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Original Article

Experimental Investigation on Structural Performance of Steel Fiber In RCC Elements

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Abstract: *The development of modern construction requires materials with enhanced ductility and crack resistance. This study experimentally examines the structural performance of hooked-end steel fibers as a reinforcement in RCC elements. The investigation utilizes M25 grade concrete with steel fiber addition at volume fractions of 0.5%, 1.0%, and 1.5%. Concrete specimens including cubes, cylinders, and beams were cast and cured under laboratory conditions. The specimens were tested for compressive strength, split tensile strength, and flexural behavior. The findings indicate that the inclusion of steel fibers significantly improves the energy absorption and ductility of the concrete matrix. While compressive strength showed a steady increase up to an optimum level, higher fiber content was found to enhance crack bridging. The study concludes that steel fibers effectively enhance the structural integrity of RCC elements for sustainable construction.*

Keywords: *Steel Fiber Reinforced Concrete (SFRC), Hooked-end Fibers, Structural Performance, Compressive Strength, Flexural Strength, Ductility, Crack Resistance.*

I. INTRODUCTION

Development in the field of infrastructure requires concrete that can withstand complex loads without developing any brittleness. Ordinary concrete is known for its superior compressive strength, but it is deficient in terms of tensile strength; therefore, it becomes susceptible to micro-crack formation and propagation. To overcome such deficiencies, there have been efforts to introduce hooked-end steel fibers in the concrete matrix to improve its mechanical properties. The current study attempts to examine the influence of steel fiber content in the range of 0% to 1%, both individually and in combination with M25 grade concrete, to investigate its effects on the mechanical behavior of concrete in terms of compressive strength, split tensile strength, and flexural strength. The introduction of steel fibers makes the concrete more flexible and enhances its ability to resist crack propagation. Such concrete demonstrates superior behavior in the presence of cracks and can efficiently carry loads despite the occurrence of cracks. Additionally, steel fiber-reinforced concrete offers improved durability and longevity of reinforced cement concrete (RCC) structures by minimizing crack width and delaying deterioration.

II. METHODOLOGY

Material Collection → physical and mechanical properties → Mix Design → Mixing → Casting → Curing → Testing → Analysis → Conclusion

III. EXPERIMENTAL INVESTIAGTION

A. CEMENT

Cement is a fine binding material used in construction that hardens when mixed with water and binds aggregates like sand and gravel to form concrete. It is made from materials such as limestone and clay and contains compounds like lime, silica, and alumina. Cement is widely used in building construction, roads, and bridges due to its strength, durability, and ability to hold materials together.

Table 1: Physical Properties of Cement

SI.NO	DESCRIPTION	VALUE
1.	Fineness	3.46%
2.	Consistency	34%
3.	Specific gravity	3.12
4.	Initial setting time	30mins
5.	Final setting time	600mins

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B. FINE AGGREGATE

Fine aggregate is a material consisting of small-sized particles, mainly sand, used in construction to fill voids between coarse aggregates and improve the strength and workability of concrete. It is usually obtained from natural sources like river sand or manufactured sand and plays an important role in providing a smooth finish, durability, and proper bonding in concrete and mortar.

Table 2: Physical Properties of FIEN Aggregate

S.No	DESCRIPTION	REMARKS
1.	Specific Gravity of Fine Aggregate	2.5
2.	Sieve Analysis of Fine Aggregate	Grading Zone-II
3.	Water Absorption Test on Fine Aggregate	1.4%
4	Bulk Density Test on Fine Aggregate	Loose Condition- 1250 Kg CompactCondition-1500Kg

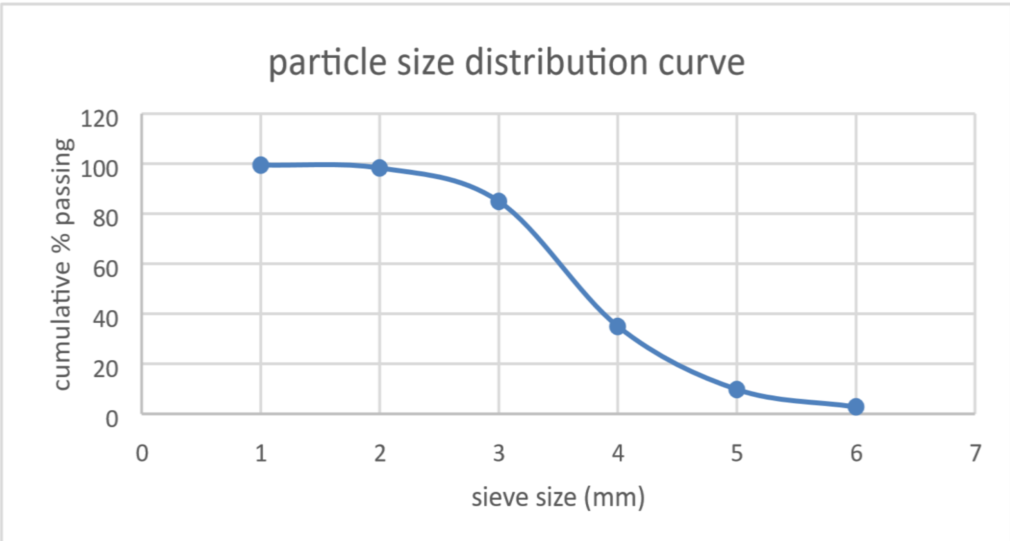

Figure 1: Sieve Analysis Graph for Fine Aggregate

C. COARSE AGGREGATE

Coarse aggregate consists of large-sized particles such as gravel or crushed stone used in concrete to provide strength and stability. It forms the main bulk of concrete, reduces shrinkage, and helps in load distribution, thereby improving the durability and overall performance of the structure.

Table 2: Physical Properties of Coarse Aggregate

S.No	DESCRIPTION	REMARKS
1.	Specific Gravity of Coarse Aggregate	2.7
2.	Sieve Analysis of Coarse Aggregate	Grading Zone-II
3.	Water Absorption Test on Coarse Aggregate	1.8%
4	Bulk Density Test on Coarse Aggregate	Loose Condition- 1400 Kg CompactCondition-1600Kg

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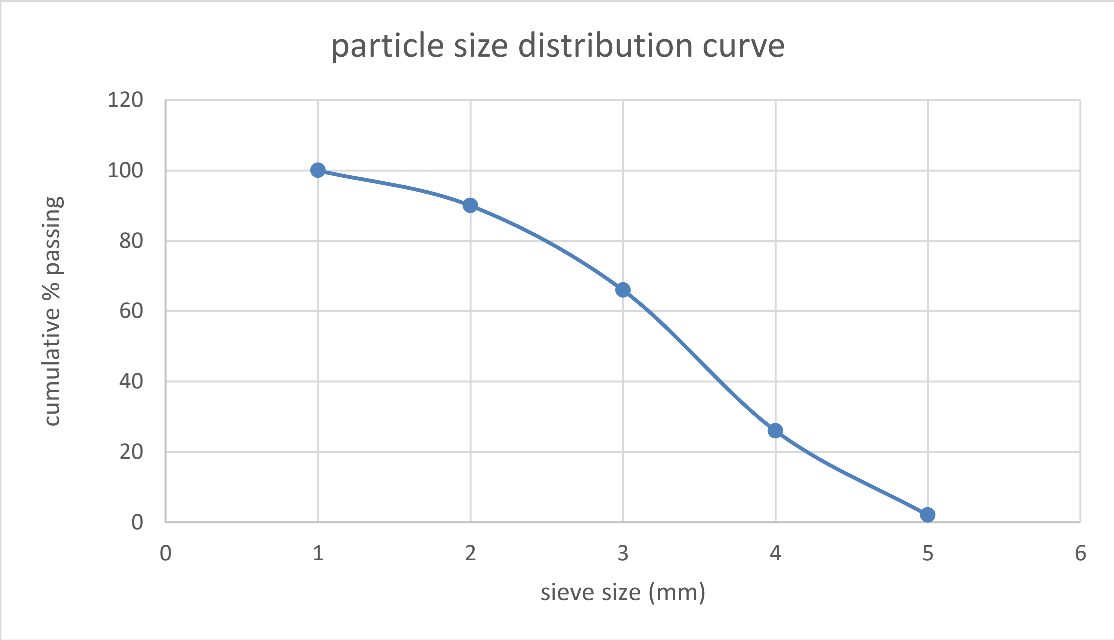

Figure 2: SIEVE Analysis Graph for Fine Aggregate

IV. MECHANICAL PROPERTIES:

A. COMPRESSIVE STRENGTH TEST

The compressive strength test is a mechanical test used to determine the ability of concrete to withstand compressive loads without failure. It is carried out by applying a gradually increasing load on a standard concrete specimen (cube or cylinder) until it fails, and the maximum load at failure is used to calculate the compressive strength of the concrete.

Test Result on Compressive Strength Test- 7 Days & 28 Days

Table 3: Compressive Strength Test Result

MIX ID	**Compressive Strength Test N/mm^2**	
	7 Days	**28 Days**
Cement Concrete	9 kN	16 kN
SFRCC-0.5%	11 kN	20 kN
SFRCC-1%	15 kN	22 kN

Figure 3: Compressive Strength Test

- The Strength will be in Decrease so we will use in superplasticizer for increase in strength
- Test Result on Compressive Strength using SP for varying Percentageslike 0.2%, 0.5% ,1%

Table 4: Compressive Strength Test Using Superplasticizer

MIX ID	Compressive Strength Test N/mm²	
	7 Days	28 Days
Cement Concrete	25	39
CC-02	26	44
CC-03	33	46

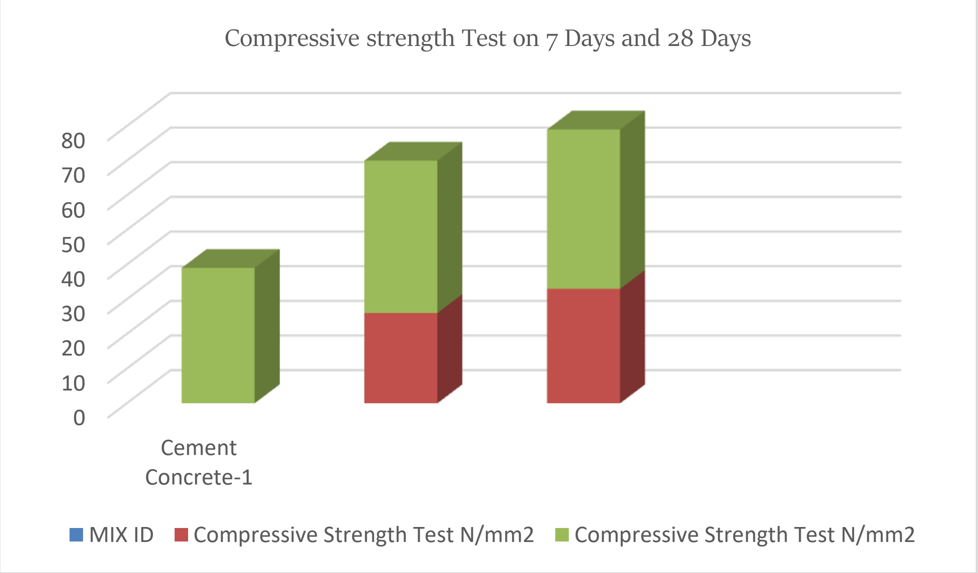

Figure 4: Graphical Representation of Compressive Strength Result for normal concrete

Compressive Strength Test Using Steel Fiber Test

Table 5: Steel Fiber Using Compressive Strength Test

MIX ID	Compressive Strength Test N/mm²	
	7 Days	28 Days
SFCC-0.5%	28 KN	43
SFCC-1%	31	45
SFCC-1.5%	34	48

Compressive strength Test on 7 Days and 28 Days

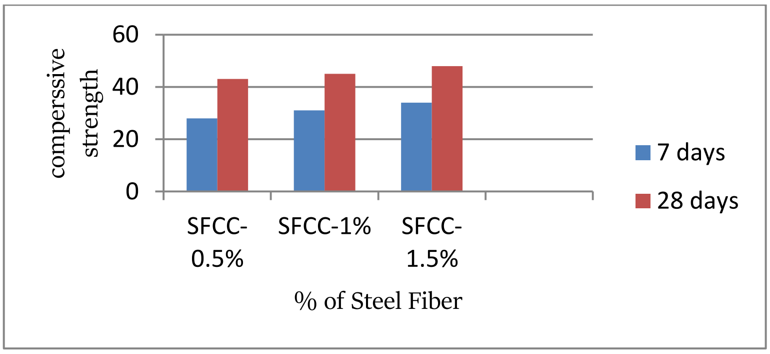

Figure 5: Graphical Representation of compressive Strength Result for using Steel Fiber Cement Concrete

V. RESULTS AND DISCUSSION

The experimental investigation on steel fiber reinforced concrete (SFRC) demonstrated a notable enhancement in the mechanical properties of concrete with the inclusion of hooked-end steel fibers. The compressive strength results indicated a consistent increase as the fiber content increased from 0.5% to 1.5%, with the highest strength observed at 1.5% fiber addition for both 7-day and 28-day tests. Compared to conventional concrete, SFRC exhibited improved resistance to crack initiation and propagation due to the crack-bridging effect of steel fibers. The incorporation of superplasticizer further enhanced the performance by improving workability and ensuring uniform distribution of fibers, which contributed to higher strength values. In terms of failure behavior, normal concrete showed brittle failure with sudden cracking, whereas SFRC displayed a more ductile response with gradual crack development and reduced crack width. Additionally, the presence of fibers significantly increased the energy absorption capacity and post-cracking behavior, making the material more suitable for structures subjected to dynamic and impact loads. However, it was observed that higher fiber content reduced the workability of fresh concrete, indicating the need for proper mix design and the use of admixtures. Overall, the study confirms that the addition of steel fibers significantly improves compressive strength, ductility, and durability, thereby enhancing the structural performance of reinforced cement concrete elements.

VI. CONCLUSION

The study investigated the structural behaviour of SFRC in reinforced concrete beams through an analysis of compressive strength, split tensile strength, and flexural tests using steel Fiber contents of 0.5%, 1%, and 1.5%. According to the research findings, the use of steel Fibers had a significant effect on improving the properties of concrete in comparison with conventional concrete mixes. First, there was a consistent improvement in the compressive strength as steel Fiber content increased to 1.5%, indicating optimum results. In addition, the split tensile strength of the samples increased significantly due to the crack bridging characteristics of steel Fibers, which delayed crack formation and propagation when subjected to tensile forces. The flexural behaviour of the beams was greatly improved through reinforcement since the beams showed improved load carrying ability, minimal crack widths, and high ductility. The concrete was found to be tough and absorb large amounts of energy due to the crack resistance characteristics of steel Fibers, making it appropriate for use in buildings designed to withstand dynamic and impact loads. However, an increase in the steel Fiber content made the fresh concrete mixture less workable, thus necessitating the use of suitable admixtures to enhance its performance during construction processes.

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