres having lower modulus of elasticity are added to the concrete is expected to enhance strain performance of concrete, whereas fibres having higher modulus of elasticity are enhance the strength performance of concrete. Moreover, the addition of heterogeneous types of fibres to makes the concrete more homogeneous and isotropic and therefore it is transformed from brittle in to ductile material. [4]

II. LITERATURE REVIEW

A. Study on the strength properties of concrete using hybrid fiber reinforced concrete.

- **Qian and Stroeven (2000).** They had investigated that basic purpose of using heterogeneous types of fibres in concrete is to control micro cracks at different size levels in different zones level of concrete (interfacial transition zone between aggregate and cement paste) at different curing ages of concrete and stress levels. The hybridization of fibres in concrete can be done in different ways that is by combining different length and diameters of fibers and geometry, moduli and tensile strength of fibres. [5]
- **Selin (2011).**In this paper highlights the study of strength and fire resistant property using glass fibers for M25 grade concrete, the experimental results was found that addition of 1% fibers gave maximum strength. They had concluded that higher the percentages of fiber addition lower will be degradation of concrete strength. [6]

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Special Issue 9, May 2016

- **Konapure and Kalyankar (2015).** This paper highlights the investigate the HFRC such as basalt fiber reinforced concrete (BFRC) & polypropylene fiber (PP) on the normal mix. Addition of 0.5% Fibers results is marginal increase in Compressive & Flexural Strength of Concrete. The flexural strength is improved for 0.5% fiber & decreased for 1% fiber this may be because of fibrillated nature of basalt & polypropylene fiber which affect the homogeneity of concrete. [7]
- **Harish and Anandh (2015).** Outline of this paper on M20 grade concrete using various combinations of hybrid fibers i.e., Coconut fiber and recron fibre. The overall test results that showed maximum Compressive strength and tensile strength is attained when the fibre quantity is 1% for coconut fibre and 1% for recron fibre. [8]
- **Leshma (2015).** In this paper highlights the HFRC in exterior beam with the use of steel and synthetic fibres (Polypropylene). The M40 grade concrete used. The compressive strength of the HFRC reached a maximum at 0.38%ST&0.12%PP volume fraction, being a 7.5% improvement over the SFRC. [9]

III. OBJECTIVES

The experimental work was carried out to overcome the problems created in plain cement concrete, the following aim and objectives are derived. The main aim of present work is to evaluate the mechanical properties hybrid fiber reinforced concrete. Objectives are:

- To determine the optimum strength obtained by using different proportion of hybrid polypropylene fiber and glass fiber in concrete.
- This study attempts to compare the strength parameters of HFRC with conventional concrete.
- To perform the experiments on the time- dependent compressive strength, split tensile strength of concrete containing mixed glass fiber and polypropylene fiber and its strength were measured at the age of 7 and 28 days curing period.
- To study the crack arresting ability of fibers in concrete.

IV. MATERIALS USED

A. Cement: In the present work PPC fly ash based (Ultra-Tech) cement is used throughout the work.

Table 1: Physical properties of PPC (per IS: 1489-Part-I 1991)

Sl. No.	Characteristics	Obtained Value	Standard Value
1	Normal Consistency Test	32%	25% - 33%
2	Initial Setting Time Test	95 min.	Not less than 30 min
3	Final Setting Time Test	320 min	Not grater then 600 min.
4	Specific Gravity Test	3.04	3.15

B. Fine aggregate: A locally available fine aggregate used for the experimental program and passing through 4.75mm IS sieve as per IS 383 provision recommended. The specific gravity is found to be 2.5. The water absorption is found to be 1.28%. Fineness modulus is - 2.59 and aggregate confirming to zone II as per IS 383-1970.

C. Coarse aggregate: Locally available course aggregate having 20 mm down size and confirming to IS 383 are used in the present investigation work. The specific gravity is found to be 2.68. The water absorption is found to be 0.64% and fineness modulus – 7.03 are found.

D. Chemical admixture: An economical admixture based on modified polycarboxylic ether superplasticizer (MasterPolyheed 8340) was used, it is high range water reducing agent (upto 10%), conforms to ASTM C494 and IS: 9103-1999.

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E. **Glass fibers:** In this study chopped strand mat glass fiber is used with properties- Type: Alkali-resistant (AR), Material: chopped MAT glass fiber, Density: 400/300 GSM (Grams per square meter), Length: 40 to 50 mm, Tensile strength: 2-3 GPa, Specific gravity is 2.6, Mechanical properties: good bonding. Glass fiber is brought from Covai seenu & company hubballi, Karnataka.

F. **Polypropylene fibers:** In this study Fibrillated 12 mm cut length fibers were used. These polypropylene fibers were brought from Pragathi industries Pvt.Ltd. Mysore, Karnataka .Their properties are as shown in below.

Table 2: Properties of polypropylene fibers

Length of fiber	12mm Cut
Specific gravity	0.91
Elongation	25-40%
Young's modulus	(5500-7000)MPa



Figure 1: Sample of Glass fibers



Figure 2: Sample of Polypropylene fiber

G. Percentage variation of fibers in mix:

The proportions of two combination of hybrid fibers (Glass & Polypropylene) used in concrete mix were at volume fractions of 0% , 0.25% , 0.5% , 0.75% , 1% and 1.25% for each proportion equal quantity (50% of both) of fibers are added to the mix by the weight of cement. The percentages are given in table No.3.

Table 3: Percentages of fibers in each mix

Designation for concrete mix	GF and PPF by Weight of cement (%)
AL0	0%
AL1	0.25%
AL2	0.5%
AL3	0.75%
AL4	1%
AL5	1.25%

V. DESIGN MIX FOR M30 GRADE CONCRETE

Mix design can done as per IS 10262-2009. [1][2]

Grade designation : M₃₀
Type of Cement : PPC
Target Strength : $f_{ck}+1.65(s) = 38.25 \text{ N/mm}^2$

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 9, May 2016

Cement content : 443.2 kg/m³
 Water/Cement ratio : 0.4
 River sand content : 715.5 kg/m³
 Coarse aggregate : 1044 kg/m³
 Chemical admixture : MasterPolyheed 8340 (0.8% by weight of Cement)

Table 4: Mix Proportions

Cement (kg/m ³)	Fine Aggregate (kg/m ³)	Coarse Aggregate (kg/m ³)	Water (lit./m ³)	Admixture (lit./m ³)
1	1.614	2.355	0.4	0.8%

❖ **TESTS CONDUCTED ON SPECIMENS.**

- Compression Tests , Split Tensile Tests , the testing will be done as per I.S Specifications
 The strength parameters of concrete specimens were evaluated for 7 and 28 days of curing period. Compressive testing machine were used for performing the compression tests and split tensile tests, with capacity of 200T is used. Size of cube specimen is 150 X 150 X 150mm and cylinder specimen is 150 (dia) X 300 (depth) are used.

VI. RESULTS AND DISCUSSIONS

❖ **Compressive strength of cubes:**

Table 5: Effect on Compressive strength of concrete for different % HFRC.

Designation for concrete mix	Total volume fraction of hybrid fibers (%)	7 Days Strength (N/mm ²)	28 Days Strength (N/mm ²)
AL0	0%	28.14	35.99
AL1	0.25%	29.18	37.03
AL2	0.5%	31.25	38.36
AL3	0.75%	32.29	38.51
AL4	1%	34.66	40.29
AL5	1.25%	31.99	37.62

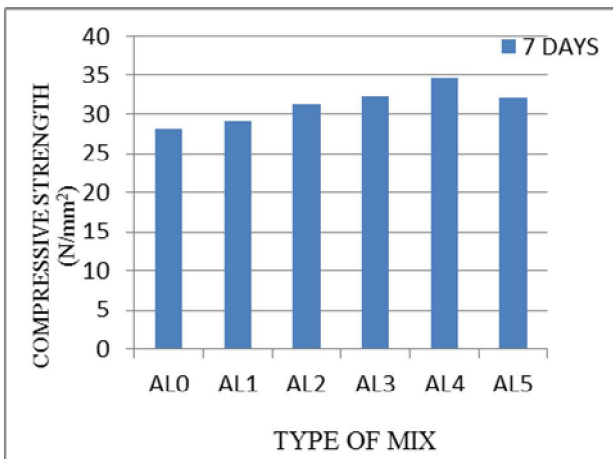


Figure 3: Compressive Strength for 7 days curing

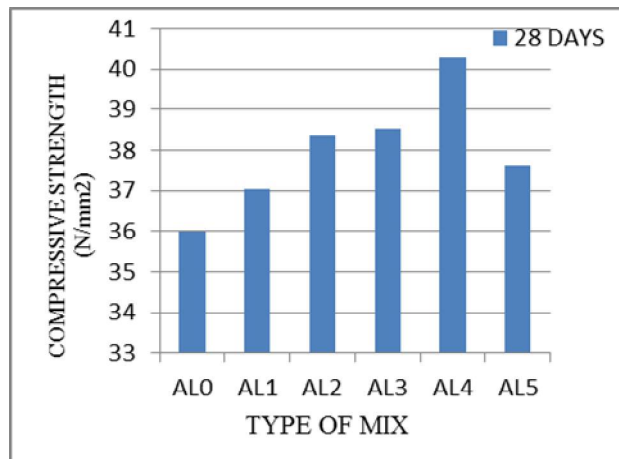


Figure 4: Compressive Strength for 28 days curing

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 9, May 2016

- From Table No. 5 it was observed that, with increase in fibre percentage, the compressive strength also increases with age of concrete. Particularly in case of hybrid fibers of HFRC (Glass fiber and polypropylene fiber) of M₃₀ mix. From the experimental investigation ,at the age of 7 days curing, the compressive strength at 0.25% , 0.5% , 0.75% , 1.0% and 1.25% were, 29.18 N/mm², 31.25 N/mm², 32.29 N/mm², 34.66 N/mm² and 31.99 N/mm² respectively. The percentage increase in strength at 0.25% , 0.5% , 0.75% , 1.0% and 1.25% were 3.69% , 11.05% , 14.74% , 23.16% and 13.68% respectively compared to plain cement concrete of strength 28.14 N/mm². The maximum increase in compressive strength at 1.0% hybrid fibers in HFRC of M30 mix was found to be 23.16%. It is the optimum strength at 7 days curing of cubes specimen. Further increase in fibers content of 1.25% addition of fibers there is a decreased strength of concrete cubes specimen.
- After 28 days curing period, the compressive strength at 0.25% , 0.5% , 0.75% , 1.0% and 1.25% were 37.03 N/mm² , 38.36 N/mm² , 38.51 N/mm² , 40.29 N/mm² and 37.62 N/mm² respectively. The percentage increase in strength at 0.25% , 0.5% , 0.75% , 1.0% and 1.25% were 2.88% , 6.58% , 7.00% , 11.94% , and 4.52% respectively compared to plain cement concrete of strength 35.99 N/mm². The test results it was observed that, the maximum increase in compressive strength at 1.0% of addition of hybrid fibers in HFRC is found to be 11.94% as compared to plain cement concrete. Further increase in fibers content decreased strength parameter of concrete. For 1.25% addition of hybrid fibers strength was 4.52% greater than plain cement concrete.

❖ **Split Tensile strength of cylinders [3]**

Table 6: Effect on Split tensile strength of concrete for different % HFRC.

Designation for concrete mix	Total volume fraction of hybrid fibers (%)	7 Days Strength (N/mm ²)	28 Days Strength (N/mm ²)
AL0	0	2.58	3.57
AL1	0.25	2.72	3.96
AL2	0.5	2.92	4.28
AL3	0.75	3.01	4.42
AL4	1	3.20	4.33
AL5	1.25	2.87	3.91

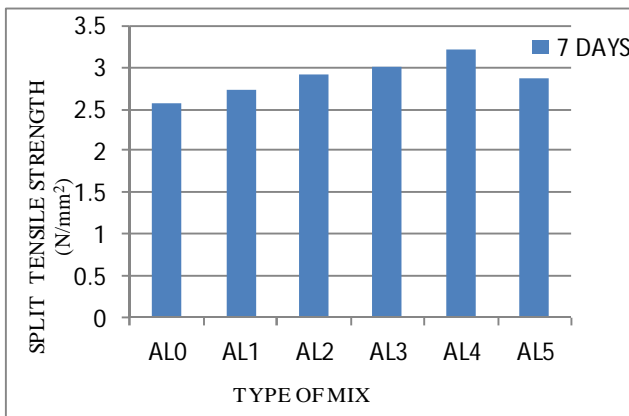


Figure 5: Tensile strength for 7 days curing

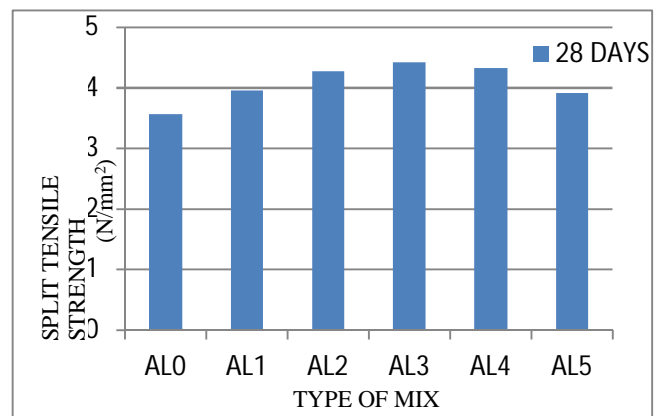


Figure 6: Tensile strength for 28 days curing

- From Table No.6, the Split Tensile strength test results of cylindrical specimens at age of 7 days and 28 days age of curing. The tensile strength at the age of 7 days curing period, it is found to be 0.25% , 0.5% , 0.75% , 1.0% and 1.25% were , 2.72 N/mm² , 2.92 N/mm² , 3.01N/mm² , 3.20 N/mm² and 2.89 N/mm² respectively. The

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Vol. 5, Special Issue 9, May 2016

percentage increase in split tensile strength at 0.25% , 0.5% , 0.75% , 1.0% and 1.25% were 5.42% , 13.17% , 16.66% , 24.03% and 12.01% respectively compared to plain cement concrete of strength 2.58 N/mm². The overall experimental test results was observed that, the maximum increasing Split Tensile strength of hybrid fiber reinforced concrete at the age of 7 days curing period is derived to be 1% of strength 3.20 N/mm²

- The 28 days curing period of Split Tensile strength at 0.25 , 0.5% , 0.75% , 1.0% and 1.25% were 3.96 N/mm² , 4.28 N/mm² , 4.42 N/mm² , 4.33N/mm² and 3.96N/mm² respectively. The percentage increase in strength at 0.25% , 0.5% , 0.75% , 1.0% and 1.25% were 10.92% , 19.88% , 23.80% , 21.28% and 10.92% respectively compared to conventional concrete of strength 3.57 N/mm². The maximum increase in Split tensile strength of hybrid concrete at age of 28 days, it is found to be 0.75% of hybrid mix is 23.80% than compared to plain cement concrete. Further increase in fibers content decreased the tensile strength of concrete specimen, it is found to be 1%, and 1.25% addition hybrid mix. Strength was found to be 21.28% and 10.92% greater than plain cement concrete.

VII. CONCLUSION

- In this study it is attempted to test and analyze the compressive strength of concrete cubes specimens for the 7 days and 28 days of curing. It is observed that addition of 1 % of hybrid fibers in HFRC there is a maximum compressive strength obtained. But it is not same for 1.25% addition of hybrid fibers, because it was found that, there is decline in compressive strength of cubes specimen. Hence optimum fiber content for the present study on compressive strength indicated it to be at 1%.
- The experimental study indicates that, split tensile strength of cylindrical specimens is increased at 1% addition of hybrid fibers in HFRC. It is the maximum split tensile strength of 7 days curing period of cylindrical specimen, and further addition of hybrid fibers will not increase the tensile strength.
- At the age of 28 days curing, the split tensile strength of cylindrical specimens is increased with addition of hybrid fibers of 0.75%. Further it was observed that, there is a sudden decrease in strength for 1 % and 1.25%.
- During experimentation of split tensile test, it was found that crack formation was slower than conventional concrete. This shows that HFRC is better in avoiding propagation of cracks
- The fire resisting properties of Glass fibers are used to build the innovative concrete structures.

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