# To Study The Structural Behaviour of Steel And Plastic Fibres

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***Abstract-*** *Fibre reinforced concrete is a most broadly used solution for improving compressive, tensile and flexural strength of concrete. Reinforcement of concrete with a single type of fiber may improve the desired properties to a limited level. A composite is termed as hybrid. The objective of this research is to investigate and compare the compressive, flexural and tensile strength of concrete for various mixture proportion of concrete. In this research, the effect of inclusion of plastic and steel fibers on the compressive, flexural and tensile properties of fiber reinforced concrete using M45 grade concrete was studied. Control and five hybrid fiber composites were cast using different fiber proportions of steel and plastic at a total volume fraction of 0.80%. The experimental work was divided into five group. Each group consists of 6 cubes (150 mm x 150 mm x 150 mm), 6 cylinder (300 mm x 150 mm dia.) and 6 beam (500 mm x 100 mm x 100 mm). Compressive strength, split tensile strength and flexural strength test were performed and results were extensively analyzed to identify performance synergy.*

***Keywords***- Hybrid fibre, Fibre reinforced concrete ,Plastic fibre,Compressive strength,Flexural strength,Tensile strength

## I. INTRODUCTION

Concrete is a material which is made by combination of hydraulic cement, water, coarse aggregate and fine aggregate. Concrete in general has a higher brittleness with increase in strength. This is a major drawback since brittleness can cause sudden and catastrophic failure, especially in structures which are subjected to earthquake, blast or impact load. This serious disadvantage of concrete can at least partially be overcome by the incorporation of fibers, especially, steel bars.

Steel bars only reinforce the concrete against local tension . Cracks in reinforced concrete members extend freely until encountering bars are not provided. Hence need for multidirectional and closely spaced steel reinforcement rises which cannot be practically possible. Fibre reinforcement resolve this problem which provide multidirectional and closely spaced steel reinforcement. Thus to enhance the tensile strength of concrete a technique is introduced to use of fibres in concrete . These fibres act as crack arrestors and prevent the circulation of the cracks. These fibres are uniformly distributed and randomly arranged. This concrete is named as fibre reinforced concrete. The main causes for adding fibres to concrete matrix is to improve the post cracking response of the concrete, i.e. to improve its energy absorption capacity and apparent ductility, and to provide crack resistance and crack control. It also helps to maintain structural integrity and cohesiveness in the material which gives better performance than the normal concrete. The addition of more than one kind of fibre is called hybrid fibre reinforced concrete which develops benefit from each of the individual fibre and further increases the performance of concrete.

## II. EXPERIMENTAL INVESTIGATION

Detailed descriptions about the materials used, specimens tested and testing methods are essentials for an experimental investigation. Hence they are described in detail in the following sections.

### Details of specimens

In order to determine the strength characteristics of HFRC using steel and plastic fibres in different proportions, compressive strength tests, split tensile strength tests, and flexural strength tests were carried out for M45 grade concrete using total volume of fibre fraction of 0.80%. In total 90 no. of tests specimen were cast (30 cubes for compressive strength test, 30 beams for flexural strength test and 30 cylinder for tensile strength test). The experimentalwork was divided into five group. Each group consists of 6 cubes (150 mm x 150 mm x 150 mm), 6 cylinder (300 mm x 150 mm dia.) and 6 beam (500 mm x 100 mm x 100 mm).

### Casting and curing of specimens

The constituent materials of concrete, viz., Cement, Sand and aggregates were tested as per the relevant Indian codes of Practice. Concrete was mixed in a tilting type drum mixer and plastic fibres were added to it and mixed thoroughly.

All the moulds of cubes, cylinders and beams were properly cleaned .In the inner surface of the moulds a thin layer of oil was applied to avoid the adhesion of concrete with the inner side of moulds. For each mix, six cubes of 150 mm x 150 mm x 150 mm were cast for compressive strength test, six cylinders of sizes 300 mm x 150 mm were cast for split tensile strength test and six beams of sizes 100 mm x 100 mm x 500 mm were cast for flexural strength test.

Concrete was placed uniformly over the length of the mould in three layers and compacted satisfactorily. After compacting the entire concrete, the excess concrete at the top of the mould was stuck off with a wooden straight edge and the top finished by a trowel. Demoulding was done after 24 hours and the specimens were cured under water. The specimens were kept in clean water tank continuously moist till the time of testing.

## III. TESTING DETAILS

Three types of tests were performed on all concrete batches, namely, Compressive strength and Split tensile strength and flexural strength.

### Compressive strength test

Compressive strength test is initial step of testing concrete because the concrete is primarily meant to withstand compressive stresses. Compressive strength test was carried out on 150 mm x 150 mm x 150 mm cubes with compression testing machine of 2000 KN capacity. The specimens after removing from the curing were cleaned and properly dried. The surface of the testing machine was cleaned. The cube was then placed with the cast faces in the contact with the plates of the testing machine. Cubes were tested at 28 and 56 days of curing. In each category, three cubes were tested and their average value is reported.

### Splitting tensile strength test

The split tensile test are performed for determining the tensile strength of concrete. The test consists of applying of compressive line load along the opposite generators of a concrete cylinder placed with its horizontal axis between the plates. Cylinders were tested at 28 and 56 days of curing. In each category, three cylinders were tested and their average value is reported

### Flexural Strength Test

Flexural strength test is requisite to estimate the load at which the concrete members may crack. The specimens cast for this test were of shape of a square prism of side 100 mm and axis length of 500 mm. Specimens were tested at 28 and 56 days of casting for strength analysis.

## IV. TEST RESULTS

### Compressive strength

The 28 day and 56 day cube compressive strength of plain concrete and fiber reinforced concrete specimens obtained from tests are given in Table 1 and 2.

### Split tensile strength

The Split tensile strength of fiber reinforced concrete specimens obtained from tests after 28 day and 56 day are given in Table 3and Table 4 respectively.

### Flexural Strength

Flexural Strength test were conducted on total 30 specimen for five different mixes and the result were carried out by taking an average from three test specimen for each mix which were shown in Table 5 and Table 6.

## V. ANALYSIS OF TEST RESULTS

### Comparison of compressive strength

The influence of the addition of 0.80% fiber on the mixes tested is compared with various concrete mixes over plain concrete and It is seem from the tables that with the introduction of 100% plastic fibres to the plain concrete, the compressive strength drops to 35.7 MPa from 40.1 MPa resulting in approximately 10% reduction. That is with the introduction of less quantity of steel fibre content. There is considerable reduction in compressive strength properties. However, an increase in the compressive strength of fibrous concrete is observed with the addition of steel fibres to the mix and maximum compressive strength is obtained for concrete containing 75% steel fibres+25% plastic fibres. In general, there is an increase in compressive strength varying from 13% to 18% on addition of fibres to concrete and also in this investigation, maximum increase in the compressive strength of 18% over plain concrete is observed with a fibres combination of 75% steel fibres + 25% plastic fibres. The percentage increase/decrease in compressive strength of HFRC is presented in table 1 and 2.

### Comparison of split tensile strength

Table 3 and table 4 depicts the comparison results of split tensile strength of the different proportions fiber concrete mixes for 28 days and 56 days curing strength.It is observed that with the introduction of 100% plastic fibres to the plain concrete, the spilt tensile strength increases from 4.3 MPa to 5.1 MPa resulting in approximately increase of 18% as compared to plain concrete. There is an increase in the split tensile strength of fibrous concrete is observed with the addition of steel fibres to the mix and maximum split tensile strength is obtained for concrete containing75% steel fibres. In general, there is an increase in spilt tensile strength varying from 18% to 130% on addition of fibres to concrete and the optimum fibre combination is 75% steel fibres + 25% plastic fibres for which the maximum increase in spilt tensile strength 130% over plain concrete is observed. There is considerable effect of plastic fibre on tensile strength. The percentage increase/decrease in spilt tensile strength of HFRC over plain concrete is presented in table 3 and.4.

**Comparison of flexural strength**

The flexural strength results for HFRC containing different combinations of steel and plastic fibres are presented in Table 5 and 6. It can be seen that in general, like compressive strength, the flexural strength of concrete containing 100% plastic fibres is less than that of the plain concrete. There is a drop of approximately 16% in the flexural strength of concrete containing 100% plastic fibres as compared to that of plain concrete. With gradual replacement of plastic fibres with steel fibres, an increase in the flexural strength is observed up to a fibre combination of 75% steel fibres + 25% plastic fibres. The increase in flexural strength taken as average of three batches of fibrous concrete containing different combinations of steel and plastic fibres varied from 25% to 75%, showing an increase of 34% for HFRC with 25% steel fibres + 75% plastic fibres; 45% for 50% steel fibres + 50% plastic fibres; 68% for concrete containing 75% steel fibres + 25% plastic fibres . Thus the optimum fibre combination for maximum flexural strength is 75% steel fibres + 25% plastic fibres as obtained in this investigation.

Table 1 Compressive Strength (28 days)

| MIX | Fibre mix proportion by volume (%) | | Fibre vol. fraction (%) | 28 DAYS COMPRESSIVE STRENGTH (MPa) CUBE COMPRESSSION | | | | |
|---|---|---|---|---|---|---|---|---|
| | SF | PF | | B 1 | B2 | B3 | Average | %age increase |
| M1 | 0 | 0 | 0 | 39.8 | 40.5 | 40.2 | 40.1 | 0 |
| M2 | 0 | 100 | 0.80 | 36.0 | 35.5 | 35.7 | 35.7 | -10 |
| M3 | 25 | 75 | 0.80 | 37.8 | 39.5 | 39.9 | 39.0 | -2.7 |
| M4 | 50 | 50 | 0.80 | 45.6 | 46.3 | 44.7 | 45.5 | 13 |
| M5 | 75 | 25 | 0.80 | 47.7 | 49.6 | 45.2 | 47.5 | 18.4 |

Table 2 Compressive Strength (56 days)

| MIX | Fibre mix proportion by volume (%) | | Fibre vol. fraction (%) | 56 DAYS COMPRESSIVE STRENGTH (MPa) CUBE COMPRESSSION | | | | |
|---|---|---|---|---|---|---|---|---|
| | SF | PF | | B 1 | B2 | B3 | Average | %age increase |
| M1 | 0 | 0 | 0 | 43.8 | 44.5 | 44.2 | 44.1 | 0 |
| M2 | 0 | 100 | 0.80 | 39.2 | 39.7 | 38.1 | 39.0 | -11.5 |
| M3 | 25 | 75 | 0.80 | 41.7 | 43.5 | 43.3 | 42.8 | -2.9 |
| M4 | 50 | 50 | 0.80 | 49.8 | 50.3 | 49.7 | 49.9 | 13.1 |
| M5 | 75 | 25 | 0.80 | 51.7 | 53.6 | 51.3 | 52.2 | 18.3 |

Table 3 Split tensile Strength (28 days)

| MIX | Fibre mix proportion by volume (%) | | Fibre vol. fraction (%) | 28 DAYS SPLIT TENSILE STRENGTH (MPa) | | | | |
|---|---|---|---|---|---|---|---|---|
| | SF | PF | | B1 | B2 | B 3 | Average | %age increase |
| M1 | 0 | 0 | 0 | 4.2 | 4.6 | 4.2 | 4.3 | 0 |
| M2 | 0 | 100 | 0.80 | 4.9 | 5.3 | 5.1 | 5.1 | 18.6 |
| M3 | 25 | 75 | 0.80 | 6.1 | 6.8 | 6.5 | 6.4 | 48.8 |
| M4 | 50 | 50 | 0.80 | 7.9 | 8.8 | 8.4 | 8.3 | 93.0 |
| M5 | 75 | 25 | 0.80 | 10.3 | 9.8 | 9.7 | 9.9 | 130 |

Table 4 Split tensile Strength (56 Days)

| MIX | Fibre mix proportion by volume (%) | | Fibre vol. fraction (%) | 56 DAYS SPLIT TENSILE STRENGTH (MPa) | | | | |
|---|---|---|---|---|---|---|---|---|
| | SF | PF | | B1 | B2 | B3 | Average | %age increase |
| M1 | 0 | 0 | 0 | 4.6 | 4.7 | 4.5 | 4.6 | 0 |
| M2 | 0 | 100 | 0.80 | 5.6 | 5.8 | 5.7 | 5.7 | 23.9 |
| M3 | 25 | 75 | 0.80 | 7.3 | 6.9 | 7.1 | 7.1 | 54.3 |
| M4 | 50 | 50 | 0.80 | 9.0 | 9.4 | 8.9 | 9.1 | 97.8 |
| M5 | 75 | 25 | 0.80 | 10.3 | 10.7 | 10.8 | 10.6 | 130 |

Table 5 Flexural Strength (28 days)

| MIX | Fibre mix proportion by volume (%) | | Fibre vol. fraction (%) | 28 DAYS FLEXURAL STRENGTH (MPa) | | | | |
|---|---|---|---|---|---|---|---|---|
| | SF | PF | | B 1 | B2 | B 3 | Average | %age increase |
| M1 | 0 | 0 | 0 | 4.3 | 4.2 | 4.9 | 4.4 | 0 |
| M2 | 0 | 100 | 0.80 | 3.4 | 3.5 | 4.3 | 3.7 | -15.9 |
| M3 | 25 | 75 | 0.80 | 6.1 | 6.0 | 5.8 | 5.9 | 34 |
| M4 | 50 | 50 | 0.80 | 6.6 | 6.3 | 6.4 | 6.4 | 45.4 |
| M5 | 75 | 25 | 0.80 | 7.5 | 7.3 | 7.6 | 7.4 | 68.1 |

Table 6 Flexural Strength (56 days)

| MIX | Fibre mix proportion by volume (%) | | Fibre vol. fraction (%) | 56 DAYS FLEXURAL STRENGTH (MPa) | | | | |
|---|---|---|---|---|---|---|---|---|
| | SF | PF | | B 1 | B2 | B3 | Average | %age increase |
| M1 | 0 | 0 | 0 | 5.1 | 4.8 | 5.4 | 5.1 | 0 |
| M2 | 0 | 100 | 0.80 | 4.1 | 4.4 | 5.1 | 4.5 | -11.7 |
| M3 | 25 | 75 | 0.80 | 6.9 | 7.1 | 6.7 | 6.9 | 35.2 |
| M4 | 50 | 50 | 0.80 | 7.2 | 7.4 | 7.5 | 7.3 | 43.1 |
| M5 | 75 | 25 | 0.80 | 8.3 | 8.5 | 8.8 | 8.5 | 66.6 |

Fig.1 Failure of cube under compression

Fig.2 Failure of cylinder under split tension

Fig.3 Flexural strength setup

## VI. CONCLUSION

The following conclusions are presented based on experimental results from the present investigation

- The maximum compressive strength reaches in the HFRC at 75% steel fibres and 25% plastic fibres because of the high elastic modulus of steel fibre and the low elastic modulus of plastic fibre work in perfect combination
- The spilt tensile strength of fibre percentage with 75% steel fibre and 25% shows maximum increase in strength. Improved tensile strength can be achieved by increasing the percentage of steel fibres. The higher number of fibres bridging the diametrical splitting crack, the higher would be the spilt tensile strength.

- The flexural strength of HFRC containing the volume fraction of 75% steel fibres and 25% plastic fibres is higher than the other fiber composition. It was observed that, under axial loads, cracks occur in microstructure of concrete and fibres limit the formation and growth of cracks.
- The brittleness of concrete can also be improved by addition of steel fibers than plastic fibre. Since concrete is very weak in tension, the steel fibers are beneficial in axial-tension to increase tensile strength.
- During the test it was observed that the HFRC specimen has greater crack control due to reduction in crack widths.
- It is evident from the present investigation that the hybridization of fibres proves to be better as compared to mono fibers in improving the strength properties of concrete.

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