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Experimental Investigation on Fibre Reinforced Concrete using Binding Wires

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***Abstract-* In recent days Fibre Reinforced Concrete (FRC) become more popular because of its better strength and crack arresting capacity. Fibre Reinforced Concrete (FRC) is a composite material consists of cement based matrix along with uniform or random distribution of short discrete fibres, which can be steel fibres, nylons, polyethylene etc.**

In this present study the effects of addition of binding wires on the compressive strength, flexural strength and split tensile strength of concrete has been investigated experimentally. Different quantities of binding wires are added to the concrete to find out the optimum quantities of binding wires in which the FRC with binding wires is more effective in terms of strength and crack resistance capacity. The results of the study shows that the addition of binding wires as fibre can significantly increase the compressive, flexural as well as split tensile strength along with the crack arresting capacity. The results also gives a detail idea of optimum quantity of steel fibre that can be used in concrete production to get better strength and at the same time it will be more economical.

Keywords- Fibre reinforced concrete; binding wire; concrete properties; compressive and flexural strength; split tensile strength.

I. INTRODUCTION

Concrete is one of the most widely used construction material consumed after water. As concrete is brittle in nature is strong under compression but weak in tension. Therefore, a form of reinforcement is needed for structure’s stability. Steel bars are used as reinforcement in concrete structures. Still there is a possibility of crack formation internally or externally. Using fibers in concrete, the concrete can be modified in more ductile manner. In the FRC, at the time of mixing a number of small fibers are distributed in random orientation in the concrete Different kinds of materials can be used as fiber like various forms of steel fibres, glass, polymer, natural fiber, synthetic fiber etc. In accordance with the various physical properties of the fiber like type of fiber, quantity of fiber, length of fiber, aspect ratio (l/D), the properties of FRC like compressive strength, flexural strength, fatigue strength, can be modified. Steel fiber reinforced concrete (SFRC) is a composite material which can be made by adding steel fibers of different form, different size and shape in ordinary concrete matrix. Orientation of these fibers is commonly in random. The properties each of the fibers are different. Generally SFRC is very ductile in nature and particularly well suited for structures which are required to resist Shrinkage, fatigue strength, and temperature. Different research articles already showed that the steel fiber gives more strength than glass, polymer and other fibers. Here in this detailed study of fiber reinforced concrete with binding wires, we intend to find out if there is an optimum quantity of steel fibre that can be used in concrete production to get better strength and at the same time it will be more economical.

II. EXPERIMENTAL INVESTIGATION

A. *Material Specifications*

The properties of concrete like workability, strength, durability, are very much influenced by the chemical and physical properties of each ingredients used for making the concrete. Portland slag cement, crushed stone chips as coarse aggregates, River sand as fine aggregates, portable drinking water, steel binding wires are used for this experimental study. Different tests were conducted to find out the properties of each ingredient with which design mix is performed.

B. *Cement*

For the experimental investigation Portland slag cement is used for making concrete specimens. Table-I shows the test results which were conducted as per IS: 4031-1988, to find out the properties of cement.

TABLE-I PROPERTIES OF CEMENT

Type	PSC
Brand	ACC
Consistency	31%
Initial Setting Time	109 Minutes
Final Setting Time	305 Minutes
Fineness	3.426%
Soundness	0.33mm
Specific Gravity	2.93

C. *Coarse Aggregates*

Crushed angular stone chips of nominal maximum size of 20mm are used and different tests have been conducted as per IS: 383-1970 and IS: 2386-1963. Table-II shows the observations taken during the tests.

TABLE-II PROPERTIES OF COARSE AGGREGATES

Water absorption	0.464%
Specific Gravity	2.86
Crushing strength	2.61N/mm2

D. Fine Aggregates

Different tests were conducted on natural river sand, which is used as fine aggregate, per IS: 383-1970 and IS: 2386-1963. Properties of sand are shown in Table-III

TABLE-III PROPERTIES OF FINE AGGREGATES

Water Absorption	0.604%
Specific Gravity	2.72
Zone	IV
Bulking of sand	16%

E. Fibres

Carbon steel Binding wires are cutted into pieces and used as fibres in this present study. The detail properties of binding wires are given in Table-IV and Fig.1.

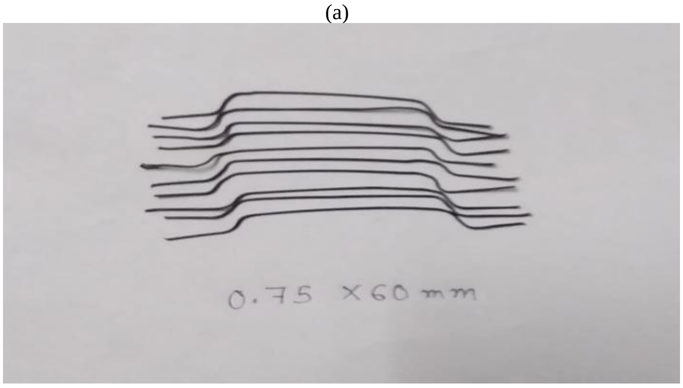
TABLE-IV PROPERTIES OF BINDING WIRES

Density	7840kg/m^3
Diameter	0.75 mm
Length	60 mm
Aspect ratio	80
L_d	1/8 of 60mm

F. Design Mix

For this present study M25 concrete is used. Using the test data of materials and as per IS 10262:2009, the mix design is carried out. All the specimens were casted using this design mix proportions. As per the design mix, the quantities required for 1m3 concrete is shown in Table-V.

(a)



(b)

Fig.1: Binding wire as Fibre.

TABLE-V PROPORTION FOR 1M^{3}CONCRETE

Grade of Concrete	M25
Slump	100mm
Size of Coarse aggregate	20mm
Cement	394 kg/m3
Fine Aggregate	581 kg/m3
Coarse Aggregate	1256 kg/m3
Water Content	197 kg/m3
W/C ratio	0.5
Mix Design Ratio	1 : 1.47 : 3.19

G. Casting and Curing of Specimen

To determine the effects of binding wire as a fire on compressive strength, split tensile strength and flexural strength of concrete, cubes of 150mm×150mm×150mm, cylinders of 150mm diameter and 300 mm height, beams of size 500mm×100mm×100mm were casted without fibre and with different quantities of fibre. Hand mixing is used for mixing the concrete without and with fibres to maintain the proper quantities of fibres in each specimen. Specimens were demoulded after 24 hours and cured for 28days under normal water. Details of specimens are given in Table-VI.

TABLE-VI DETAILS OF SPECIMENS

Specimens	**Name of test**	**Quantities of fibre added kg/m^3**	**No. of specimens**
Cubes 150mm×150mm×150mm	Compressive strength test	0 kg/m^3	6 Nos.
		5 kg/m^3	6 Nos.
		10 kg/m^3	6 Nos.
		15 kg/m^3	6 Nos.
		20 kg/m^3	6 Nos.
		25 kg/m^3	6 Nos.
		30 kg/m^3	6Nos.
Cylinders 150mm diameter and 300 mm height	Split tensile test	0 kg/m^3	6 Nos.
		5 kg/m^3	6 Nos.
		10 kg/m^3	6 Nos.
		15 kg/m^3	6 Nos.
		20 kg/m^3	6 Nos.
		25 kg/m^3	6 Nos.
		30 kg/m^3	6 Nos.
Beams 500mm×100mm×100mm	Flexural strength test	0 kg/m^3	6 Nos.
		10 kg/m^3	6 Nos.
		15 kg/m^3	6 Nos.
		20 kg/m^3	6 Nos.
		25 kg/m^3	6 Nos.

III. RESULTS AND DISCUSSIONS

The objective of the present study was to find out the effects of addition of binding wires as fibres on concrete. For these three types of tests were conducted, compressive strength test on cubes, split tensile test on cylinders and flexural strength tests on beams, without and with different quantities of fibres added into the samples while casting.

A. *Compressive Strength Test*

Prepared cube samples without and with fibres are tested after 28 days curing as per IS 516-1959. The test results are shown in Table-VII and Figs-2 and 3. The crack pattern of cubes without and with fibres after testing is shown in Fig. 4.

From Table-VII and Figs.-2 and 3 it is shown that the addition of binding wires as fibre significantly increase the compressive strength of concrete. It is also clear that with increase with the quantities of fibres the compressive strength of concrete is increasing.

TABLE-VII VALUES OF AVERAGE COMPRESSIVE STRENGTH AND PERCENTAGE INCREASE FOR DIFFERENT QUANTITIES OF FIBRES

Quantity of Fibre added (kg/m3)	Average compressive strength (N/mm2)	% Increase in compressive strength
0	30.21	0.00
5	32.96	9.10
10	35.158	16.38
15	35.71	18.21
20	36.701	21.49
25	38.38	27.04
30	40.62	34.46

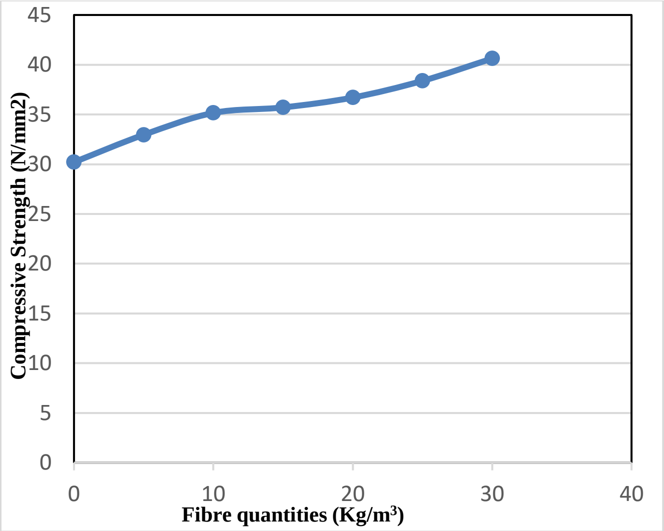


Fig. 2. Variation of average compressive strength for different quantities of fibres.

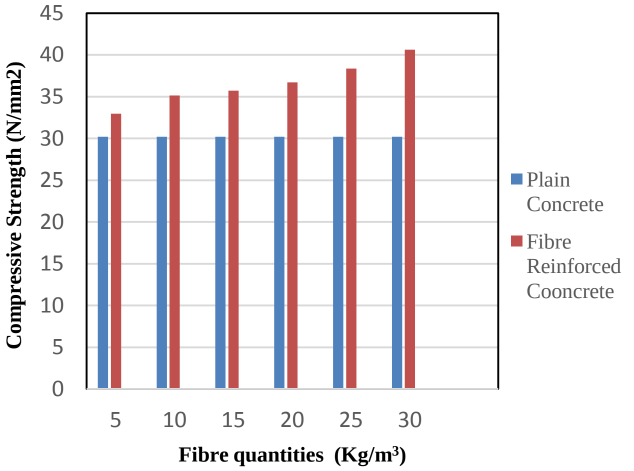


Fig. 3. Comparison of average compressive strength for different quantities of fibres with plain concrete.

(a)Without fibres

(b)With fibres

Fig. 4. Crack pattern of cubes without and with fibres.

B. *Split Tensile Strength Test*

Split tensile test was carried out on cylinder specimens with and without fibres after 28 days curing according to IS: 5816-1999. Table-VIII and Figs.5 and 6 shows the split tensile test results of specimens without and with different quantities of fibres as well as the percentage increase in split tensile strength using fibres are also given. The crack pattern of cylinders without and with fibres after testing is shown in Fig.7.

The results shows that like compressive strength, with addition of binding wires as fibres increases the split tensile strength of concrete. It is also observed that plain concrete fails suddenly once the ultimate load carrying capacity exceeded on the other hand fibre reinforced concrete continues to sustain considerable loads even the loads exceeded the ultimate load.

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TABLE-VIII VALUES OF AVERAGE SPILT TENSILE STRENGTH AND PERCENTAGE INCREASE FOR DIFFERENT QUANTITIES OF FIBRES

Quantity of Fibre added (kg/m3)	**Average Split tensile value**	**% Increase in split tensile strength**
0	3.41	0
5	3.81	11.73
10	4.23	24.05
15	4.27	25.22
20	4.32	26.69
25	4.47	31.09
30	4.59	34.60

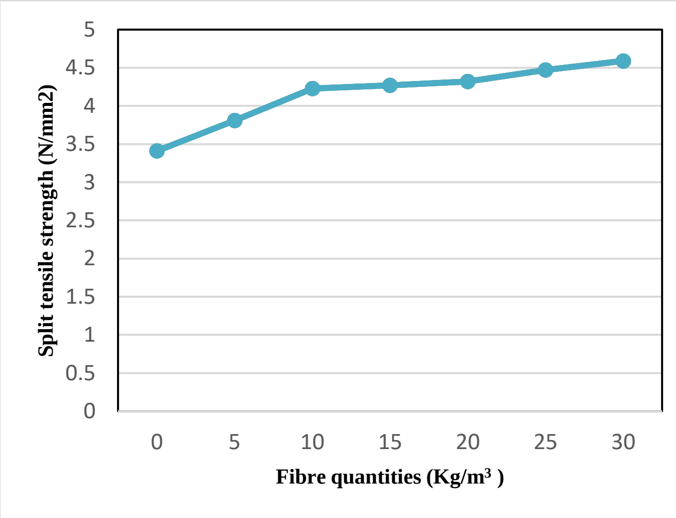

Fig. 5: Variation of average split tensile strength for different quantities of fibres.

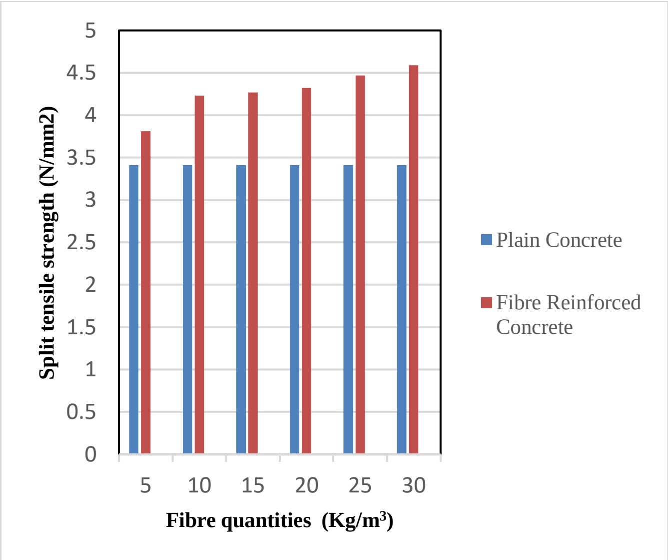

Fig. 6. Comparison of average split tensile strength for different quantities of fibres with plain concrete.

(a)Without fibres

(b)With fibres

Fig.7: Crack pattern of cylinders without and with fibres after testing.

C. *Flexural Strength Test*

Flexural strength was determined according to IS: 516-1999 for the beam specimens with and without fibres. Test results obtained from the flexural strength test carried out on the beam specimens with and without fibres are shown in Table-IX and Figs. 8 and 9.

It can be seen from the flexural strength test results that addition of fibres can considerably increase the flexural strength of concrete. The bridging action of fibres keeps the bond strength between fibre and concrete which prevent the sudden failure of concrete.

TABLE-IX. VALUES OF AVERAGE FLEXURAL STRENGTH AND PERCENTAGE INCREASE FOR DIFFERENT QUANTITIES OF FIBRES

Quantity of Fibre added (kg/m3)	Average flexural strength value	% Increase in Strength
0	2.82	0
10	3.2	13.48
15	3.37	19.50
20	3.42	21.28
25	3.54	25.53

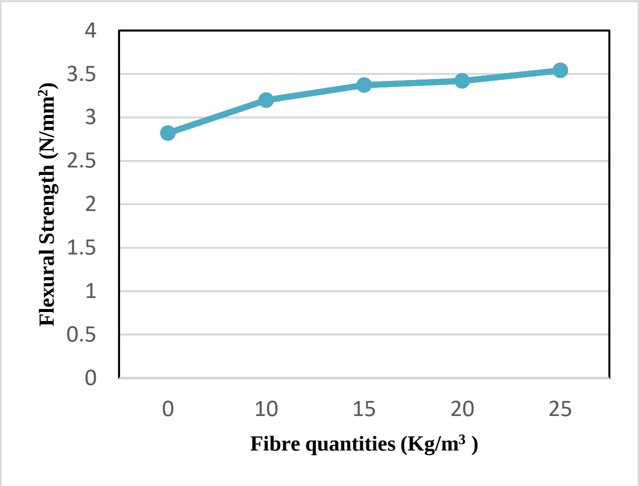

Fig.8. Variation of average compressive strength for different quantities of fibres.

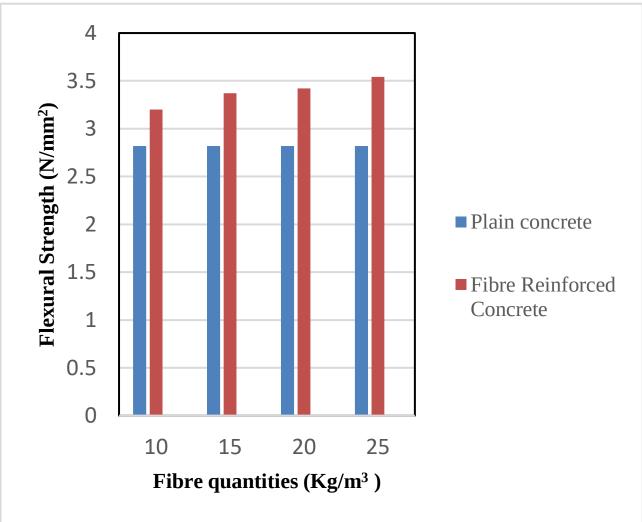

Fig. 9. Comparison of average flexural strength of beams for different quantities of fibres with plain concrete.

(a)Without fibres

(b)With fibres

Fig.10. Crack pattern of beams without and with fibres after testing.

From the crack formation pattern of all specimens used for compressive, split tensile and flexural strength, it is also clear that with fibres the crack formation is very small compared to the non fibre specimens. Addition of binding wires as fibres, improve the ductility of the concrete along with its post cracking load carrying capacity.

IV. CONCLUSIONS

The result of the study shows that addition of binding wires improves the strength characteristics of concrete. It is also seen that with increase with the quantities of fibre, the compression, split tensile and flexural strength of concrete is increasing. But with increase with the quantities of fibres in concrete, impart extra load on the structure and also increase the cost. Apart from the strength characteristics, it is also clear from the results and the crack pattern of the tested specimens that addition of binding wires as fibre improve the ductility of the concrete along with its post cracking load carrying capacities.

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