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Hooked Steel Fibred Reinforced Cement Concrete

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***Abstract*: Continuous advancement in the concrete is necessary for its different purposes in different structures. Adding different fibres in concrete (as per the recommendations of structure) for its enhancement proved successful. In this paper we are studying 'Hooked steel fibred reinforced concrete', by adding hooked steel fibre in varying percent (0%, 1% and 2%) in the concrete and testing it for different forces(compressive, tensile and Flexure). Changes happened after adding hooked steel fibres are studied with the help of table and graph. A significant improvement in compressive, tensile, flexural strength and lowered value of deflection of a member is observed due to inclusion of hooked steel fibre in the concrete. Optimum fibre content is found to be strength dependent.**

***Keywords*: Aspect ratio of fibre, Deflection of member, Fibre, flexural, Strength of concrete, Split tensile.**

1. Introduction

Concrete design is both an art and science, by using scientific knowledge of concrete and applying artistically, we can achieve the desired. For different sizes and structural shapes, we required design as per required conditions. Special structures required special designs and applied knowledge.

In this paper we are discussing on 'hooked steel fibre'. Steel fibres are not new, but it contains different shapes which came in market regularly updated and their study is important to use them in practice. Here, we used hooked steel fibre in concrete and taken different tests on it, as compression, split tensile, and flexural. From these test's results, we can analyse the members with and without hooked steel fibres.

2. Concrete

For our study, we use M-40 grade of concrete with the following proportion,

Table 1
Proportion of concrete mixture

Cement	Fine Aggregate	Coarse Aggregate	Water
1	1.45	2.43	0.4

Ordinary Portland Cement of 53grade. Coarse Aggregate by 10mm and 20mm mixed equally.

Hooked steel fibres were added as 1% and 2% of the weight of cement (as the quantity is less it used as additive).

3. Steel fibres

There are various Fibre shapes for the different purpose, we used hooked steel fibre. Criteria for the selection of hook fibres are only study purpose of particular one.

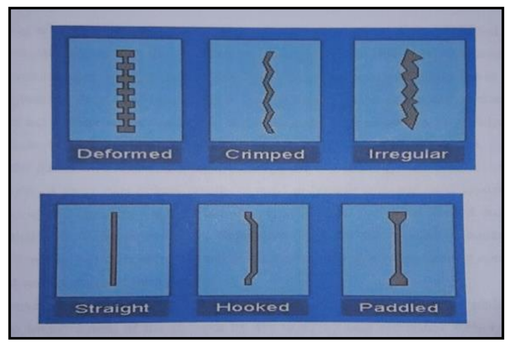

Fig. 1. Different types/shapes of steel fibres

Aspect ratio is one of the important factors for deciding steel fibre elasticity; it defined as the fibre length divided by an equivalent fibre diameter. Generally, it varies from 30 to 150. For hooked steel fibre, diameter of the fibre is 1mm and length is 49mm (averagely), and having aspect ratio of 49.

4. Testing Method

For study we conducted following tests,

a. Compressive testing.
b. Split tensile test.
c. Flexural test.

For the above tests equipment's size and standard are as per of 'IS 10086:1982'. And Procedures followed with reference to textbooks [3] [4] given in 'Refrences'.

For all concrete blocks, time given for set is 24hrs. And curing done under curing tank for 28 days (with water temperature is between 24°c to 30°c).

For the mentioned tests, we cast 3 samples of concrete block for each percent of fibre (for 0%, 1% and 2% percent of fibre). And after that average value of those 3 samples are taken (for more accuracy).

A. Compressive testing method

The compression test was performed to find out compressive strength of normal concrete (0% fibre), and Hooked steel fibre reinforced concrete (1%, 2% fibre) on test specimen cubical in shape of size 150mm × 150mm × 150mm, confirming to IS 10086:1982. All specimens of cube compression were air dried prior to testing. Test was conducted in a compression testing machine with a capacity of 200 Ton. Rate of loading was kept 140 kg/cm²/min. After taking load value at which cube is failed, strength can be determined from following equation,

Fcu= PC/A

Where,

Fcu = Compressive strength (MPa)

PC = Failure load in compression (N)

A = Loaded area of cube (Sq.mm)

Fig. 2. Performing compressive testing at lab

Table 2
Average Compressive strength of cubes with varying hooked steel fibre percent

Sr. No.	Fibre percent	Compressive strength (in MPa)	Average strength (in MPa)	Strength increase in percentage
1	0%	49.18	47.24	-
2	0%	51.30		
3	0%	41.22		
4	1%	41.69	48.53	2.72%
5	1%	53.03		
6	1%	50.87		
7	2%	47.85	51.59	9.20%
8	2%	53.03		
9	2%	53.89		

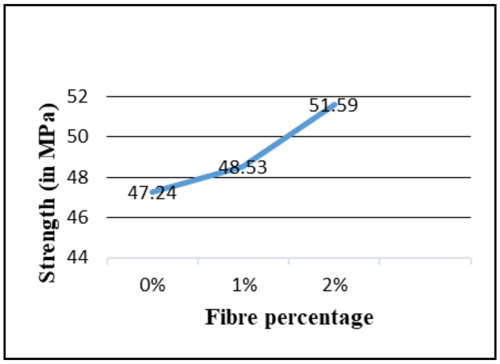

Fig. 3. Fibre percentage to compression strength graph

B. *Split tensile test*

The tensile strenth of concrete can be obtained indirectly by compressing the concrete cylinder (kept in horizontal position) between the plates of the compressive testing machine the knowledge of tensile strength of concrete is required for the design of structural concrete elements subjected to transverse shear, torsion, shrinkage, etc.

Test conducted with Compression testing machine and plywood strips (platens) of size 8mm× 12mm× 300mm. Concrete cylinder in horizontal position is placed in between the platens of the Compressive testing machine, along with the plywood packing at top and bottom. Load is applied gradually, till the concrete cylinder fails.

Table 3
Average Tensile Strength of Cylinders with Varying hooked steel fibre percent

Sr. No.	Fibre percent	Tension strength(in MPa)	Average strength(in MPa)	Strength increase in percentage
1	0%	7.63	6.758	-
2	0%	6.54		
3	0%	6.104		
4	1%	7.63	7.412	9.67%
5	1%	6.54		
6	1%	8.066		
7	2%	8.066	7.848	16.12%
8	2%	7.194		
9	2%	8.284		

As the direct tensile strength is difficult to find, the split tensile strength is normally used, and it can be determined as,

ft = 2P/DL

Where,

ft = split tensile strength of concrete in N/mm²

P = Load at failure in N

D = Diameter of cylinder = 150 N/mm²

L = length of cylinder = 300mm.

Since, in this test cylinder splits vertically in to two halves, this test is known as splitting test.

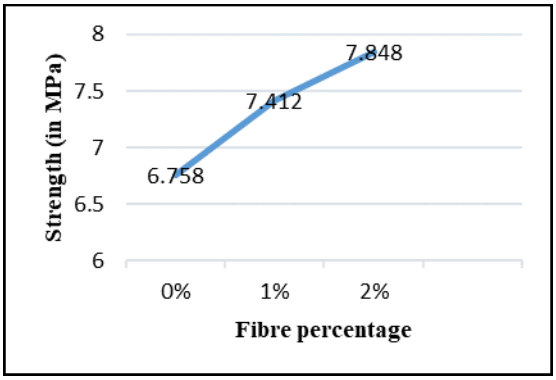

Fig. 4. Fibre percentage to tensile strength graph

C. Flexural test

To find out flexural strength of concrete, beam specimen of size 150mm×150mm×700mm were used. The beam specimen was placed in the machine in such a manner the load shall be applied to the uppermost surface as cast in the mould, along two lines spaced 200mm apart i.e. two-point load. The axis of specimen shall be carefully aligned with the axis of loading device. The load was applied without shock and increasing continuously at a rate of 400 kg/min. The deflection at the centre span of the beam was measured by sensitive sail gauge. Setup of federal test for concrete beam is shown in fig.

Flexural strength (MPa) = $(P \times L) / (b \times d^2)$

Where,

P = Failure load in KN

L = Center to center distance between point load = 200mm,

b= Width of specimen = 150 mm,

d = depth of specimen = 150 mm.

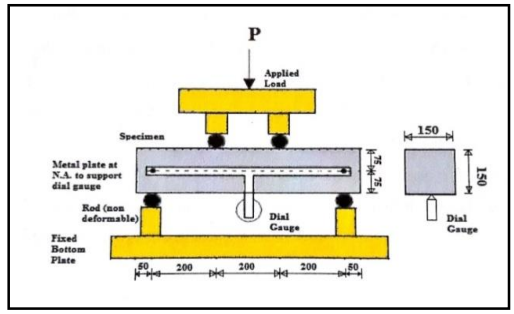

Fig. 5. Two-point loading setup in flexural test (All dimensions are in mm)

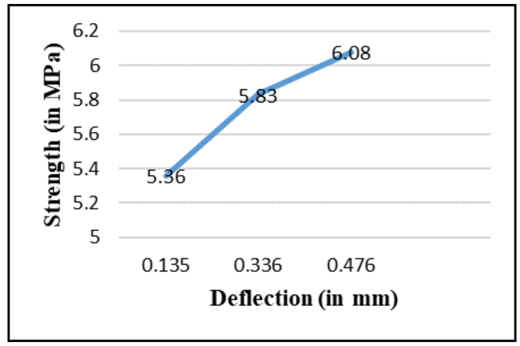

Fig. 6. Deflection to flexural strength graph for 0% fibre

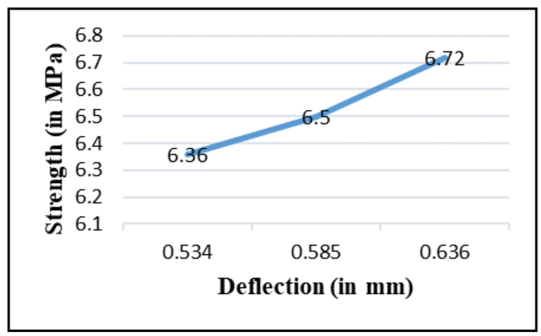

Fig. 7. Deflection to Flexural strength graph for 1% fibre

Table 4
Average Flexural strength of beam with varying fibre percent

Sr.No.	Fibre Percent	Flexural strength(in MPa)	Deflection (in mm)	Avg. flexural strength(in MPa)	Avg. deflection (in mm)	Increased strength in percentage
1	0%	5.83	0.336			
2	0%	5.36	0.135	5.75	0.316	-
3	0%	6.08	0.476			
4	1%	6.72	0.636			
5	1%	6.36	0.534	6.52	0.585	13.39%
6	1%	6.5	0.585			
7	2%	7.69	1.205			
8	2%	6.96	0.723	7.14	0.723	24.17%
9	2%	6.79	0.242			

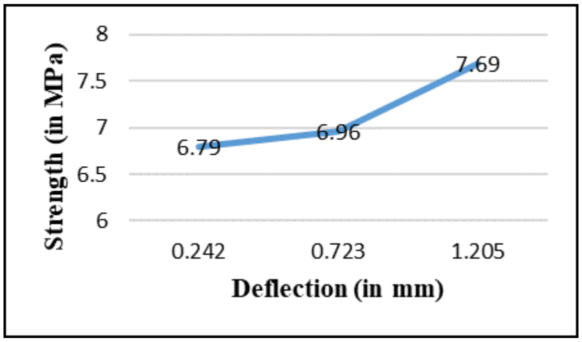

Fig. 8. Deflection to Flexural strength graph for 2% fibre

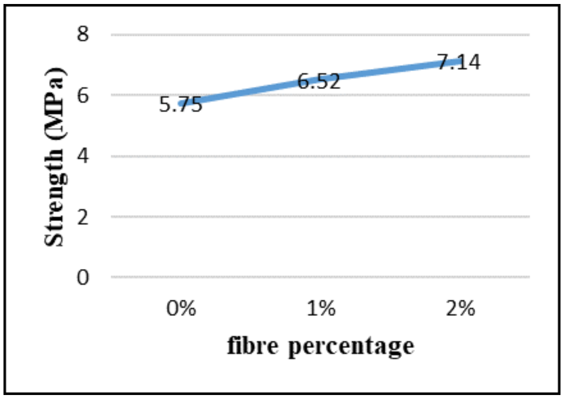

Fig. 9. Fibre percentage to flexural strength graph

Fig. 10. Cracks formed in beam due to flexural strength test (shows fibre bonding)

5. Conclusion

An experimental study of effectiveness of steel fibre in concrete has been carried out in the laboratory. On the basis of result obtained from experimental work, observation made during casting and testing of specimen, and result of the behavior of fibre reinforced concrete and normal concrete, the following conclusion are drawn.

1. In fibre modified mixes, reduction in slump, slump loss is happen. But, density of hooked steel fibre modified concrete mix increases observed higher than density of normal concrete.
2. The maximum cube compressive strength achieved are 47.24MPa, 48.53MPa, 51.59MPa are for 0%, 1% and 2%. Whereas the strength are increased as increase in fibre % till optimum point.
3. In flexural and tensile strength test, fibre increases the load carrying capacity by filling all pores and increasing its strength in different manner.
4. In flexural test, fibre also reduces deflection values.

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