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Steel Fibre Reinforced Concrete

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Abstract*: Steel Fibre Reinforced Concrete (SFRC) has emerged as a promising composite material that significantly enhances the mechanical properties of conventional concrete. By integrating discrete steel fibres within the cementitious matrix, SFRC exhibits improved tensile strength, toughness, and crack resistance, addressing many of the inherent weaknesses found in plain concrete. This paper investigates the influence of fibre content, aspect ratio, and distribution on the structural behavior of SFRC under various loading conditions. Experimental results are compared with theoretical predictions and existing design standards to assess the material's performance in real-world applications. Particular attention is given to the post-cracking response, which demonstrates how fibre reinforcement contributes to energy absorption and ductility. The findings suggest that SFRC holds considerable potential for applications requiring high durability and resilience, such as in pavements, industrial flooring, and seismic zones. This study aims to contribute to a more nuanced understanding of SFRC, encouraging further exploration into its optimization and implementation in modern construction practices.
Keywords: Steel fibre, steel, concrete, modified concrete, ductility.

I. INTRODUCTION

Concrete has long been the cornerstone of modern infrastructure due to its availability, versatility, and compressive strength. However, its brittle nature and poor tensile capacity remain critical drawbacks, particularly under dynamic or unpredictable loading conditions. In an effort to overcome these limitations, researchers and engineers have explored the inclusion of fibres within the concrete mix, giving rise to a range of fibre-reinforced composites. Among these, Steel Fibre Reinforced Concrete (SFRC) stands out for its ability to significantly enhance toughness, ductility, and resistance to cracking. The incorporation of steel fibres transforms the concrete's internal structure, enabling it to redistribute stresses more effectively after the onset of cracking. This unique behavior has made SFRC an attractive choice in applications where durability and post-cracking performance are paramount, such as industrial flooring, tunnel linings, and structures in seismic zones. Despite its growing adoption, the behavior of SFRC is influenced by a variety of factors including fibre volume fraction, aspect ratio, orientation, and bond characteristics. As a result, its performance can vary widely depending on mix design and application. This study aims to explore the mechanical and structural responses of SFRC under controlled conditions, with an emphasis on how fibre properties influence crack propagation, load-carrying capacity, and energy absorption. By examining these aspects, the research seeks to contribute practical insights that can inform material selection and design approaches for engineers seeking more resilient concrete solutions.

II. METHODOLOGY

1) Comparison Of Compressive Strength Of SFRC At Different Percentage Of Steel Fiber (by weight of Cement):
Compressive Strength of concrete is defined as the Characteristic strength of 150mm size concrete cubes tested at 28 days.

2) Why Do We Test At 7, 14 & 28 Days?
Concrete is a composite construction material made from a mixture of cement, sand (fine aggregate), and coarse aggregate (such as gravel or crushed stone), combined in specific proportions known as the mix ratio. When water is added, a chemical reaction called hydration occurs, initiating the hardening process. Over time, typically 28 days under standard curing conditions, concrete gradually gains strength until it reaches its full design capacity. The final strength and durability of concrete depend on factors such as the quality of materials, water-cement ratio, curing method, and environmental conditions during setting and hardening. Concrete is widely used in construction due to its high compressive strength, workability, and long-term performance.

3) Concrete Strength Overtime

DAYS AFTER CASTING	STRENGTH GAIN

Day 1	16%
Day 3	40%
Day 7	65%
Day 14	90%
Day 28	99%

TABLE 1:CONCRETE STRENGTH OVERTIME

Grade of Concrete	Minimum compressive strength (N/mm^2) at 7 days	Specified characteristics compressive strength(N/mm^2) at 28 days
M15	10	15
M20	13	20
M25	17	25
M30	20	30
M35	23.5	35
M40	27	40
M45	30	45

TABLE 2 GRADE OF CONCRETE

III. PROCEDURE

1) Measure the dry proportion of ingredients (Cement, Sand & Coarse Aggregate) as per the design requirements. The Ingredients should be sufficient enough to cast test cubes.
2) Thoroughly mix the dry ingredients to obtain the uniform mixture.
3) Add design quantity of water to the dry proportion (water-cement ratio) and mix well to obtain uniform texture.
4) Fill the concrete to the mould with the help of vibrator for thorough compaction.
5) Finish the top of the concrete by trowel & tapped well till the cement slurry comes to the top of the cubes.
6) After some time the mould should be covered with red gunny bag and put undisturbed for 24 hours at a temperature of 27 ° Celsius ± 2
7) After 24 hours remove the specimen from the mould.
8) Keep the specimen submerged under fresh water at 27 ° Celsius. The specimen should be kept for 7 or 28 days. Every 7 days the water should be renewed.
9) The specimen should be removed from the water 30 minutes prior to the testing.
10) The specimen should be in dry condition before conducting the testing.
11) The Cube weight should not be less than 8.1 Kgs.
    Testing
12) Now place the concrete cubes into the testing machine. (centrally)
13) The cubes should be placed correctly to the machine plate (check the circle marks on the machine). Carefully align the specimen to the spherically seated plate.
14) The load will be applied to the specimen axially.
15) Now slowly apply the load at the rate of 140kg/cm2 per minute till the cube collapse.
16) The maximum load at which the specimen breaks is taken as a compressive load.

IV. ESTIMATION AND COSTING

1) *For Plain Concrete*

For compressive strength test three samples are taken and average strength is calculated.

No. of samples	Cement	Coarse aggregates	Fine aggregates	Water cement ratio (%)
Sample 1	4.8kg	10.77kg	9.6kg	0.45
Sample 2	4.8kg	10.77kg	9.6kg	0.45

TABLE -3:MATERIAL USED

2) *For Steel Fiber Reinforced Concrete:*

No. of sample	Cement	Fine aggregates	Coarse aggregates	Percentage of steel fiber
1	9.6kg	21.54kg	19.2kg	1%
2	9.6kg	21.54kg	19.2kg	1.25%
3	9.6kg	21.54kg	19.2kg	1.50%

TABLE -4:MATERIAL USED

Cost Analysis
ESTIMATION OF PLANE CONCRETE
Volume of dry Concrete = 1.54 times Volume of wet concrete.

CALCULATIONS-
Volume of the sample = (0.15 x 0.15 x 0.15) x 1.54 x 6 = 0.031m^3.
Quantity of cement = 1/8.25 x 0.031 x 1440 = 5.41kg.
Quantity of fine aggregate = 3.19/8.25 x 0.031 = 0.011m^3.
Quantity of coarse aggregate = 4.06/8.25 x 0.031 = 0.015m^3

S.No	Material	Quantity	Cost	Total Cost
1.	Cement	5.41kg	350/bag	38Rs
2.	Fine Aggregate	0.011m^3	2116/m^3	24Rs
3.	Coarse Aggregate	0.015m^3	1940/m^3	29Rs

Cost of one cube = 16Rs
Estimation of Steel Fiber Reinforced Concrete
CALCULATIONS-
Volume of the sample = (0.15x 0.15 x 0.15) x 1.54 x 6 = 0.031m^3.

Quantity of cement = 1/8.25 x 0.031 x 1440 = 5.41kg.
Quantity of fine aggregate = 3.19/8.25 x 0.031 = 0.011m^3.
Quantity of coarse aggregate = 4.06/8.25 x 0.031 = 0.015m^3.
Total quantity of Steel fiber = 1.88kg.

S.NO.	Material	Quantity	Cost	Total cost
1.	Cement	16.23kg.	350/bag	114 Rs.
2.	fine aggregate	0.033m^3	2116/m^3	70 Rs.
3.	coarse aggregate	0.045m^3	1940/m^3	87 Rs.
4.	steel fiber	1.88kg.	70/kg.	132Rs.
TOTAL COST=403Rs.				

Table-6: Cost Involved In SFRC

Percentage Of Steel Fibre	Cost Of 1 Cube (0.00519m^3)
1%	22Rs
1.25%	24Rs
1.5%	25Rs

3) Results:

S.NO.	M45+Steel FIBRE	COMPRESSIVE STRENGTH (N/mm^2)	
		7 Days	28 Days
1.	1.0%	33.29	46.34
2.	1.25%	33.90	47.48
3.	1.50%	35.71	46.34

TABLE – 7 COMPRESSIVE STRENGTH

S.NO.	M45+Steel FIBRE	FLEXURAL STRENGTH (N/mm^2)	
		7 Days	28 Day
1.	1.0%	4.04	4.76
2.	1.25%	4.07	4.82
3.	1.50%	4.18	4.87

Plain concrete		SFRC
	Compressive strength (N/mm^2)	Compressive strength N/mm^2)

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S.NO.	7DAYS	28 DAYS	% G.F.	7DAYS	28DAYS
1.	32.08	44.98	1	33.29	46.34
2.			1.25	33.90	47.48
3.			1.50	35.71	46.34

TABLE 8:COMPARISONS BETWEEN SFRC AND PLAIN CONCRETE

S.NO.	M45+steel FIBRE	SLUMP (mm)
1.	1%	41
2.	1.25%	35
3.	1.5%	32

TABLE 9:WORKABILITY

4) Effect of Compressive Strength on Glass Fiber Concrete:

This figure represents the graph between the Compressive strength vs % of glass fiber. The glass fiber is added at the rate of 1%, 1.25%, and 1.50%. Out of these, the compressive strength is very high at 1.50% having for 7 days is 35.71N/mm^2 and for 28 days is 46.34N/mm^2.

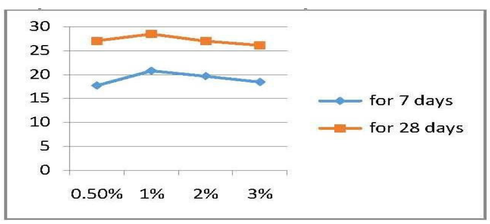

CHART 1: COMPRESSIVE STRENGTH VS. % OF STEEL FIBER

5) Effect of Flexural Strength on Steel Fiber Concrete:

This figure represents the graph between the Compressive strength vs % of Steel fiber. The Steel fiber is added at the rate of 1%, 1.25%, and 1.5%. Out of these, the tensile strength is very high at 1.50% having for 7 days is4.18N /mm^2 and for 28 days is 4.87N /mm^2.

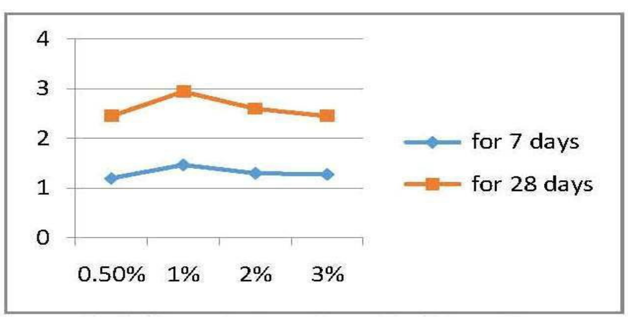

CHART 2: FLEXURAL STRENGTH (N/MM^2) V/S % OF STEEL FIBER

V. CONCLUSIONS

Steel Fibre Reinforced Concrete represents a significant advancement in the development of durable and high-performance concrete composites. Through the inclusion of steel fibres, the material overcomes many of the inherent weaknesses of conventional concrete, particularly in terms of tensile strength, crack resistance, and post-cracking behavior.

The findings of this study underscore the role of fibre characteristics—such as content, orientation, and aspect ratio—in influencing the mechanical performance of SFRC. The experimental results confirm that the addition of steel fibres enhances the load-bearing capacity and energy absorption of concrete, making it a suitable material for applications where durability and toughness are critical. Moreover, the improved ductility and crack control exhibited by SFRC contribute to its reliability in structural applications, especially in scenarios involving dynamic loading or long-term wear. While the potential of SFRC is clear, further research is necessary to refine mix designs, optimize fibre distribution, and develop more accurate predictive models for structural behavior. As the construction industry continues to evolve toward more resilient and sustainable materials, SFRC is likely to play an increasingly important role in future infrastructure projects.

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