Experimental Study on Steel Fiber Reinforced Concrete

Amit Prakash[1], Tripti kumari[2] , Shiwani kumari[3] , Ekta kumari[4], Sonali Kumari[5]
Assistant Professor[1], Netaji Subhash Institute of Technology, Bihta
Students[2,3,4,5] , Netaji Subhash Institute of Technology, Bihta

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Abstract -
The purpose of this research is based on the investigation of the use of steel fibres in structural concrete to enhance the mechanical properties of concrete. The objective of the study was to determine and compare the differences in properties of concrete containing without fibres and concrete with fibres. This investigation was carried out using several tests, compressive test and flexural test. A total of eleven mix batches of concrete containing 0% to 5% with an interval of 0.5% by wt. of cement. 'Hooked' steel fibres were tested to determine the enhancement of mechanical properties of concrete. The workability of concrete significantly reduced as the fibre dosage rate increases.

Key Words: Steel fibres, SFRC, Workability, Strengths.

1.INTRODUCTION *(Size 11, Times New roman)*

Infrastructure is the key to a country's economic growth and social development. Concrete is the simplest and versatile construction material compared to other construction materials. In Steel Fiber Reinforced Concrete (SFRC), steel fiber is added to concrete due to its ability to restrict the growth of cracks and thus changing the brittle mode of composite to a strong cement matrix with superior crack resistance. Steel fiber reinforced concrete (SFRC) is a composite material whose components include the traditional constituents of Portland cement concrete and a dispersion of randomly oriented short discrete steel fibers. The development of steel fiber reinforced concrete began in the early 1960s. since then, the use of SFRC has gathered great interest, with research demonstrating the potential benefits that may lie in the use of the material in both structural and non-structural applications. The most common applications are pavements, tunnel linings, pavements and slabs, shotcrete and now shotcrete also containing silica fume, airport pavements, bridge deck slab repairs, and so on. There has also been some recent experimental work on roller-compacted concrete (RCC) reinforced with steel fibres. This paper presents an experimental program to investigate the compressive & flexural strength characteristics of concrete with or without steel fibers. The concrete shows the brittle behaviour and fails to handle tensile loading hence leads to internal micro cracks which are mainly responsible for brittle failure of concrete. The workability of concrete significantly reduced as the fibre dosage rate increases. Further, compressive strength at the ages of 7, 14, and 28 days was also determined and results are included

2. LITERATURE REVIEW

James Romualdi (1963), [1] in at the Carnegie Institute of Technology that a clearer understanding of the properties of SFRC emerged. Steel fibre reinforce concrete has been a later extension of this understanding, with the first application being to stabilise the rock slope of a tunnel portal, Idaho in 1972.

Ghugal Y.M., Nandanwar & Bansode C.V. (2010) [7], Studied 'Effect of different sizes of aggregate on steel fiber reinforced concrete'. They have found by using short and randomly distributed fiber in concrete arrests the propagating of micro cracks and results in better strength of concrete. He considers the variables as different sizes of aggregates. Concrete mix design for M20 grade is carried out with giber. Beams of size 500x100x100 mm were cast for flexural strength. In this test beam break into two parts and broken pieces after test were used for compressive strength and prism split tensile strength. The maximum flexural strength, compressive strength, split tensile strength in case of M20 grade concrete is found to be maximum at 1 % steel fiber.

Nitin Kumar et al (2015) [9],, presented the use of steel fibers as reinforcement material with concrete. In this study, the mixing of various materials weather chemicals natural or official for improving the strength and durability of parent substance. Critical investigation for M 40 grade of concrete having mix proportion 1:4:3 with water cement ratio 0.35 to study the compressive strength flexural strength, split tensile strength of steel fibers reinforced concrete containing fibers of 0%, 1%, 2% and 3% volume fraction of hooks the result shown that steel fiber reinforced concrete increase strength toughness ductility and flexural strength of concrete.

3.MATERIALS AND METHODS

4. Steel Fibers

Steel Fibers Steel fibers have been used in concrete since the early 1900s. The early fibres were round and smooth and the wire was cut or chopped to the required lengths. The use of straight and smooth fibres has largely disappeared and modern fibres have either rough surfaces or hooked ends or are crimped or undulated through their length. Modern commercially available steel fibres are manufactured from drawn steel wire, from slit sheet steel or by the melt-extraction process which produced fibres that have a crescent-shaped cross section. Typically steel fibres have equivalent diameters (based on cross sectional area) of from 0.15 mm to 2 mm and lengths from 7 to 75 mm. Aspect ratios generally range from 20 to 100. (Aspect ratio is defined as the ratio between fibre length and its equivalent diameter, which is the diameter of a circle with an area equal to the cross-sectional area of fibre.)

5.Compressive Strength:

The compressive strength test was carried using 2000kN compression testing machine in accordance with BIS (IS: 516-1959). A typical arrangement for compression testing of cubes is present in Fig below.

Fig 1. Compressive Strength Test Machine

6.Split Tensile Strength

The split tensile strength of concrete was determined after 7 days & 28 days of curing on cylindrical specimens. The cylindrical mould shall be of 150 mm diameter and 300 mm height conforming to BIS (IS:10086-1982), using 2000 KN compression testing machine as per the procedure given in BIS (IS:5816-1999). Therefore, the most commonly used tests for estimating the tensile strength of concrete is the splitting tension test. In the splitting tension test a 150mmx300mm concrete cylinder is subjected to compression loads along to axial lines which are diametrically opposite. The load is applied continuously at a constant rate until the specimen fails. The compression stress produces a transverse tensile stress which is uniform along the vertical diameter. The splitting tension stress is computed by the formula.

$$T=2P/\pi LD$$

Fig 1. Split Tensile Strength Test Machine

7.Flexural Strength

The flexural strength test was carried out on a prism specimen of dimension 100mm×100mm×500mm as per IS specification. So, in total forty-two numbers prisms were cast to measure the flexural strength after 28-days. The flexural strength of specimen shall be calculated as:

$$PL / bd^2$$

Where P = load applied on the prism (KN), L = length of the specimen from supports (mm), b = measured width of the specimen (mm), d = measured depth of the specimen (mm).

Concrete mix proportions. Concrete for M25 grade were prepared as per I.S.- 10262:2009. A mix proportion of 1:1.508:2.465 with 0.44 water cement ratio to get a characteristic strength of M25 was considered for this study. The exact quantity of materials for each mix was calculated. The constituent of materials used for making the concrete were tested and the results are furnished in Table2. The cement, fine aggregate, coarse aggregate were tested prior to the experiments and checked for conformity with relevant Indian standards. Concrete was mixed using a tilting type mixer and specimens were cast using steel moulds, compacted with table vibrator. Mix proportion for M25 grade concrete for tested material as follows:

8.RESULTS AND DISCUSSION

The below tables are of results represent the different strength test for 7, 14 & 28 days with different percentage of steel fiber and coarse aggregate in (MPa).

Table.1. Slump Test Results

S.NO	% Replacements Steel fiber concrete & Coarse Aggregate	Slump for M25 GRADE in (mm)	Slump for M30 GRADE in (mm)
1	1%SFC+99%CA	98	90
2	2%SFC+ 98%CA	90	86
3	3%SFC+ 97%CA	85	72
4	4%SFC+96%CA	76	70
5	5%SFC+ 95%CA	72	68
6	10%SFC+90%CA	73	60
7	15%SFC+85%CA	84	72
8	20%SFC+80%CA	86	80

Fig -1: Slump Test Results

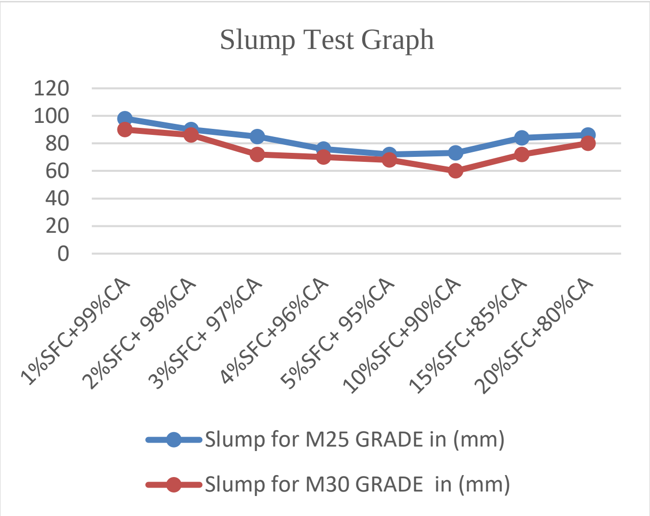


Table.2. Compaction factor test results

S.NO	% Replacement **Steel fiber concrete & Coarse Aggregate**	Compaction factor for M25 GRADE in (mm)	Compaction factor for M30 GRADE in (mm)
1	1%SFC+99%CA	0.82	0.84
2	2%SFC+ 98%CA	0.89	0.88
3	3%SFC+ 97%CA	0.83	0.94
4	4%SFC+96%CA	0.84	0.91
5	5%SFC+ 95%CA	0.84	0.9
6	10%SFC+90%CA	0.85	0.86
7	15%SFC+85%CA	0.79	0.84
8	20%SFC+80%CA	0.78	0.83

Table.3. Compressive Strength Test Results in (MPa)

S.NO	% Replacement Steel fiber concrete & Coarse Aggregate	Compressive strength of concrete			
		for M25grade		for M30 grade	
		7days (N/mm2)	28days (N/mm2)	7days (N/mm2)	28days (N/mm2)
1	1%SFC+99%CA	28.78	33.76	29.25	42.25
2	2%SFC+ 98%CA	24.68	34.45	31.34	44.55
3	3%SFC+ 97%CA	23.32	36.25	31.50	44.85
4	4%SFC+96%CA	24.87	34.45	30.89	43.45
5	5%SFC+ 95%CA	22.74	33.95	30.45	43.25
6	10%SFC+90%CA	21.64	33.35	29.60	42.25
7	15%SFC+85%CA	19.73	33.20	29.45	41.25
8	20%SFC+80%CA	19.82	32.25	28.25	35.55

Fig -2: Compressive strength of concrete

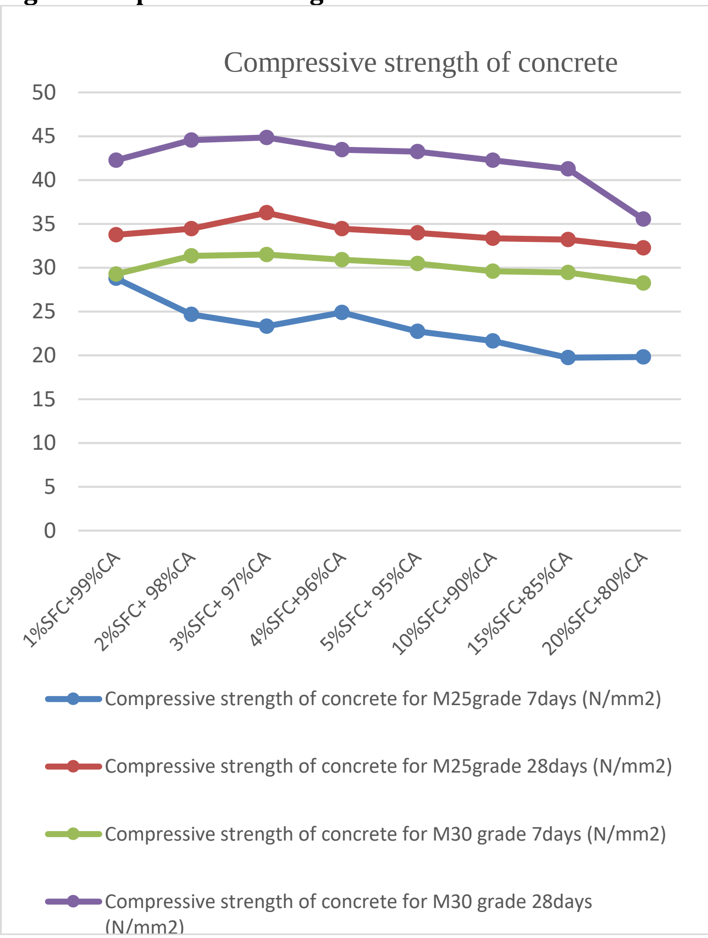


Table.4 Split tensile strength test results in (MPa)

S.NO	% Replacement Steel fiber concrete & Coarse Aggregate	Split tensile strength of concrete			
		for M25grade		for M30 grade	
		7days (N/mm2)	28days (N/mm2)	7days (N/mm2)	28days (N/mm2)
1	1%SFC+ 99%CA	4.10	4.24	5.25	5.10
2	2%SFC+ 98%CA	4.11	4.15	5.15	5.45
3	3%SFC+ 97%CA	4.24	4.85	5.55	5.65
4	4%SFC+ 96%CA	3.55	4.65	4.80	4.85
5	5%SFC+ 95%CA	3.25	4.48	4.55	4.65
6	10%SFC+ 90%CA	3.72	4.31	4.25	4.75
7	15%SFC+ 85%CA	3.45	3.65	3.45	3.80
8	20%SFC+ 80%CA	3.44	3.54	3.36	3.55

Graph-3 Split tensile strength test results in (MPa)

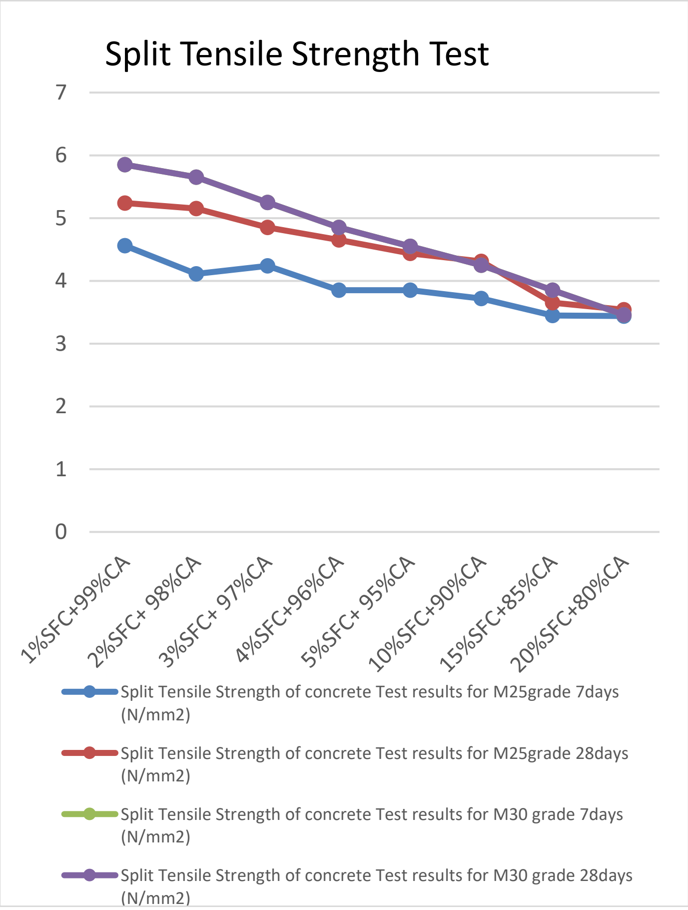
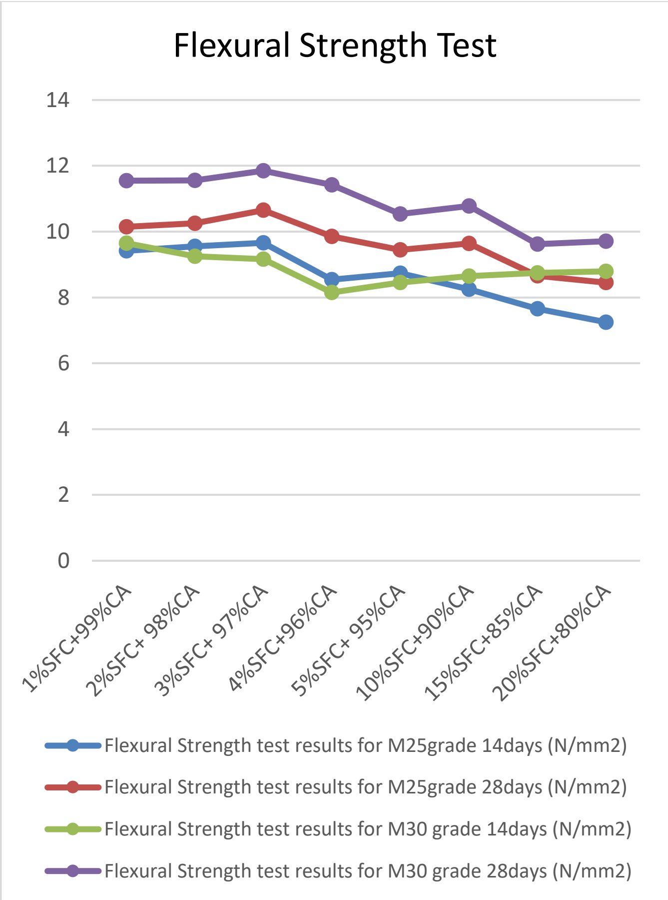


Table.5 Flexural Strength Test Results in (MPa)

S.NO	% Replacement Steel fiber concrete & Coarse Aggregate	Flexural Strength test results			
		for M25grade		for M30 grade	
		14days (N/mm2)	28days (N/mm2)	14days (N/mm2)	28days (N/mm2)
1	1%SFC+ 99%CA	9.42	10.15	9.65	11.55
2	2%SFC+ 98%CA	9.55	10.25	9.25	11.56
3	3%SFC+ 97%CA	9.66	10.65	9.16	11.85
4	4%SFC+ 96%CA	8.54	9.85	8.15	11.42
5	5%SFC+ 95%CA	8.74	9.45	8.45	10.54
6	10%SFC+ 90%CA	8.25	9.64	8.65	10.78
7	15%SFC+ 85%CA	7.66	8.66	8.75	9.62
8	20%SFC+ 80%CA	7.25	8.45	8.79	9.71

Graph-4 Flexural strength test results in (MPa)



9. CONCLUSIONS

1. Workability decreases with increase in fibre content.
2. The wet and dry density (7 and 28 Days) goes on decreasing as the percentage fibre volume fraction increases.
3. The maximum percentage increase in compressive strength, achieved are 36.25 for M25, and 44.85, for M30 respectively at 3.0%, of fibre volume fractions for 28days respectively. Similarly the split tensile results are 4.85 and 5.56 for 28days test results, the flexural strength was found to be 10.65 and 11.85 for 28days test results for M25 and M30 grade of concrete.
4. In general, the satisfactory improvement in various strengths is observed with the inclusion of Steel fibres in the plain concrete. However, maximum gain in strength of concrete is found to depend upon the amount of fibre content. The optimum fibre content to impart maximum gain in various strengths varies with type of the strengths.
5. Ductility of concrete is found to increase with inclusion of fibres at higher fibre content. The width of cracks is found to be less in SFC than that in plain cement concrete beam.

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