An Experimental Investigation on Hybrid Fiber Reinforced Concrete Produced Using PPC & subjected to Sulphate Attack

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Abstract - *In this experimental investigation work is carried out on effect of Hybrid Fiber Reinforced Concrete. The strength of concrete for M30 grade has been studied by varying the percentage of fibers in concrete. Basalt Fiber and Steel Fibers are used in this experiment. In this experiment fixed 2% of total dosage of fiber content was fixed. Fiber content were varied by 0%BF-SF, 25%BF-75%SF, 50%BF-50%SF and 75%BF-25%SF of total dosage(i.e. 2%) by weight of cement. Cubes, Beams, Cylinders and Shear specimens are casted to check the compressive, flexural, Split tensile and Shear strength of concrete. In this experiment it is also aimed to study the effect HFRC when subjected to sulphate attack. Here study cited on effect of sulphate on hybrid fiber reinforced concrete. Also checking the strength parameters compare the test results with sulphate and without sulphate attack. Results are taken after 28days curing and 60days of sulphate attack. The optimum fiber content while studying the strength parameters of all specimens is found 75%BF-25%SF. Here seen that 75% of Basalt Fiber content giving more strength of 2% in both with sulphate and without sulphate attack.*

Key Words: **Basalt Fibre, Steel Fibre, Hybrid Fibre Reinforced Concrete, Compressive Strength, Split Tensile Strength, Shear Strength, and Duarabilty.**

1. INTRODUCTION

Concrete is a widely or fully known used material on earth. It is a material which consists of cement, aggregates, water and so on. Concrete is one of the foremost production materials. For that reason concrete plays crucial role in the layout and construction field. Concrete made using OPC or PPC has unique advantages and find it irresistible and strong in sustaining compressive load but susceptible in maintaining tension forces and accordingly has a tendency to get brittle. Concrete is composite substances which compose of granular material like aggregates which is firmly and deeply repair in the matrix and ensure with cement or binder and glues them together. The fundamental fault in concrete is that it starts to develop cracks because the concrete is positioned and before it has hardened. Those cracks are fundamental cause of reducing the power of concrete and causing failure and lack of durability assets. This drawback towards tension can be conquered through using steel reinforcement and to a degree by using addition fibers within the concrete.

1.1 Hybrid Fibre Reinforced Concrete (HFRC)

Hybrid fiber reinforced concrete characterized by its mixture and also known to the situation in which two or more fiber act And/or co-operation of the two or more fibers that acts as a secondary reinforcement in the concrete in which interaction between fibers is implemented to produce a combined effect.

Fiber reinforced concrete (FRC) is concrete were the addition of fibers to concrete contains fibers that are uniformly distributed in concrete. The weakness in tension can be overcome by the use of sufficient volume of certain fibers. In order to improve the mechanical properties of concrete it is good to mix cement with fiber which have good tensile strength. Addition of fibers to concrete greatly increases the toughness of the material. The use of fibers also alters the behavior of the fiber matrix composite after it has cracked, thereby improving its toughness. When two different fibers added to concrete to make the composite structure gives maximum strength to concrete that type of concrete is hybrid fiber reinforced concrete (HFRC).

2. OBJECTIVE OF THE STUDY

There are numerous studies on the strength characteristic of concrete containing fly ash. However, there is little study in the literature regarding the strength of Hybrid Fiber Reinforced Concrete with fibers subjected to sulphate attack. Thus the main aim of this work is to study the effect of variation of fiber content from 0% (BF-SF) to 75%BF-25%SF in Hybrid Fiber Reinforced Concrete under sulphate attack. It is also aimed to study the effect of fibers on HFRC with different sulphate expose condition. The studies are made to evaluate the compressive strength, tensile strength, flexural strength and shear strength subjected to sulphate media.

3. MATERIALS USED

3.1 Cement

In the present research work Portland Pozzolona Cement is used. The tests on cement were conducted in accordance with Indian standards confirming to IS: 8112 – 1989[8]. The specific gravity of cement is 3.15.

Table -1: Properties of PPC

Sl.no.	Particulars	Experimental Results	As Per Standard
1	Fineness	268m2/kg	225m2/kg
2	Soundness		
	Le Chatelier	1.00mm	10mm
	Autoclave	0.16	0.8 maximum
3	Setting time (min)		
	Initial Set	150 minute	30
	Final Set	270	600

3.2 Fine Aggregate

The fine aggregates used in this experimental program is procured locally from Ghataprabha river bed. The test on sand is conducted according to IS: 2386 – 1963 and IS:383-1970.

Table-2: Properties of Fine Aggregate

Properties	Results
Zone of Fine aggregate	1
Specific Gravity	2.6
Loose Bulk Density	1284 kg/m^3
Compacted Bulk Density	1556 kg/m^3

3.2 Coarse Aggregate

Locally available crushed granite coarse aggregates having maximum size of 20 mm are used in the present work. The aggregates are tested as per IS: 2386-1963. The specific gravity was found to be 2.82.

3.3 Super plasticizer

Conplast- SP430, a concrete super plasticizer based on Sulphonated Naphthalene Polymer is used as a water-reducing admixture and to improve the workability of fly ash concrete.

3.4 Steel Fiber

Crimped steel fibers manufactured by M & J International, India (P) Ltd., Mumbai, are used in the present study. The aspect ratio is 50.

3.4 Basalt Fiber

Basalt fibers brought by Nickunj Eximp Pvt, Ltd. India (P) Ltd., Mumbai, are used in the present study. The density of fiber is 2.63.

3.5 Mix Proportion

The mix proportion was carried as per IS CODE 10262-2009 and using the preliminary test results. The mix proportion of 1:2.02:3.73 was arrived with water to binder ratio of 0.4 for M30 concrete.

4. EXPERIMENTAL TEST PROCEDURE

The design mix of M30 concrete is designed in accordance with the guidelines of IS: 10262-2009 and using the preliminary test results. PPC cement is used in this experiment. The mix proportion arrived is 1:2.02:3.73 (BC: FA: CA) with water binder ratio of 0.4 and super plasticizer dosage of 1% (by weight of cement). Fibers are added at varying percentages of 0%BF-SF, 25%BF-75%SF, 50%BF-50%SF and 75%BF-25%SF, of total dosage of 2% of total fiber content, by weight of cement.

The specimens are cast for compressive strength, split tensile strength, flexural strength and shear strength test. The specimens are cured in water for 28 and then the specimens are subjected to sulphate attack for 60 days. They are immersed in magnesium sulphate solution of 10% concentration for 60 days. After 60 days of sulphate attack, the specimens are removed from the sulphate media and weighed accurately. Then they are tested for their respective strengths.

5. EXPERIMENTAL TEST RESULTS

5.1 Overall results of Compressive Test

Following table 3 gives the overall results of compressive strength of HFRC for 28 and when subjected to sulphate attack for 60 days with magnesium sulphate solution of 10% concentration. Also it gives the percentage increase or decrease of compressive strength with respect to reference mix. Variation in the compressive strength can be depicted in the form of graph as shown in fig 1.

Table 3: Overall Results of Compressive Strength

Different % of Basalt Fiber and Steel Fiber Added (2% total fiber content)	28 Days Mean Compressive strength (MPa)	% Variation With respect to Reference Mix	60 Days Mean Compressive strength (MPa)	% Variation With respect to Reference Mix
0% (ref. mix)	39.40	-	42.52	-
25%BF-75%SF	42.36	7.51	44.44	4.51
50%BF-50%SF	45.18	14.67	48.30	13.59
75%BF-25%SF	46.07	16.92	51.90	22.06

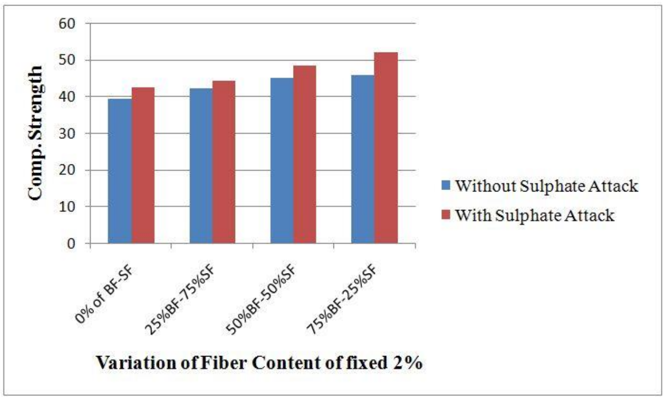

Chart -1: Variation in Compressive Strength

5.2 Overall results of Split tensile Test

Following table 4 gives the overall results of compressive strength of HFRC for 28 and when subjected to sulphate attack for 60 days with magnesium sulphate solution of 10% concentration. Also it gives the percentage increase or decrease of compressive strength with respect to reference mix. Variation in the compressive strength can be depicted in the form of graph as shown in fig 2.

Table 4: Overall Results of Split Tensile Strength

Different % of Basalt Fiber and Steel Fiber Added (2% total fiber content)	60 Days Mean Tensile strength (MPa)	% Variation With respect to Reference Mix	60 Days Mean Tensile strength (MPa)	% Variation With respect to Reference Mix
0% (ref. mix)	3.64	-	3.95	-
25%BF-75%SF	3.67	0.82	4.13	4.55
50%BF-50%SF	3.96	8.79	4.57	15.69
75%BF-25%SF	4.38	20.32	4.89	23.79

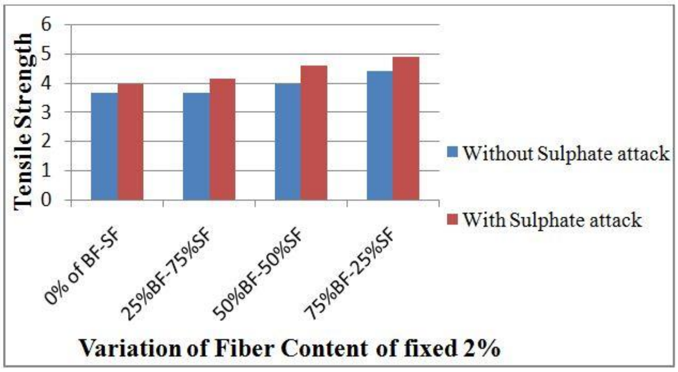

Chart -2: Variation in Split Tensile Strength

5.3 Overall results of Flexural Test

Following table 5 gives the overall results of compressive strength of HFRC for 28 and when subjected to sulphate attack for 60 days with magnesium sulphate solution of 10% concentration. Also it gives the percentage increase or decrease of compressive strength with respect to reference mix. Variation in the compressive strength can be depicted in the form of graph as shown in fig 3.

Table 5: Overall Results of Flexural Strength

Different % of Basalt Fiber and Steel Fiber added(2% total fiber content)	28 Days Mean Flexural strength (MPa)	% Variation With respect to Reference Mix	60 Days Mean Flexural strength (MPa)	% Variation With respect to Reference Mix
0% (ref. mix)	6.45		6.80	
25%BF-75%SF	6.83	5.89	7.23	6.32
50%BF-50%SF	6.99	8.37	7.52	10.58
75%BF-25%SF	7.15	10.85	7.90	14.70

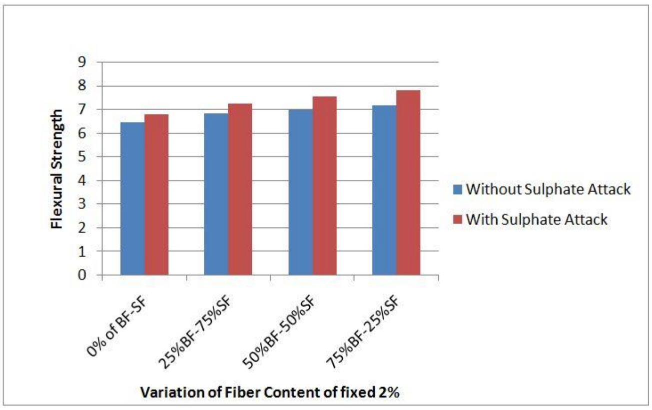

Chart -3: Variation in Flexural Strength

5.4 Overall results of Shear Test

Following table 6 gives the overall results of compressive strength of HFRC for 28 and when subjected to sulphate attack for 60 days with magnesium sulphate solution of 10% concentration. Also it gives the percentage increase or decrease of compressive strength with respect to reference mix. Variation in the compressive strength can be depicted in the form of graph as shown in fig 4.

Table 6: Overall Results of Split Tensile Strength

Different % of Basalt Fiber and Steel Fiber added(2% total fiber content)	28 Days Mean Shear strength (MPa)	% Variation With respect to Reference Mix	60 Days Mean Shear strength (MPa)	% Variation With respect to Reference Mix
0% (ref. mix)	5.63	-	5.96	-
25%BF-75%SF	574	1.95	6.33	6.20
50%BF-50%SF	6.14	9.05	6.67	11.91
75%BF-25%SF	6.59	17.05	6.92	16.10

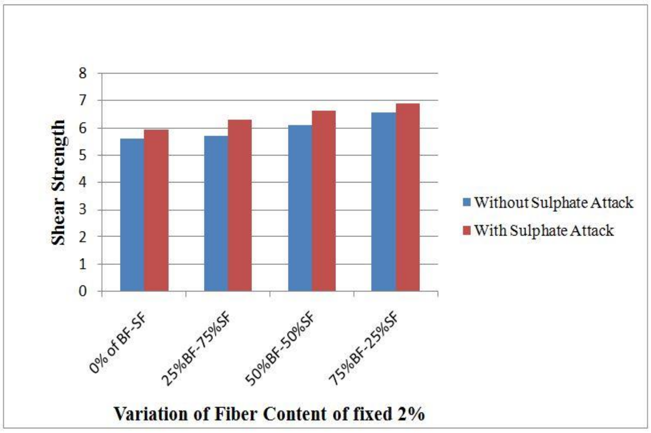

Chart -4: Variation in Split Tensile Strength

6. OBSERVATIONS AND DISSCUSSION

The following observations were made out of the experimentation conducted on the effect of Sulphate attack on the properties of concrete produced by adding Basalt Fiber and Steel Fiber.

6.1 Compressive Strength

It has been observed that the compressive strength goes on increasing as the addition or variation of fibers takes place. The comp. strength achieves maximum strength when addition 75%BF-25%SF of 2% of total fiber content. The compressive Strength is slightly lesser when 50%BF-50%SF added than the 75%BF- 25%SF of addition.

It has been also observed that specimens subjected to Sulphate Attack for 60 days attended the more strength compare to the normal curing which are not subjected to Sulphate Attack. Specimens shows slight increase in weight when subjected to sulphate attack compare to without subjected to sulphate attack. Therefore compressive strength increases because of addition of fibers.

6.2 Split Tensile Strength

It has been observed that the split tensile strength goes on increasing as the addition or variation of fibers takes place. The split tensile strength achieves maximum strength when addition 75%BF-25%SF of 2% of total fiber content. The split tensile strength is slightly lesser when 50%BF-50%SF added than the 75%BF- 25%SF of addition.

It has been also observed that specimens subjected to Sulphate Attack for 60 days attended the more strength compare to the normal curing which are not subjected to Sulphate Attack. Specimens shows slight increase in weight when subjected to sulphate attack compare to without subjected to sulphate attack. Therefore tensile strength increases because of addition of fibers.

6.3 Flexural Strength

It has been observed that the flexural strength goes on increasing as the addition or variation of fibers takes place. The flexural strength achieves maximum strength when addition 75%BF-25%SF of 2% of total fiber content. The flexural strength is slightly lesser when 50%BF-50%SF added than the 75%BF- 25%SF of addition.

It has been also observed that specimens subjected to Sulphate Attack for 60 days attended the more strength compare to the normal curing which are not subjected to Sulphate Attack. Specimens shows slight increase in weight when subjected to sulphate attack compare to without subjected to sulphate attack. Therefore flexural strength increases because of addition of fibers.

6.4 Shear Strength

It has been observed that the shear strength goes on increasing as the addition or variation of fibers takes place. The shear strength achieves maximum strength when addition 75%BF-25%SF of 2% of total fiber content. The shear strength is slightly lesser when 50%BF-50%SF added than the 75%BF- 25%SF of addition.

It has been also observed that specimens subjected to Sulphate Attack for 60 days attended the more strength compare to the normal curing which are not subjected to Sulphate Attack. Specimens shows slight increase in weight when subjected to sulphate attack compare to without subjected to sulphate attack. Therefore shear strength increases because of addition of fibers.

6.5 Discussion:

Whenever fibers are added to a concrete matrix an act as discrete material. Fibers consistence Basalt Fiber and Steel Fiber are added. Steel Fiber imparts more ductility and Basalt Fiber adds more strength and stability. Therefore strength parameters increase because of addition of fibers.

When the specimens are subjected to Sulphate Attack since we are using PPC (Portland Pozzolana Cement) some amount of fly ash is present in it which reacts with the sulphate media and it fills minuet pores which are present in the concrete matrix making the concrete denser. Hence the strength of specimens when subjected to sulphate attack shows enhances strength properties. When the sulphate media reacts with concrete it gives a right pozzolonic reaction is induced at allowed to room temperature because of which the target mean strength has increased than what was expected.

7. CONCLUSIONS

Following conclusions can be drawn based on the study conducted

From the above observations and discussions we conclude that addition of fibres in different proportions increases the strength of concrete.

a. When Basalt fiber and Steel fiber added in ratio of 75%BF-25%SF of fixed 2% of total dosage of fiber content it attains maximum strength of concrete.
b. When concrete specimens are subjected to sulphate attack it has shown increased strength as compared to specimens without subjected to sulphate attack.
c. Therefore, it is recommended that 75%BF-25%SF of 2% dosage can be added to the concrete for effective strength.

d. Similarly the higher Compressive strength of HFRC when subjected to sulphate attack is observed at 75%BF-25%SF and the percentage increase in compressive strength is 22.06%.
e. Similarly the higher Split tensile strength of HFRC when subjected to sulphate attack is observed at 75%BF-25%SF and the percentage increase in Split tensile strength is 23.79%.
f. Similarly the higher Flexural strength of HFRC when subjected to sulphate attack is observed at 75%BF-25%SF and the percentage increase in Flexural strength is 14.70%.
g. Similarly the higher Shear strength of HFRC when subjected to sulphate attack is observed at 75%BF-25%SF and the percentage increase in Shear strength is 16.10%.

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