Performance of Steel Fibers on Standard Concrete in Compression, Tension & Flexure

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ABSTRACT:

In this paper an attempt is made to present the results of an experimental investigation carried out on standard steel fiber reinforced concrete. Fiber content was varied from 0% to 4 % at intervals of 1% by weight of cement. The fibers considered in this study were hook end type with aspect ratio 40. The grade of concrete designed for investigation was M30 by using IS 10262-2009 having mix proportion 1:1.82:3.35:0.45. The strengths considered for investigation are Compressive strength, Flexural Strength and Split tensile strength. Cubes of size 150 x 150 x 150 mm to check compressive strength, Cylinders of size 300mm length and 150mm diameter to check split tensile strength were casted and the beam of size 500 x 100 x 100 mm were casted to check the flexural strength. All the specimens were cured for 1,3, 7, 28 & 56 days. The workability can test by using C.F Apparatus. The cubes, Cylinders are tested on 200T DCTM and the beams are tested on 100T UTM.

KEY WORDS:

Aspect ratio, Hook end type steel fibers, Fiber reinforced concrete, Compressive strength, Split tensile strength, Flexural strength and Workability.

1. INTRODUCTION:

Concrete is most widely used construction material in the world due to its ability to get cast in any form and shape. In the present days civil engineering constructions have their own structural and durability requirements related with concrete to better suit the intended function of the structure.

Plain cement concrete is most widely used material for construction of various structures; however it suffers from numerous Drawbacks such as low tensile strength, Brittleness & unstable concrete propagation and low fracture resistance.

Addition of steel fibers to plain cement concrete results in improving structural properties such as compressive strength, Split tensile strength, Flexural Strength, Shear and bond strength etc., Ductility also increased by adding steel fiber concrete. Hence Steel Fiber Reinforced Concrete (SFRC) has been proved as a reliable composite construction material having superior performance characteristics compares to conventional concrete characteristics.

SFRC is the concrete made with hydraulic cement containing fine and coarse aggregates and discrete fibers. In SFRC thousands of small fibers are dispersed and distributed randomly in the concrete during mixing and thus improve concrete properties. The unique properties of SFRC suggest the use of such material for making structural applications with and without traditional internal reinforcement.

The use of SFRC is, thus, particularly suitable for structures when they are subjected to loads over the serviceability, limit state in bending & shear and when exposed to impact and dynamic forces as they occur under seismic action.

The fibers help to transfer the loads at the internal micro cracks.

2.LITERATURE REVIEW

a) Concrete in Compression.Prasanth Y. Pawade[1] et al Studied on Performance of Steel Fibre on Standard Strength:

They had investigate a series of compression tests were conducted on 150mm x 150mm x 150mm cubes, 150mm x 300mm cylinders to find compressive strength, static and dynamic modulus of elasticity with and without steel fibers of volume fractions 0%, 0.5%, 1%, 1.5% of 0.5mm dia of aspect ratio 60 on PPC concrete. The weight density of concrete increasing with increasing of steel fibre content. Compressive strength and modulus of elasticity increased with addition of steel fibers. The compressive strength increased with the increase in silica fume with normal concrete. As a result the incorporation of steel fibers, silica fume and cement as produced a strong composite with superior crack resistance, improved ductility and strength behaviour prior to loading.

b) Vikrant S. Vairagade[1] and Kavitha S. Kene[2] Studied on Introduction to Steel Fibre Reinforced Concrete on Engineering Performance of Concrete.

They had studied the effect of fibers on workability, compressive strength, split tensile strength, modulus of rupture of concrete and also studied the effect of fibers on impact and toughness of concrete.

They investigated an experimental study were steel fibers added at the volume of 0.5%, 1%, 1.5%, 2%.. They draw the following conclusions: Due to high content of fibre, large surface area of fibers, fibers are sure to absorb more cement paste and increase of viscosity of mixture makes slump loss. The compressive strength increased from 6% to 17% with the increase of volume fraction of fibers. The split tensile strength increased from 18% to 47% with the increase of volume fraction of fibers. Flexural strength increased from 22% to 63% with the increase of volume fraction of fibers. Modulus of elasticity increased from 8% to 25% with the increase of volume fraction of fibers. Toughness increased by 19.27% with the increase of volume fraction of fibers when compared to plain concrete.

c) Kavitha S. Kene[1] et al investigated an Experimental Study on Behaviour of Steel and Glass Fibre Reinforced Concrete Composites.

They draw the following conclusions from their investigation: They had used M20 grade concrete with water cement ratio 0.5. They tested the specimens for a curing period of 7 and 28 days, type of steel fibers used are hook end with aspect ratio of 50 and 53.85.the volume fractions of steel fibers are 0% and0.5% by weight of cement. The type of glass fiber used is alkali resistant of 12 mm cut length. The volume fractions of glass fibers are 0% and0.25% by weight of cement. The maximum compressive strength was obtained by addition of 0.5% of fibers of 50mm length hookend type steel fibers. The maximum split tensile strength was obtained by addition 0.5% and 30mm length hookend type steel fibers. The ratio of compressive strength of cylinder to the cube was found to be 3:4.

d) Vikrant S. Vairagade[1] et al Studied on Investigation of Steel Fibre Reinforced Concrete on Compressive Strength and Tensile Strength.

They had studied the effect of steel fibers of different volumes fractions i.e. 0% and 0.5% of different aspect ratio i.e. 50, 53.85, 62.5 and of different fibers i.e. hookend type and crimped round type on M25 grade concrete. They had compared the results of steel fibers reinforced concrete with M20 plain concrete. The specimens were tested for 7 and 28 days curing period. The addition of 0.5% of steel fibers reduces the slump value of fresh concrete. This problem of workability and flow properties of concrete can be overcome by using suitable admixture like super plasticizers. By addition of 0.5% of steel fibers shows maximum compressive strength. By addition of 0.5% of steel fibers shows maximum tensile strength.

Split tensile strength depend on length of fibers, longer length fibers addition increases the split tensile strength of concrete. The change of the length of the fibers results nearly minor effect on compressive strength of concrete.

e) Job Thomas[1] and Anant Ramaswamy[2] Studied on Mechanical Properties of Steel Fiber Reinforced Concrete.

The variables considered were M35 normal concrete, M65 and M85 high strength concrete. The volume fraction of fibers were 0%, 0.5%, 1% and 1.5%. The type of fibers used was hookend type and the aspect ratio of fiber was 55. All the specimens were cured for 28 days. The maximum increase in compressive strength, modulus of elasticity, Poisson ratio due to addition of steel fibers was found to be very small (less than 10%) in various grades of concrete (35, 65 and 85 Mpa). The maximum increase in the split tensile strength and modulus of rupture due to addition of steel fibers was found to be about 40% in various grades of concrete (35, 65 and 85 Mpa). The post cracking response was significantly enhanced for using fiber dosage across the different grades of concrete.

3.EXPERIMENTAL PROGRAMMES

3.1 Materials used:

In this experimental study, Cement, Sand, Coarse aggregate, Water and Steel fibers were used.

Cement:- **Portland Pozzolana Cement** (PPC) was used in this experiment confirming to IS- 1489-1(1991)

Sand: Locally available sand Zone II with specific gravity 2.57 confirming to IS - 383- 1970

Water: Portable water was used for the experiment

Coarse aggregate: 2/3 from 20mm passing and 10mm retaining, 1/3 from 10mm passing and 4.75mm retaining from the weight approved in mix design. Specific gravity 2.78

Steel fiber: Hooked type with Aspect Ratio 40 (l = 30, d = 0.75)

Mix proportion for M30: 1:1.82:3.35 confirm to with W/C ratio 0.45 (Using- 13262- 2009)

3.2 Casting and Curing of Specimen:

The size of cubes 150 X 150 X 150 mm used to find compressive strength of concrete. The size of Cylinder 300mm Length & 150mmØ were used to find split tensile strength of concrete. The size of beams 500 X 100 X 100mm were used to find the flexural strength of concrete. The specimens were demoulded after 24 hours from the time of casting and the specimens under water till the time of testing i.e. 1,3, 7, 28 & 56 days.

3.3 Testing of Specimen:

The cubes and cylinders are tested on 200T DCTM. The beams are tested on 100T UTM. The workability test is conducted on Compacting factor apparatus.

4. EXPERIMENTAL METHODOLOGY:

4.1 Compressive strength test: For compressive strength test above specimens of 150 X 150 X 150 mm were cast for M30 grade standards concrete. The % of fibers added were 0,1,2,3, 4% by weight of cement. Vibration was given to the moulds using table vibrator. After 24 hours the specimens were demoulded and are shifted to curing tanks where they allowed to cure for 1,3, 7, 28 & 56 days. After completion of curing period these cubes were tested on DCTM (200KN) as per IS 516-1959. The tensile load was tested. In each category three cubes and three cylinders were tested and their average value is reported i.e. compressive strength was calculated as below.

$$\text{Compressive strength} = \frac{\text{Failure load}}{\text{Cross sectional area}}$$

4.2 Split tensile strength test:

For tensile strength, cylindrical specimens of 300mm height and 100mmØ were cast. The specimens were demoulded after 24 hours of casting and were shifted to curing tank where they were allowed to cure for 1,3, 7, 28 & 91 days. These specimens were tested under DCTM (200KN). In each category three cylinders were tested and their average value is reported as per IS 5816- 1999.

Tensile strength was calculated as follows

$$\text{Tensile strength} = \frac{2P}{\Pi DL}$$

Where,

P= Failure load

D= Diameter of cylinder

L=Height of Cylinder

4.3 Flexural strength test:

For Flexural strength test, beam specimens of dimensions 500 X 100 X 100mm were cast. The specimens were demoulded after 24 hours of casting and were shifted to curing tank where they were allowed to cure for 1,3, 7, 28 & 91 days. These specimens were tested under 2 point loading as per IS 516- 1959, over an effective span of 400mm on 100T UTM . In each category three beams were tested and their average value is reported.

Flexural strength was calculated as follows

$$\text{Flexural strength} = \frac{Pl}{bd^2} \quad (\text{if } a > 133\text{mm})$$

$$\text{Flexural strength} = \frac{3Pa}{bd^2} \quad (\text{if } 110 < a > 133\text{mm})$$

Where,

P= Failure load
l = c/c distance between supports = 400mm
b = Width of Specimen = 100mm
d = Depth of Specimen = 100mm
a = Distance to crack from nearst support

5. EXPERIMENTAL RESULTS

5.1 Compressive strength:-

Fig-1: Compressive strength test

Compressive strength of SFRC, Mpa (Hook end type fiber), l/d = 40, M30 concrete

Table-1

Fiber content by weight of cement (%)	Compressive strength(Mpa)				
	1 Day	3 Days	7 Days	28 Days	56 Days
0	10.83	14.66	18.49	37.28	43.96
1	14.51	18.87	23.78	39.71	56.59
2	14.16	18.93	29.15	40.92	42.11
3	14.68	20.10	24.24	42.95	45.13
4	14.49	17.95	23.98	41.20	44.71

4.4 Workability test:

Workability is carried out by conducting the C.F test as per IS 1199-1959with w/c ratio 0.45

Fig-2: Bar chart

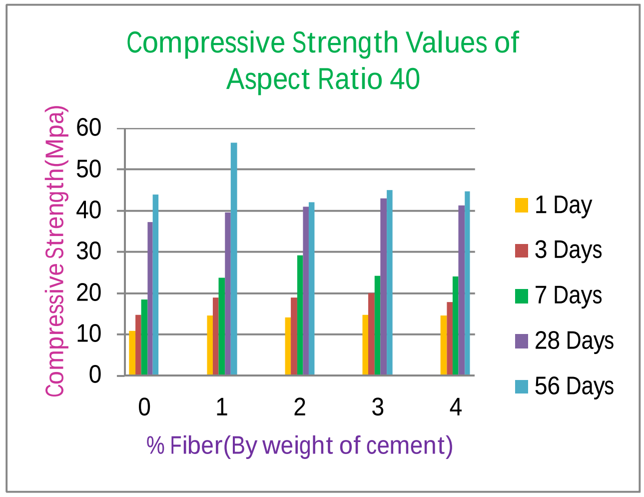
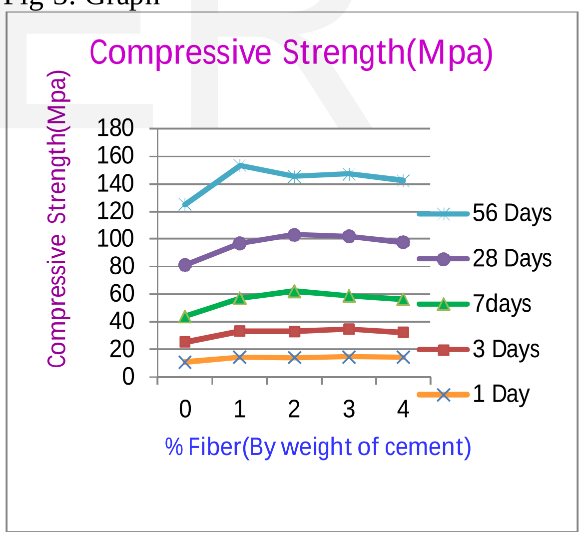


Fig-3: Graph



5.2 Split tensile strength (N/mm²):-

Fig-4 : split tensile strength test

Split tensile strength of SFRC, Mpa (Hook end type fiber), l/d = 40, M30 concrete

Table-2

Fiber content by weight of cement (%)	Spilt tensile strength(Mpa)				
	1 Day	3 Days	7 Days	28 Days	56 Days
0	1.10	1.54	2.07	2.96	3.28
1	1.21	1.73	2.28	3.04	3.46
2	1.34	1.8	2.00	2.95	3.53
3	1.32	1.72	1.82	3.21	3.50
4	1.28	1.73	2.31	3.22	3.47

Fig-5: Bar chart

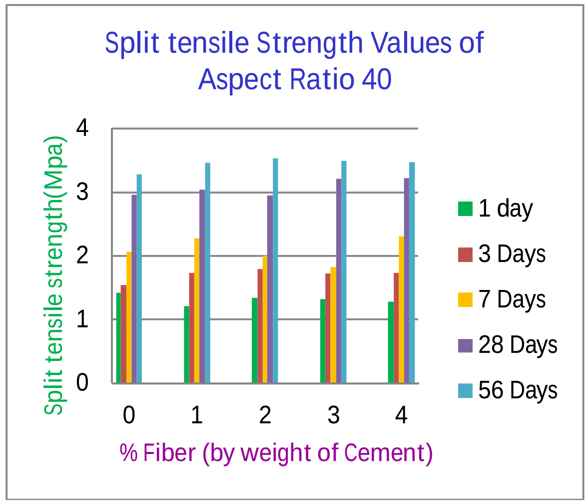
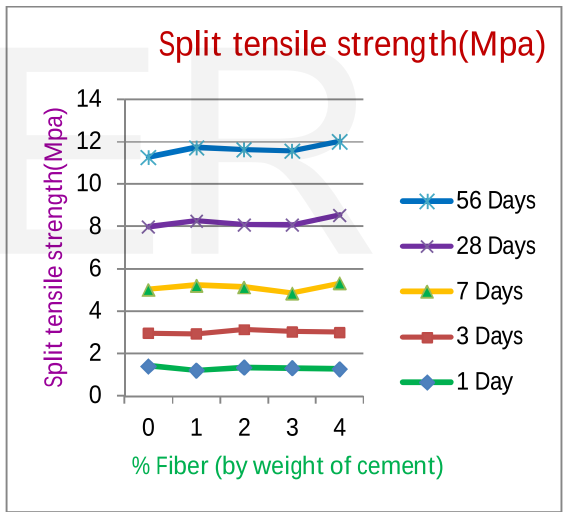


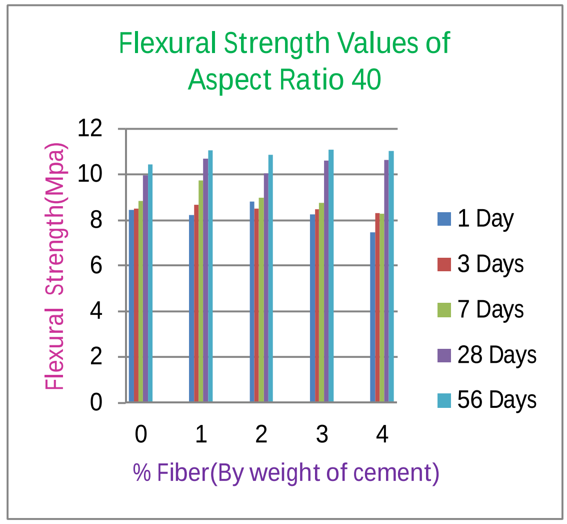
Fig- 6 : Graph



5.3 Flexural strength:-

Fig-7: Flexural strength test

Fig-8: Bar chart

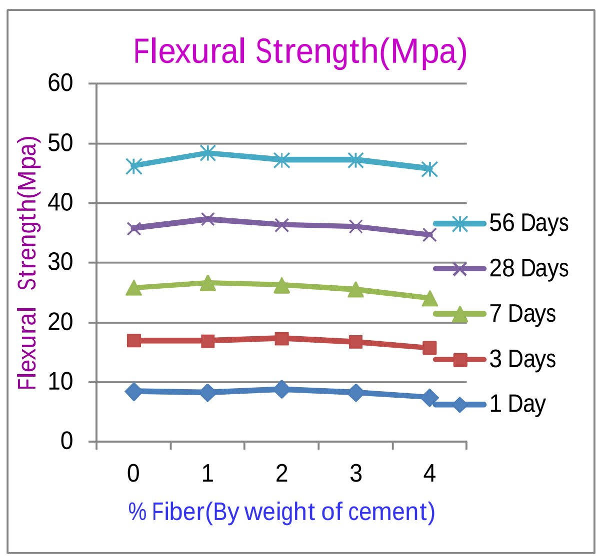


Flexural strength of SFRC, Mpa (Hook end type fiber), l/d = 40, M30 concrete

Table-3

Fiber content by weight of cement (%)	Flexural strength(Mpa)				
	1 Day	3 Days	7 Days	28 Days	56 Days
0	8.05	8.52	8.84	9.96	10.45
1	8.24	8.68	9.73	10.68	11.06
2	8.81	8.49	9.00	10.06	10.86
3	8.27	8.48	8.77	10.60	11.09
4	7.46	8.31	8.28	10.64	11.04

Fig-9: Bar chart



5.4 Workability test (C.F):-
Workability of fresh concrete, M30, Hook end type fiber with different aspect ratios.

Fig- 10 : Workability test

Table-.4

Fiber content by weight of cement (%)	C. F Value		
	l/d = 40	l/d = 50	l/d = 60
0	0.823	0.823	0.823
1	0.801	0.830	0.834
2	0.814	0.835	0.828
3	0.801	0.825	0.831
4	0.816	0.821	0.816

Fig-11: Bar chart

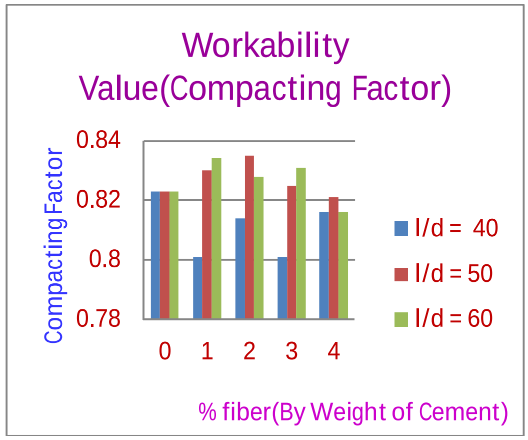
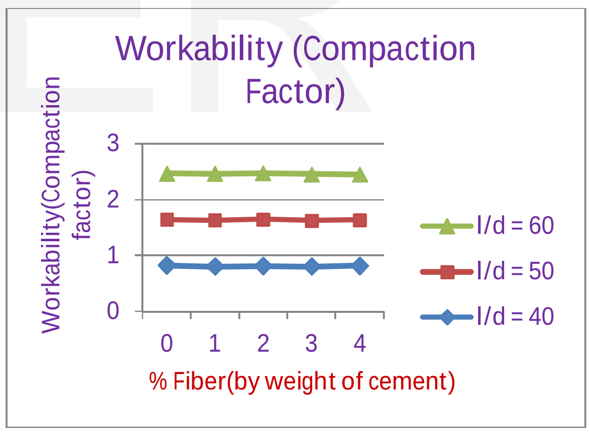


Fig-12 : Graph



6. CONCLUSION

1 The compressive strength of fiber reinforced concrete composed with steel fiber is found to be maximum at 3% of total fiber content by weight of cement at the age of 1,3 & 28 days, at 2% of total fiber content by weight of cement at the age of 7 days and at 1% of total fiber content by weight of cement at the age of 56 days.

2 The Split tensile strength of fiber reinforced concrete composed with steel fiber is found to be maximum at 4% of total fiber content by weight of cement at the age of7 & 28 days, at 2% of total fiber content by weight of cement at the age of 1, 3 & 56 days.

3 The Flexural strength of fiber reinforced concrete composed with steel fiber is found to be maximum at 1% of total fiber content by weight of cement at the age of 3,7 & 28 days, at 2% of total fiber content by weight of cement at the age of 1 day and at 3% of total fiber content by weight of cement at the age of 56 days.

4 The workability SFRC will be only marginally effected as % of steel fibers increases.

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