MIXED FIBRE REINFORCED CONCRETE WITH AND WITHOUT MICROSILICA- STUDY OF STREGTH PROPERTIES

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ABSTRACT

The present experimental investigation is conducted by combining the two types of fibers of glass and steel to make a concrete called Mixed Fiber Reinforced Concrete through which the advantages of these both fibers can be achieved for anefficient concrete. Glass fiber and steel fiber were mixed by volume percentage in different proportions of 0-100, 25-75, 50-50, 75-25 and 100-0 in each of the total fiber percentages of 0.5, 0.75, 1.0 and 1.5. By doing this it is aimed to generate higher strength and better elastic properties of MFRC.Microsilica at 15 percentage was tried as replacement to cement in preparing the MFRC composite for strength properties. Based on the test results, it has been found that mixed fiber combination results in substantial increase in the strength,and elastic properties. Out of the combinations, 100% steel fiber without glass fiber is giving the highest modulus. With other mixed combinations of glass and steel fibers like 75% - 25%, 50%-50% and 25%-75%, the failure of the specimens is found to be smoother with better crack behavior. With microsilica in the mix the strengthsare further increased and is optimum with 15% microsilica..

Keywords: FRC, Mixed Fibers, Microsilica, Stress, Strain, Young's Modulus.

I. INTRODUCTION AND REVIEW

More and more emphasis is being placed on specifying the reliability, evaluations and production performance of concrete intended for a specific purpose by adding admixtures in the form of mineral admixtures like silica fume [1, 16], ground granulated blast furnace slag, metakaolin, fly ash as blends or by partial replacement in terms of cement and the chemical admixtures like super plasticizers, polymers, etc. are also being employed. This has lead to the development of enhancement of the properties of concrete and its applications as self compacting concrete. High strength concrete, High performance concrete, Ultra High performance concrete, Fiber Reinforced concrete [2, 3, 4, 5, 6].The reinforcement in concrete further enhances these strength properties. Because of the flexibility in methods of fabrication, fiber reinforced concrete can be an economic and useful construction material [2, 8, 9]. By using mixed fibre(steel and glass), in addition to strength, other properties like ductility and preventions of microcracks can be achieved at an optimum combinations.

II. EXPERIMENTAL INVESTIGATION

The following materials are used for the casting of specimens.

2.1 Cement

Ordinary Portland cement of 53 Grade from Ultra Tech conforming to I.S: 12269 [19] is used.

2.2 Fine Aggregate

River sand locally available is used as fine aggregate conforming to I.S: 2386 and I.S: 383 [10, 13].

2.3 Coarse Aggregate

Machine crushed well graded angular granite aggregate of nominal size from local source is used.

2.4 Water

Potable water locally available is used for mixing and curing the concrete.

2.5 Glass Fiber and Steel Fiber

Fibers of alkali resistant glass with an aspect ratio of 857:1 and steel fiber with an aspect ratio of 55 are used conforming to ASTM C 1666M and ASTM A 820M . The details are given in Table 1.

Table 1. Properties of Fibers (Glass and Steel)

Fiber	Type	Density kg/m^3	Elastic modulus GPA	Tensile strength MPA	Dia.	Length mm	No. of fiber
AR-Glass	Cem- FIL ARC 14 306 HD	2600	73	1700	14 micron	12	212 million /kg
Steel	Steel wire	7850	210	250	1mm	55	Mono filament

2.6 Microsilica

The Microsilica used in these experimental investigations is densifiedmicrosilica 920 D supplied by M/S Elkem India Pvt. Ltd. Mumbai. The typical bulk density is ranged between 500 Kg/m^3 – 700 Kg/m^3, conforming to standard ASTM C 1240 [16]. Two Percentages of 5 and 15 are used by replacing a part of cement by weight.

2.7 Concrete Mix Details

The details of the M25 Concrete mix used are given in Table 2 is arrived at as per I.S: 10262 [17, 18].

Table 2.Materials Required for 1 Cubic Meter of Concrete

Grade	Cement (kg)	Fine aggregate (kg)	Coarse aggregate	Water cement

			(kg)	ratio
M25	425	682	1277.76	0.5

2.8 Casting and Curing of Specimens

The specimens of MFRC with and without microsilicawere cast and cured following the standard procedures [14, 15].

2.9 Testing of Specimens

The specimens of MFRC with and without micosilicawere tested for compressive strength, split tensile strength and flexural strength [11,12]. The results are tabulated in Tables 3 to 4 for compressive strength without and with microsilica. Figures 1 to 4 show the variation of split tensile strength and flexural strengths by means of bar charts for various total fibre percentages and for various combinations of steel and glass fibres.

Table 3.Compressive Strength Results of MFRC Specimens with Various Total Fiber Percentages at 28 days.

S. No.	Total Fiber (%)	Mixed Fiber (%)		Ultimate Load (KN)	Compressive Strength (N/mm^2)	Increase in Compressive Strength over the Base Reference (%)
		Glass	Steel			
1	0.0	0.0	0.0	463.0	46.30	--
2	0.50	0	100	611.2	61.12	32.01
3	0.50	25	75	607.9	60.79	31.29
4	0.50	50	50	589.9	58.99	27.41
5	0.50	75	25	571.8	57.18	23.49
6	0.50	100	0	551.6	55.16	19.14
7	0.75	0	100	637.0	63.70	37.58
8	0.75	25	75	625.6	62.56	35.12
9	0.75	50	50	612.8	61.28	32.35
10	0.75	75	25	594.5	59.45	28.40
11	0.75	100	0	572.7	57.27	23.69
12	1.00	0	100	652.4	65.24	40.91
13	1.00	25	75	641.2	64.12	38.49
14	1.00	50	50	625.6	62.56	35.12
15	1.00	75	25	610.8	61.08	31.92
16	1.00	100	0	590.1	59.01	27.45
17	1.50	0	100	668.5	66.85	46.21
18	1.50	25	75	648.2	64.82	41.78
19	1.50	50	50	634.6	63.46	38.80
20	1.50	75	25	614.3	61.43	34.36
21	1.50	100	0	591.5	59.15	29.37

Table 4.Compressive Strength Results of MFRC Specimens with Various Total Fiber Percentages and 15 Percent Microsilica at 28 days.

S. No.	Total Fiber (%)	Total Micro silica (%)	Mixed Fiber (%)		Compressive strength (N/mm^2)	Increase in Compressive Strength with 15 % Microsilica Reference (%)	Increase in Compressive Strength over the Base Reference (%)
			Glass	Steel			
1	0.0	0.0	0.0	0.0	46.30	--------	----------
2	0.0	15.0	0.0	0.0	52.76	--------	13.95
3	0.50	15.0	0	100	65.91	24.92	42.35
4	0.50	15.0	25	75	64.73	22.69	39.80
5	0.50	15.0	50	50	62.57	18.59	35.14
6	0.50	15.0	75	25	60.15	14.00	29.91
7	0.50	15.0	100	0	58.19	10.29	25.68
8	0.75	15.0	0	100	67.94	28.77	46.73
9	0.75	15.0	25	75	66.26	25.59	43.11
10	0.75	15.0	50	50	64.83	22.88	40.02
11	0.75	15.0	75	25	62.82	19.07	35.68
12	0.75	15.0	100	0	59.42	12.62	28.33
13	1.00	15.0	0	100	69.22	31.19	49.50
14	1.00	15.0	25	75	68.86	30.51	48.72
15	1.00	15.0	50	50	66.99	26.97	44.68
16	1.00	15.0	75	25	64.14	21.57	38.53
17	1.00	15.0	100	0	61.34	16.26	32.48
18	1.50	15.0	0	100	70.08	32.83	51.36
19	1.50	15.0	25	75	69.75	32.20	50.65
20	1.50	15.0	50	50	67.73	28.37	46.28
21	1.50	15.0	75	25	64.39	22.04	39.07
22	1.50	15.0	100	0	62.71	18.86	35.44

III. DISCUSSION OF RESULTS

The strength results of MFRC specimens are discussed as follows.

3.1 Workability Results

Medium workability was maintained throughout while casting the MFRC specimens. In the present basic concrete mix of M25 with a water to binder ratio of 0.5 workability of MFRC could be maintained at medium level. Only at a total fibre percentage of 1.5 by volume a small dosage(less than 0.5) of superplasticizer is required to maintain the workability. Microsilica admixture used as replacement to cement has helped in the flow of concrete.

3.2 Compressive Strength

- From Table 3 and 4, it is observed that with increase in fiber percentage, the compressive strength also increases. At the age of 28 days with 1.5 percentage fiber the compressive strength is 46.21 percent in excess over the strength of reference mix.
- As the percentage replacement of steel fiber by glass fiber is increased, the compressive strength decreases, but on the overall it is more than that of control concrete. The same trend is observed in the MFRC specimens with 15 percent microsilica added as partial replacement by weight of cement.
- It is observed that the compressive strength of MFRC specimens with 15 percent microsilica and 1.5 percent total fiber content with 100 percent steel fiber is 51.36 percent more over the base reference specimens with no fiber and no microsilica.

3.3 Split tensile strength

- From Fig 1 and 2, it is observed that with increase in fiber percentage, the split tensile strength also increases.
- At the age of 28 days with 1.5 percentage fiber the split tensile strength with mixed fiber proportion of 25 – 75 percentage is 46.03 percent in excess over strength of reference mix.
- The mixed proportion of 25 – 75 percentages of glass and steel fibers exhibited higher strength compared to other proportions. It is also observed that as the percentage replacement of steel fiber by glass fiber is increased and steel fiber percentage decreases beyond the proportion of 25 – 75 percentage , the split tensile strength goes on decreasing. The same trend is observed in all the total fiber percentages. The same trend is observed in the MFRC specimens with 15 percent microsilica added as partial replacement by weight of cement
- It is observed that the Split tensile strength of MFRC specimens with 15 percent microsilica and 1.5 percent total fiber content with mixed fiber proportion of 25 – 75 percentage is 90.73 percent more over the base reference specimens with no fiber and no microsilica.

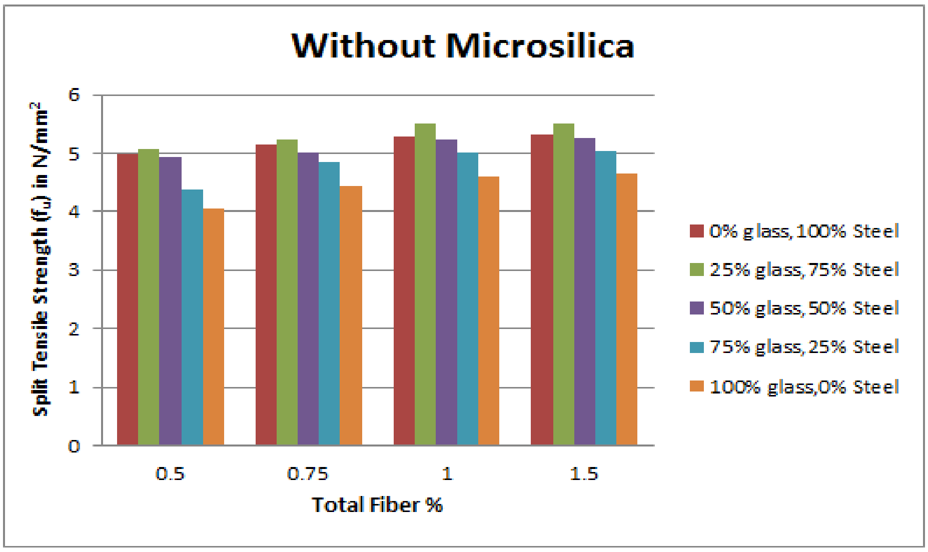

Fig 1: Variation of Split tensile strength for various total fibre percentages for various combinations

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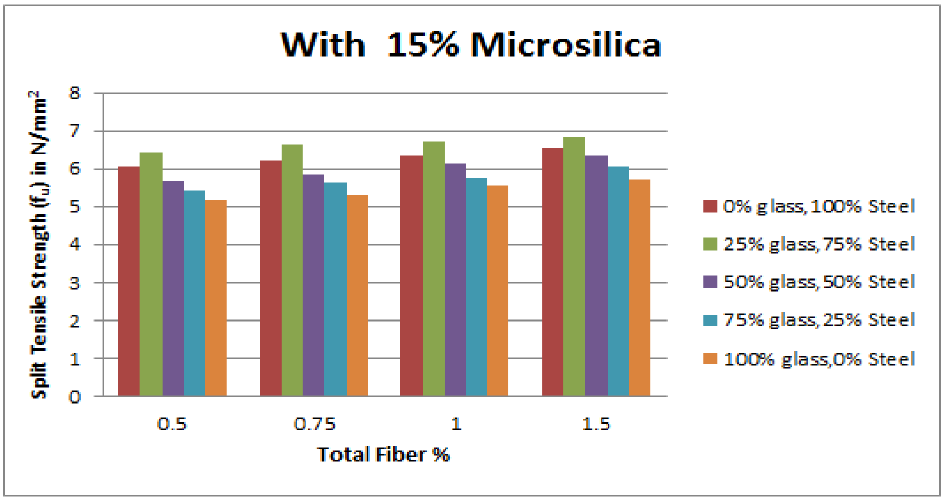

Fig 2: Variation of Split tensile strength for various total fibre percentages for various combinations

3.4 Flexural strength

- From Fig 3and 4 it is observed that with increase in fiber percentage, the flexural strength also increases.
- At the age of 28 days with 1.5 percentage fiber the flexural strength with mixed fiber proportion of 25 – 75 percentage is 77.7 percent in excess over the strength of reference mix
- It is observed that as the percentage of total fiber content is increased, the flexural strength also increases and it is seen as maximum at mixed fiber proportion of 25 – 75 percentage of glass and steel fibers in all the total fiber percentages.
- The same trend is observed in all the total fiber percentages. The same trend is observed in the MFRC specimens with 15 percent microsilica added as partial replacement by weight of cement.
- It is observed that the flexural strength of MFRC specimens with 15 percent microsilica and 1.5 percent total fiber content with mixed fiber proportion of 25 – 75 percentage is 133.91 percent more over the base reference specimens with no fiber and no microsilica.

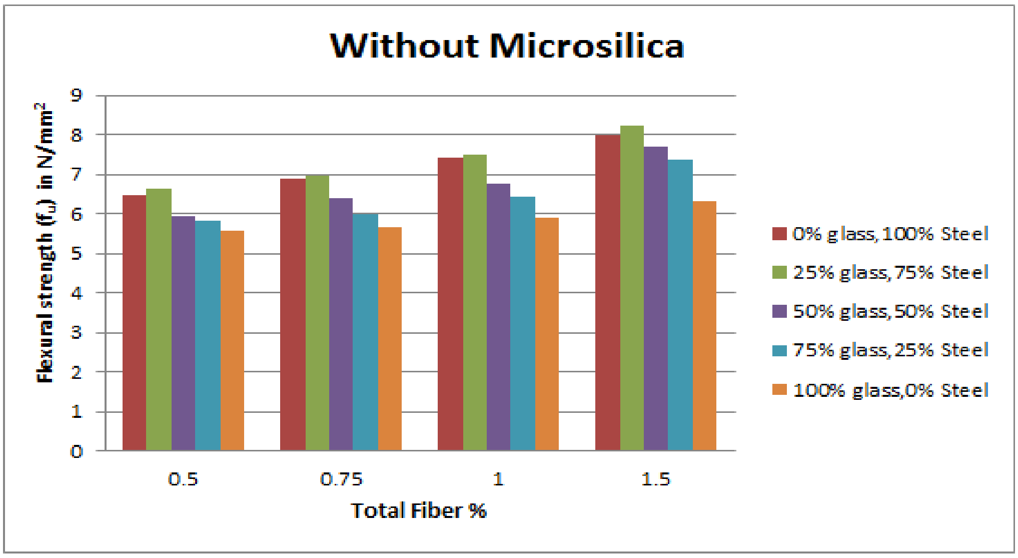

Fig 3: Variation of flexural strength for various total fibre percentages for various combinations

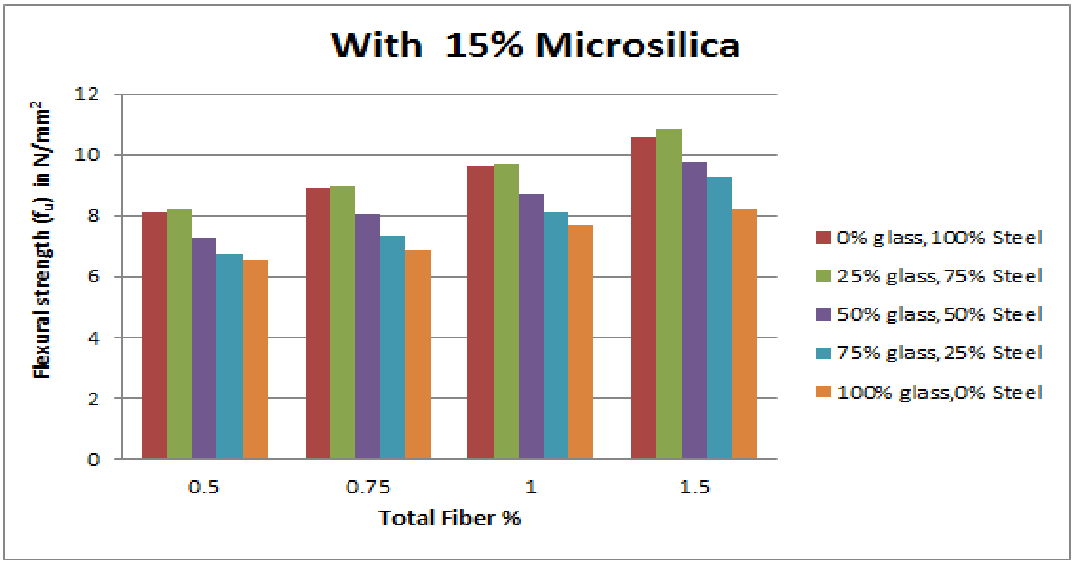

Fig 4: Variation of flexural strength for various total fibre percentages for various combinations

3.5 Influence of Microsilica

It is observed that microsilica has contributed to smooth movement of concrete with an optimum percentage of 15% microsilica used as replacement to OPC, in flexural the strengths are increased subsequently. But microsilicadoes not contribute towards ductility.

3.6 Cracking and Ductility

The MRFC specimens on the whole exhibited better cracking behavior at failure. It is noted that the beam specimens have undergone gradual failure with MRFC compared to brittle failure of specimens of reference concrete without fibres. The specimens have undergone more deflections. Cracks have propogated gradually. MRFC has rendered concrete more ductile with better cracking behavior.

IV. CONCLUSIONS

The following conclusions are drawn for Compressive strength and Elastic Properties of MFRC.

1. Even with a total fiber content of 1.5% by volume. Steel fiber of 1mm diameter and length of 55mm having an aspect ratio of 55 can be satisfactorily mixed along with glass fiber having an aspect ratio of nearly 857 to increase the strength characteristics without losing the workability.
2. There is a maximum increase of 46.21% in the compressive strength of mixed fiber reinforced concrete at 28 days at 1.5% of total fiber content with 100% steel fiber over reference plain concrete. With 15% microsilica, there is a further increase to 51.36%.
3. Mixed fiber combination results in substantial increase in the compressive strength. Optimum percentage of microsilica used as replacement to cement contributes to further increase.
4. The mixed fibre percentage of 25-75 between glass and steel is found to be optimum giving highest tensile strength. MRFC with 15% microsilicaat 1.5 total percent of mixed fibre at this combinations has shown an increase of 90.73 percent in split tensile strength compared to that of reference concrete.
5. At 1.5percent total fibre with a combination of 25-75 percents between glass and steel has MRFC mix has given optimum flexural strength. This further increases with 15 percent microsilica in the mix and this is 133.91 percent more than that of reference concrete.
6. Microsilica with an optimum 15 percent used as replacement to OPC in the mix , contributes in increasing the strengths substantially. Microsilicadoesnotcontiliribute towards ductility of MRFC.
7. Mixed Fibre Reinforced Concrete (MRFC) has shown not only higher strength but also more ductility.
8. By judiciously combining steel and glass fibres ,MRFC possessing optimum properties like strengths , ductility can be produced. Even micro-cracking due to shrinkage etc., also can be controlled.

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