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Experimental Behaviour Of Steel Fiber Reinforced Concrete

A Study on Mechanical Performance of Steel Fibre Reinforced Concrete

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Abstract: This work investigates the performance of Steel Fibre Reinforced Concrete (SFRC) prepared with M30 grade concrete incorporating different fibre volume fractions (0%, 0.5%, 1.0% and 1.5%). The primary aim of the investigation was to assess how the addition of steel fibres affects the workability and mechanical behaviour of concrete, including compressive, split tensile, and flexural strengths. The concrete mix design followed the guidelines of IS 10262:2019, and tests were conducted on specimens after 7, 14, and 28 days of curing.The inclusion of steel fibres led to notable improvement in tensile and flexural performance, whereas compressive strength showed only moderate enhancement. The maximum improvement in overall mechanical behaviour was observed at 1.0% fibre content. The results demonstrate that SFRC exhibits superior structural efficiency, toughness, and energy absorption capacity due to its enhanced post-cracking response, improved ductility, and effective crack-bridging mechanism. In comparison to conventional concrete, SFRC achieved substantially higher tensile and flexural strengths with only marginal gains in compressive strength. Therefore, the study confirms the suitability of SFRC for structural applications where improved toughness, ductility, and energy dissipation characteristics are required.

***Index Terms* -** Steel Fibre Reinforced Concrete, M30 Concrete, Fibre Volume Fraction, Compressive Strength, Tensile Strength and Flexural Strength.

1. INTRODUCTION

Concrete is the most commonly utilised construction material because of its high compressive strength and adaptability in various structural applications. Despite these advantages, conventional concrete shows poor tensile performance, a brittle mode of failure, and low ability to absorb energy. Micro-cracks generally form at an early stage, later widening into major cracks, which adversely affects durability and service life.

The incorporation of short, discrete fibres provides an effective mechanism to restrain crack opening and facilitate stress transfer across cracks. This leads to improved ductility, enhanced post-cracking response, and better resistance to fatigue. Among various fibre types, steel fibres are preferred due to their superior tensile properties, stiffness, and suitable interaction with cement-based materials.

Steel Fibre Reinforced Concrete (SFRC) is a composite material produced by dispersing small steel fibres uniformly within fresh concrete. These fibres act to restrict crack growth, increase toughness, and enhance the load-bearing capability of the material. SFRC is commonly used in pavements, industrial flooring, tunnel linings, earthquake-resistant structures, and various precast elements because of its improved mechanical performance and durability.

2. Materials and Methodology

2.1 Materials

Cement: OPC 53 grade was used, complying with IS 12269:2004. Fineness, consistency, setting time and soundness were confirmed to be within permissible limits. Mean compressive strength of cement mortar at 28 days was 56 MPa.

Fine Aggregate: Locally available river sand conforming to Zone II was used. Average properties: specific gravity = 2.78, fineness modulus = 2.65, water absorption = 1.1%.
Coarse Aggregate: Crushed angular aggregate of nominal size 20 mm was utilised. Average specific gravity = 2.80, water absorption = 0.68%.

Steel Fibres: Hooked-end steel fibres with aspect ratio 50 and tensile strength 1100 MPa were used at 0%, 0.5%, 1.0% and 1.5% volume fractions.

Water: Potable water free from impurities was used for mixing and curing.

2.2 Mix Design

Mix proportions were designed for M30 grade concrete as per IS 10262:2019. Fibre addition was based on volume replacement, without altering binder content.
Specimens were cast for each fibre fraction and cured for 7, 14 and 28 days.

2.3 METHODS

Specimens were prepared as follows:

- Mixing of materials
- Compaction and casting
- Demoulding after 24 hours
- Curing in water for designated periods

Testing included:

- Compressive strength on cubes (150 × 150 × 150 mm)
- Split-tensile strength on cylinders (150 × 300 mm)
- Flexural strength on beams (100 × 100 × 500 mm)

3. Result and discussion

3.1 Compressive Strength

Average compressive strength values are summarised in Table 1.

Table 1: Compressive Strength of SFRC

Fibre %	**7 Days (MPa)**	**28 Days (MPa)**
0%	24.8	35.2
0.5%	26.9	38.5
1.0%	28.6	41.1
1.5%	28.0	40.4

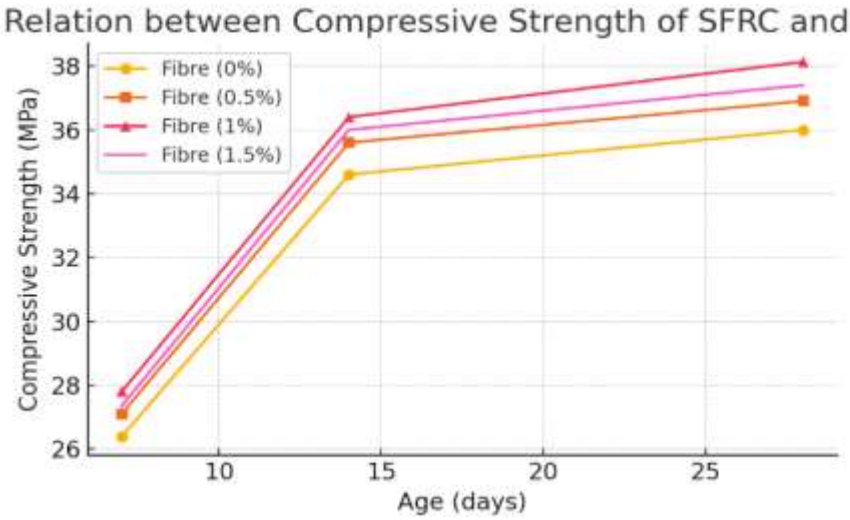

Fig 1: Relation between Compressive strength of SFRC with age of specimen cured in water

Strength improvements were modest, with maximum gain of ~16% at 1.0% fibre volume. Excess fibre content reduced workability and compaction efficiency, causing slight reduction beyond optimum level.

3.2 Split-Tensile Strength

Steel fibres exhibited a substantial influence on tensile performance. Average split- tensile strength values are summarised in Table 2.

Table 2: Split-Tensile strength of SFRC

Fibre %	7 Days (MPa)	28 Days (MPa)
0%	1.69	2.37
0.5%	1.94	2.67
1.0%	2.16	2.98
1.5%	2.12	2.92

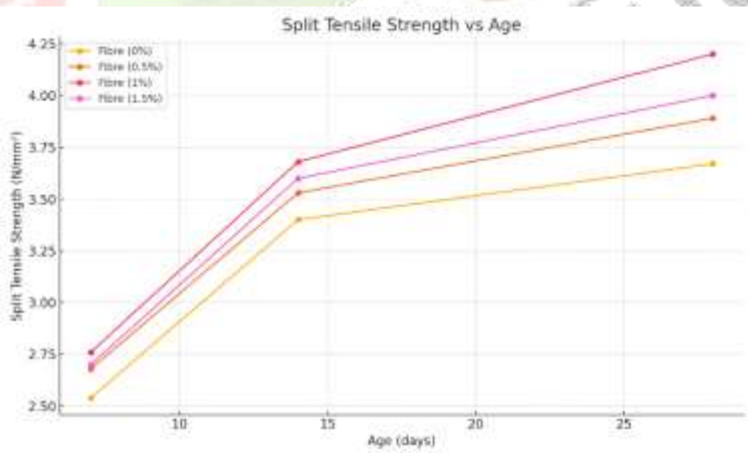

Fig 2: Relation between split-tensile strength of SFRC with age of specimen cured in water

At 1.0% fibre content, tensile strength increased by ~26% compared to control mixes, demonstrating greater crack resistance and energy dissipation.

3.3 Flexural Strength

Flexural performance showed the most notable improvement. Average flexural strength values are summarised in Table 3.

Table 3: Flexural Strength of SFRC

Fibre %	7 Days (MPa)	28 Days (MPa)
0%	3.21	4.52
0.5%	3.85	5.48
1.0%	4.22	5.93
1.5%	4.10	5.81

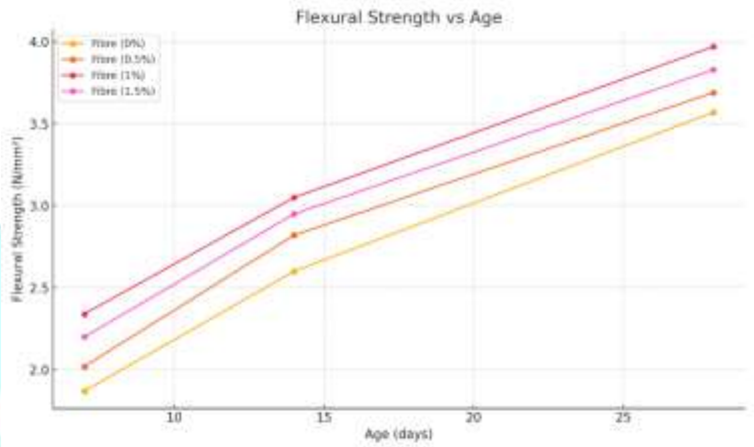

Fig 3: Relation between Flexural strength of SFRC with age of specimen cured in water

Steel fibres enhanced residual strength, toughness and arresting of micro-cracks. Increased post-cracking load-carrying capacity indicates ductile behaviour beneficial in seismic applications.

4. Discussion

Across all mechanical properties, strength improved with increasing fibre volume up to 1.0%. Performance declined slightly beyond this due to reduced workability and non-uniform dispersion.

Trends observed:

- Compressive strength: moderate increase
- Tensile strength: significant increase
- Flexural strength: highest increase

The improvements are attributed to:

- Crack bridging
- Enhanced bonding
- Energy absorption
- Toughness and ductility

SFRC demonstrated superior post-peak performance, suggesting suitability for pavements, slabs, seismic and blast-resistant systems.

5. Conclusion

- Incorporating steel fibres improves strength and structural performance of M30 grade concrete.
- Compressive strength improved moderately, with maximum increase at 1.0% fibre volume.
- Tensile strength increased significantly (~26–30% enhancement).
- Flexural strength showed the greatest improvement (~30–35% enhancement).
- Optimum fibre content was observed at 1.0%, beyond which workability and strength declined.
- SFRC exhibits improved ductility, crack control and energy absorption, making it suitable for applications subjected to high tensile or flexural stresses.

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