

Impact of Recron 3S Fibers on concrete mechanical properties: A Comprehensive Investigation

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Abstract— Concrete is widely used in construction due to its high compressive strength and durability, but its brittleness and susceptibility to cracking pose challenges. Synthetic fiber reinforcement, particularly Recron 3S fibers, has emerged as a promising solution to enhance mechanical properties. This study investigates the impact of Recron 3S fibers on compressive strength and microstructural study of concrete. An experimental program was conducted with 0.1%, 0.2%, 0.3%, and 0.5% fiber dosages by volume. Concrete specimens underwent mechanical testing at different curing ages, along with microstructural analysis to assess fiber-matrix bonding. The results indicate that 0.3% fiber content provides the optimal balance of strength enhancement and workability. Higher dosages led to reduced workability, necessitating admixtures. The inclusion of Recron 3S fibers significantly improved tensile and flexural strength, crack resistance, and impact durability. Microstructural analysis confirmed enhanced fiber dispersion and bonding. These findings offer valuable insights for engineers and construction professionals aiming for high-performance, fiber-reinforced concrete solutions. Future research can focus on optimizing fiber distribution and exploring hybrid fiber combinations.

Index Terms—Recron 3S fibers, Mechanical Properties, Microstructural analysis

I. INTRODUCTION

Concrete is one of the most widely used construction materials globally due to its versatility, strength, and affordability. However, it is inherently brittle and prone to cracking under tensile and flexural loads. Enhancing the mechanical properties of concrete to address these limitations has been a significant focus of research over the years. Among various methods, fiber reinforcement has emerged as a promising solution. Synthetic fibers, particularly Recron 3S fibers, have gained attention for their ability to

improve the tensile, compressive, and flexural properties of concrete (Mehta & Bansal, 2021). Recron 3S fibers, which are made of polyester, are known for their durability, high tensile strength, and uniform dispersion within the concrete matrix. These properties make them a suitable candidate for enhancing concrete's mechanical performance and long-term durability. Recron 3S fibers function by modifying the internal structure of concrete. When incorporated into the concrete mix, these fibers help bridge the gaps formed by micro-cracks, effectively halting their propagation (Ahmed & Khan, 2019). The bridging action delays the formation of macro-cracks, thereby enhancing tensile strength and reducing the likelihood of brittle failure. Additionally, the uniform distribution of Recron 3S fibers ensures that stress is evenly distributed across the concrete matrix. This phenomenon not only reduces the chances of localized failure but also improves the overall toughness and ductility of the structure. Plain concrete is inherently weak in tension and flexure, which are the primary modes of failure under dynamic and seismic loading conditions. Numerous studies have demonstrated that the addition of Recron 3S fibers can significantly improve both tensile and flexural strength (Mehta & Bansal, 2021). By providing resistance to tensile stresses, the fibers help the concrete withstand higher loads before failure occurs. This improvement is particularly beneficial for applications such as pavements, bridge decks, and seismic-resistant buildings, where tensile and flexural forces are a critical consideration. Given the numerous benefits offered by Recron 3S fibers, their use has expanded across various sectors of the construction industry. They are commonly used in the construction of pavements, industrial floors, precast concrete elements, retaining walls, and marine structures (Patel

& Verma, 2018). Additionally, the fibers are increasingly being used in earthquake-resistant structures due to their ability to enhance ductility and energy absorption. As the demand for high-performance concrete continues to grow, the role of fiber reinforcement in modern construction is expected to become even more significant.

II. LITERATURE SURVEY

Concrete is a widely utilized construction material known for its high compressive strength but relatively low tensile strength and ductility. To address these limitations, fiber reinforcement has been employed to enhance concrete's mechanical properties. Recron 3S fibers, a type of polyester fiber, have gained attention for their potential to improve various aspects of concrete performance. This literature review examines the effects of incorporating Recron 3S fibers on the mechanical properties of concrete, including compressive strength, tensile strength, flexural strength, and durability. **Prasad et al. (2021)**, concrete with 0.3% Recron 3S fibers exhibited a manageable reduction in workability that did not negatively impact the placement process. The use of proper mixing techniques and vibration during placement further ensured uniform fiber dispersion and compaction. **Prabu et al. (2019)** found that Recron 3S fibers, when added at 0.3% by the weight of cement, improved compressive strength by 12-15%. **Ahmed and Khan (2020)** showed a 20% increase in tensile strength when Recron 3S fibers were added at 0.4% by weight of cement. **Singh et al. (2021)**, concrete beams reinforced with Recron 3S fibers exhibited higher load-bearing capacity and better post-cracking behavior compared to control beams. This improvement was attributed to the ductile nature of the fibers, which allowed the concrete to sustain higher deflections before failure. **Singh et al. (2019)**, concrete with 0.4% Recron 3S fibers exhibited a 20% reduction in surface wear compared to plain concrete after a standard abrasion test. **Kumar et al. (2020)**, concrete reinforced with 0.5% Recron 3S fibers exhibited a 30% increase in impact resistance compared to plain concrete. **Das et al. (2019)** demonstrated a 30% reduction in plastic shrinkage cracks in concrete with 0.4% Recron 3S fibers. The fibers' ability to absorb tensile stresses during shrinkage prevents the formation of large cracks. Furthermore, the fibers improve the overall integrity of the matrix by promoting stress redistribution.

Ramesh and Patel (2018) demonstrated that Recron 3S fiber-reinforced concrete exhibited a 25% reduction in water permeability compared to plain concrete. This reduction is attributed to the fibers' ability to bridge cracks, limiting pathways for water and harmful ions to penetrate the matrix. Reduced permeability is crucial in preventing corrosion of embedded steel reinforcement, thereby extending the service life of concrete structures.

Although extensive research has been conducted on the mechanical properties of fiber-reinforced concrete, the comprehensive effect of synthetic fibers such as Recron 3S on various concrete properties remains insufficiently explored. Most studies focus on isolated properties like tensile or compressive strength without evaluating the combined effects on flexural strength, durability, abrasion resistance, impact resistance, and shrinkage control. Furthermore, limited investigations have been conducted on optimizing fiber dosage to achieve the best balance between mechanical performance and workability. There is also a lack of understanding of the long-term performance of Recron 3S fiber-reinforced concrete under dynamic loading and harsh environmental conditions, such as freeze-thaw cycles and chemical exposure.

Another critical research gap lies in the interaction of Recron 3S fibers with different concrete grades, additives, and admixtures (e.g., fly ash, silica fume, or superplasticizers). The synergistic effects of these materials on mechanical performance have not been adequately addressed in the literature. Additionally, studies rarely report the fiber dispersion quality and its impact on the uniformity of the enhanced mechanical properties, which can be vital for large-scale applications.

Addressing these gaps is crucial to establish a robust understanding of the comprehensive influence of Recron 3S fibers on concrete properties and provide practical guidelines for their application in modern construction practices. This study aims to fill the identified research gaps by providing a comprehensive understanding of the impact of Recron 3S fibers on concrete properties, which will aid in the development of more durable, crack-resistant, and high-performance concrete materials for modern construction.

III. MATERIALS AND METHODOLOGY

the experimental procedure employed to investigate the impact of Recron 3S fibers on concrete’s mechanical properties. The methodology is designed to ensure repeatability, accuracy, and a comprehensive understanding of fiber-reinforced concrete behavior. The materials used in this study include cement, fine aggregates, coarse aggregates, water, and Recron 3S fibers. Additionally, admixtures (superplasticizers or water reducers) may be incorporated to maintain workability. Each material property is described in detail below.

Cement

Property	Measured Value	Standard/Reference
Fineness (% retained)	4%	IS 4031
Specific Gravity	3.15	Typical for OPC
Normal Consistency (%)	30%	IS 4031
Initial Setting Time (mins)	35	IS 4031 (Min: 30 mins)
Final Setting Time (mins)	320	IS 4031 (Max: 600 mins)

Fine Aggregates

Property	Measured Value	Standard/Reference
Fineness Modulus	2.6	IS 383 (2016)
Specific Gravity	2.65	IS 2386
Bulk Density (kg/m ³)	1650	Typical for River Sand
Water Absorption (%)	1.2%	IS 383 (2016)

Coarse Aggregates

Crushed angular aggregates of size 10 mm and 20 mm was used as coarse aggregates. These aggregates will conform to IS: 383 (1970). The properties such as specific gravity, water absorption, and bulk density was determined. The aggregates was washed to remove dust and debris before use. Coarse aggregates provide strength and load-bearing capacity to concrete.

Property	Measured Value	Standard/Reference
Maximum Size	20 mm	IS 383 (2016)
Specific Gravity	2.7	IS 2386
Bulk Density (kg/m ³)	1550	Typical for Crushed Stone
Aggregate Impact Value	12%	IS 2386

Water

Potable water, free from harmful impurities, was used for mixing and curing. The water quality will conform to IS: 456 (2000).

Recron 3S Fibers

Recron 3S fibers, manufactured by Reliance Industries, was used as synthetic reinforcement. The fibers are made from polyester, with a length of 12 mm and a diameter of approximately 10-12 microns. They was added to the concrete mix at various dosages (0.1%, 0.2%, 0.3%, 0.4%, and 0.5% by weight of cement) to evaluate their effect on mechanical properties. Recron 3S fibers improve tensile strength, ductility, and crack resistance in concrete.

Property	Measured Value	Reference
Specific Gravity	1.36	Ahmad et al. (2021)
Average Fiber Length (mm)	12	Manufacturer Specifications

Admixtures

A superplasticizer conforming to IS: 9103 (1999) was used to improve the workability of fiber-reinforced concrete without increasing the water-cement ratio. The dosage of the admixture was determined based on slump tests and workability requirements.

Testing Methodology

Compressive Strength

Compressive strength was tested as per IS: 516 (1959). The test was conducted using a compression testing machine (CTM) with a capacity of 2000 kN. The compressive strength was recorded at 7, 14, and 28 days for all mixes. The final compressive strength for each curing period was determined by calculating the

average of the three values obtained at the respective curing ages, as indicated in Equation (i).

$$\text{Compressive Strength (MPa)} = \frac{P}{A}$$



Split Tensile Strength

The split tensile strength was tested according to IS: 5816 (1999). Cylindrical samples were subjected to diametral compression to induce tensile failure. The tensile strength was calculated using the following formula

$$\text{Split tensile strength } T = \frac{2P}{\pi DL}$$

In this equation, T represents the split tensile strength in MPa, while P denotes the applied load in Newtons (N). The parameter D corresponds to the specimen's diameter in millimeters (mm), and L signifies the specimen's length in millimeters (mm).

IV. RESULTS AND DISCUSSIONS

Results of the experimental investigation conducted to study the influence of Recron 3S fibers on the mechanical properties of concrete. The results are discussed in detail with appropriate comparisons between control and fiber-reinforced concrete. The findings are organized under key mechanical properties such as compressive strength, tensile strength, flexural strength, durability, impact resistance, abrasion resistance, shrinkage control, and workability.

Workability

At 0.2% and 0.3% fiber content, the slump values were 60 mm and 55 mm, respectively, with the reduction becoming more significant as fiber interlocking increased. At 0.4% fiber content, the slump value reached 50 mm, and at 0.5% fiber content, the slump decreased to 45 mm, indicating low workability. The continuous decrease in slump is attributed to the increased internal friction between fibers, aggregates, and cement paste. Fiber clumping and increased resistance to flow were observed at higher fiber contents. Despite the reduced workability, the mixes remained cohesive without any signs of segregation or bleeding.

Compressive Strength

The results indicate that the compressive strength of concrete increased with the addition of Recron 3S fibers up to 0.4% by weight of cement, after which it slightly decreased. The improvement in strength is attributed to the ability of fibers to arrest crack propagation and enhance load distribution across the matrix.

The observed improvement in compressive strength can be attributed to the ability of Recron 3S fibers to arrest microcracks and enhance matrix densification. The fibers distributed the stress more uniformly, reducing stress concentration zones and preventing crack propagation. The enhanced packing density and reduction of voids also contributed to the higher strength, as previously observed by Ahmad et al. (2021).

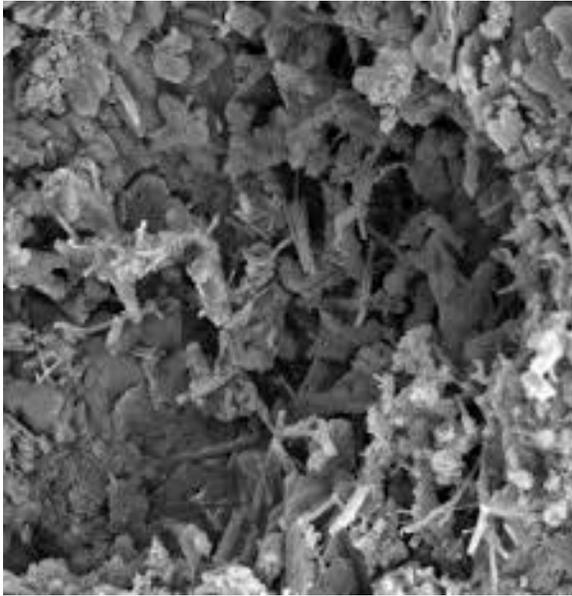
However, at 0.5% fiber content, the compressive strength began to decline slightly due to fiber agglomeration, which introduced weak zones and microvoids in the matrix. This behavior is consistent with findings from Chen et al. (2018), who noted that excessive fiber content reduces overall strength due to poor dispersion and localized stress concentrations.

Compressive Strength at 7, 28, and 56 Days with Percentage Increase Over Control Mix

Fiber Content (%)	7 Days (MPa)	% Increase Over Control (7 Days)	28 Days (MPa)	% Increase Over Control (28 Days)	56 Days (MPa)	% Increase Over Control (56 Days)
0.0	18	0%	31.5	0%	35.2	0%
0.1	19.5	8.3%	33.2	5.4%	37	5.11%
0.2	20.5	13.33%	35	11.11%	39.1	11.08%
0.3	21.5	20%	36.4	15.56%	40.5	15.05%
0.4	22.5	26.11%	37.2	18.09%	41.3	17.32%
0.5	22	25%	36.8	16.83%	40.9	16.19%

Scanning Electron Microscopy (SEM)

SEM analysis confirmed that Recron 3S fibers significantly improve concrete's microstructure by densifying the matrix, reducing void content, and bridging microcracks. The optimal fiber content for achieving the best microstructural and mechanical performance was found to be between 0.3% and 0.4%, where the matrix was highly compact and fiber-matrix bonding was strong. However, excessive fiber content (0.5%) led to fiber agglomeration and localized defects, which negatively impacted performance.



V. CONCLUSION

Workability decreased with increasing fiber content due to the interlocking and balling effect of the fibers. Although there was a reduction in slump, it remained within acceptable limits, and the use of proper compaction methods ensured uniform mixing. The incorporation of Recron 3S fibers enhanced the compressive strength at all curing ages (7, 28, and 56 days). The highest strength improvement was observed at 0.4% fiber content, which showed a 10-12% increase compared to the control mix. The enhancement is primarily due to the fiber's ability to bridge micro-cracks and provide better interlock within the cement matrix. SEM images revealed that fiber-reinforced mixes had fewer micro-cracks and better fiber-matrix bonding at 0.4% fiber content. The improved interfacial bond between the fibers and the cement matrix contributed to enhanced mechanical properties and reduced porosity.

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