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Effect of Micro Steel Fibre on Properties of Concrete

Aamir Hussain Wani[1], Er. Bhawna[2]

[1]*M. Tech Scholar, Civil Department, Gurukul Vidyapeeth College of Engineering and Technology, Banur, Punjab*

[2]*Assistant Professor, Civil Engineering Department, Gurukul Vidyapeeth College of Engineering and Technology, Banur, Punjab*

Abstract: Concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. Various types of fibre reinforced concrete are being used against plain concrete due to their higher flexural strength, better tensile strength, modulus of rupture and crack resistance. In the present investigation properties of steel fiber reinforced concrete like flexure, compressive strength and split tensile strength are studied. Tests were conducted to study the flexural, split tensile test and compressive strength of steel fibre reinforced concrete with varying aspect and varying percentage of fibre. In the experiments conducted percentage of steel in each case varied from 0.5% to 2.% at interval of 0.5%. The various strength parameters studied are compressive strength, split tensile strength and flexural strength as per the relevant IS standards. The experimental results indicate that the addition of steel fibre into concrete significantly increases the flexural strength. The research paper proposes that due to these properties of steel fibre reinforced concrete, it can be used for the design of curvilinear forms.

Key Words: Experimental investigation, Fibre reinforced concrete, flexural strength, compressive strength, aspect ratio, steel fibres.

1. Introduction

Concrete is most widely used construction material in the world due to its ability to get cast in any form and shape. It also replaces old construction materials such as brick and stone masonry. The strength and durability of concrete can be changed by making appropriate changes in its ingredients like cemetatious material, aggregate and water and by adding some special ingredients. Hence concrete is very well suitable for a wide range of applications. However concrete has some deficiencies as listed below:

- Low tensile strength
- Low post cracking capacity
- Brittleness and low ductility
- Limited fatigue life
- Incapable of accommodating large deformations
- Low impact strength

The presence of micro cracks in the mortar-aggregate interface is responsible for the inherent weakness of plain concrete. The weakness can be removed by inclusion of fibres in the mixture. Different types of fibers, such as those used in traditional composite materials can be introduced into the concrete mixture to increase its toughness, or ability to resist crack growth. The fibres help to transfer loads at the internal micro cracks. Such a concrete is called fibre-reinforced concrete (FRC). The introduction of the paper should explain the nature of the problem, previous work, purpose, and the contribution of the paper. The contents of each section may be provided to understand easily about the paper.

2. Experimental Investigations

In order to study the interaction of Steel fibres (straight) with concrete under compression, flexure, split and tension, various cylinders were casted respectively. The experimental program was divided into six groups. Each group consists of cubes, cylinders and beams, of 15x15x15cm, 10 x20cm and 15x15x50cm respectively. The first group is the control concrete with 0% fibre. The second group consisted of 0.5% of Steel fibres, by total volume of concrete. The third group consisted of 1% of Steel fibres, by volume of concrete. The fourth group consisted of 1.5% of Steel fibres by volume of concrete. The fifth group consisted of 2% of Steel fibres by volume of concrete

2.2 Materials and Tests:

- Cement 43 Grade
- Fine aggregate
- Coarse aggregate
- Fibre

The brass coated micro steel fibre used in the experiment is obtained from Fibre Zone Ahmadabad Gujarat**.** Micro brass coated steel fiber is a new type of additive for reinforcing concrete, which has the high tensile strength, and improve the concrete's unity obviously.

1. Material: low carbon cold drawn steel wire Tensile strength :> 2850Mpa
2. Length: 6mmm
3. Diameter:0.2+/-0.02mm Aspect ratio: 35-100.)

Micro steel fibers have the advantages comparing with steel bars in the fields below:

1. Ultra high performance concrete
2. Reactive powder concrete
3. Reinforcing mortar

Plain concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. Internal micro cracks are inherently present in the concrete and its poor tensile strength is due to the propagation of such micro cracks, eventually leading to brittle fracture of the concrete. It has been recognized that the addition of small, closely spaced and uniformly dispersed fibers to the concrete would act as crack arrester and would substantially improve its Compressive and flexural strength properties. This type of concrete is known as fiber reinforced concrete. The straight steel fibers are used. The length of the steel fibers is 6mm and diameter is 0.18mm.

2.3 Casting Of Specimens

For casting the cubes, beam and cylinder specimens, standard cast iron metal moulds of size (150x150x150) mm cubes, (100x100x500) mm beam and (100x200) mm cylinder moulds are used. The moulds have been cleaned of dust particles and applied with mineral oil on all sides, before the concrete is poured into the moulds. Thoroughly mixed concrete is filled into the mould in three layers of equal heights followed by tamping. Then the mould is placed on the table vibrator for a small period. Excess concrete is removed with trowel and top surface is finished to smooth level.

Fig no. 3.5 Casting of specimens

2.4 Tests on Hardened Concrete

2.4.1 Cube Compression Test

This test was conducted as per IS 516-1959. The cubes of standard size 150x150x150mm were used to find the compressive strength of concrete. Specimens were placed on the bearing surface of UTM, of capacity 100tones without eccentricity and a uniform rate of loading of 550 Kg/cm2 per minute was applied till the failure of the cube. The maximum load was noted and the compressive strength was calculated.

Cube compressive strength (f_{ck}) in MPa = P/A

Where, P= cube compression load.

A= area of the cube on which load is applied (= 150 x 150= 22500 mm^2)

2.4.2 Flexural Test

SFRC beams of size (100x100x500) mm are tested using a flexure testing machine. The specimen is simply supported on the two rollers of the machine which are 600mm apart, with a bearing of 50mm from each support. The load shall be applied on the beam from two rollers which are placed above the beam with a spacing of 200mm. The load is applied at a uniform rate such that the extreme fibres stress increases at 0.7N/mm2/min i.e., the rate of loading shall be 4 KN/min. The load is increased till the specimen fails. The maximum value of the load applied is noted down. The appearance of the fracture faces of concrete and any unique features are noted.

The modulus of rupture is calculated using the formula □**s** =Pl/bd²

Where,

P = load in N applied to the specimen

l = length in mm of the span on which the specimen is supported

b = measured width in mm of the specimen

d = measured depth in mm of specimen at the point of failure

2.4.3 Split Tensile Test

SFRC cylinders of size 10cm (diameter) x 20cm (height) are casted. The test is carried out by placing a cylindrical specimen horizontally between the loading surface of a compression testing machine and the load is applied until the failure of the cylinder, along the vertical diameter. When the load is applied along the generatrix, an element on the vertical diameter of the cylinder is subjected to a horizontal stress of 2P/πld.

Where, P is the compressive load on the cylinder l is the length of the cylinder

d is diameter of the cylinder.

The main advantage of this method is that the same type of specimen and the same testing machine as used for the compression test can be employed for this test. This is why this test is gaining popularity. The splitting test is simple to perform and gives more uniform results than the other tension tests. Strength determined in the splitting test is believed to be closer to the true tensile strength of concrete, than the modulus of rupture. Splitting strength gives about 5 to 10% higher value than the direct tensile strength.

3. Results And Discussions

Table no. 3.1.1 Compression test values of M30 grade SFRC 7 days curing

Percentage of fibers	Trial 1	Trial 2	Trial 3	Average compressive strength (in N/mm2)
0	18.90	19.50	19.28	19.29
0.5	20.60	20.40	20.00	20.32
1	20.90	20.65	20.35	20.80
1.5	21.60	21.95	21.40	21.90
2	22.60	22.90	22.85	22.68

Table 3.1.2 Compression test values of M30 grade SFRC at 28 days curing

Percentage of fibers	Trial 1	Trial 2	Trial 3	Average compressive strength (in N/mm2)
0	32.40	32.60	31.95	32.73
0.5	33.70	33.35	33.50	33.88

1	34.60	34.20	34.45	34.68
1.5	36.40	36.80	36.20	36.51
2	37.90	37.40	37.65	37.80

Table no. 3.1.3 Split tensile test values of M30 grade SFRC at 7 days curing

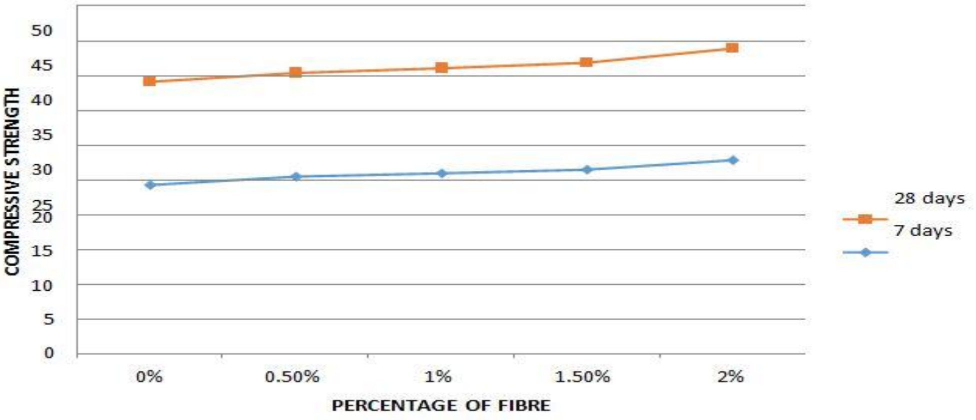


Table no. 3.1.4 Split tensile test values of M30 grade SFRC at 7 days curing

Percentage of fibers	Trial 1	Trial 2	Trial 3	Average split tensile strength (in N/mm2)
0	1.90	1.95	1.98	1.99
0.5	2.20	1.90	1.95	2.05
1	2.33	2.28	2.40	2.34
1.5	2.70	2.45	2.56	2.55
2	2.90	2.86	2.65	2.80

Table no. 3.1.5 Split tensile test values of M30 grade SFRC at 28 days curing

Percentage of fibers	Trial 1	Trial 2	Trial 3	Average split tensile strength (in N/mm2)
0	3.20	3.15	3.20	3.13
0.5	3.30	3.40	3.20	3.43
1	3.85	3.60	3.80	3.90
1.5	4.20	4.30	4.33	4.26
2	4.55	4.48	4.44	4.49

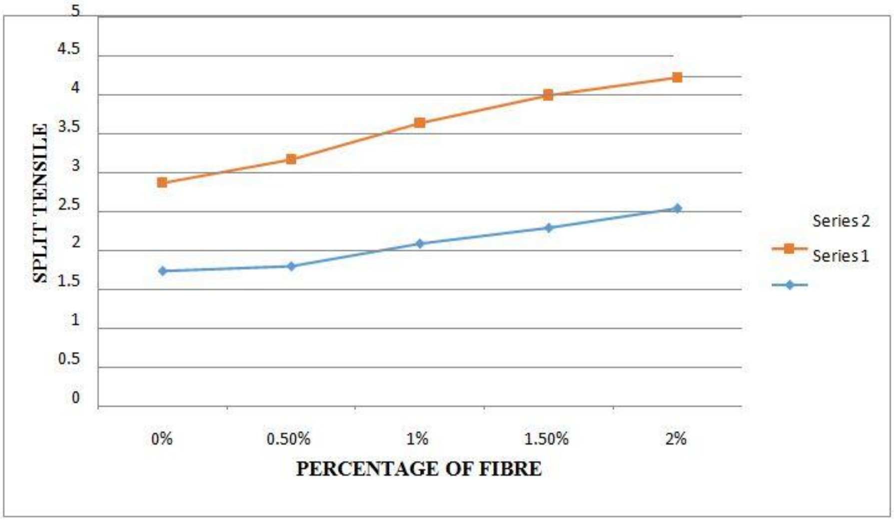
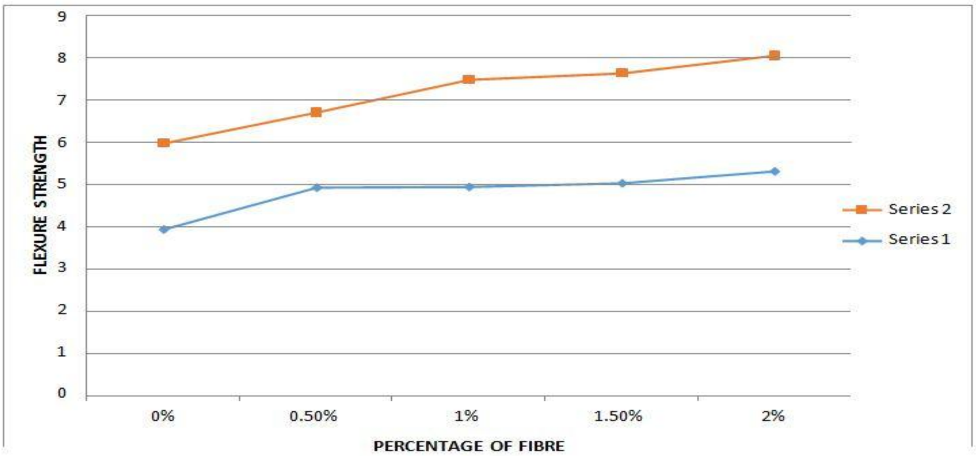


Table 3.1.6Flexural test values of M30 grade SFRC at 7 days curing

Percentage of fibres	Trial 1	Trial 2	Trial 3	Average modulus of rupture (in N/mm2)
0	3.98	3.91	3.85	3.93
0.5	4.42	4.50	4.46	4.92
1	4.98	4.86	4.83	4.93
1.5	5.22	5.08	5.13	5.02
2	5.42	5.21	5.24	5.30

Table 3.1.7 Flexural test values of M30 grade SFRC at 28 days curing

Percentage of fibres	Trial 1	Trial 2	Trial 3	Average modulus of rupture (in N/mm2)
0	5.20	5.76	5.92	5.96
0.5	6.80	6.66	6.62	6.70
1	7.40	7.50	7.44	7.47
1.5	7.60	7.68	7.55	7.62
2	8.10	8.00	7.6	8.04

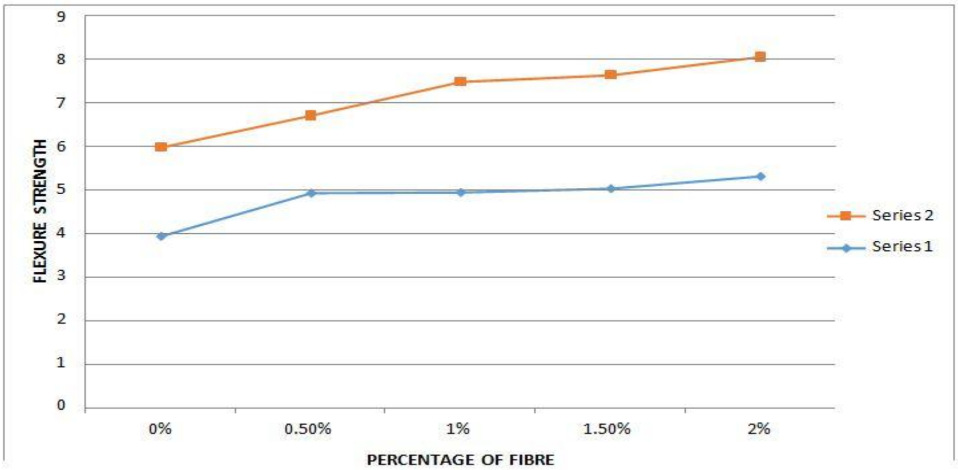


4. Conclusion

The Steel fibres straight used in this project has shown considerable improvement in all the properties of concrete when compared to conventional concrete like. The steel fibres are free from water absorption. With improved understanding of the link between fibre characteristics and composite or structural performance, the tailoring of fibres for use in high volume construction market exists, particularly for load carrying structural systems and for several applications especially in Earthquake prone areas. The time is not far that such materials will be used in building better and safe constructions for the future.

For M30 concrete:

1. Compressive strength is increased by 15.49% for 2% of steel fibres.
2. Split Tensile strength is increased by 43.45% for 2% of steel fibres.
3. Flexural strength (Modulus of Rupture) by 35.23% for 2% of steel fibres.



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