

Review on Mechanical Properties of Multi Fiber Reinforced Concrete

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Abstract—Concrete is one of the most widely used construction materials due to its high compressive strength, durability, and versatility in forming various structural shapes. However, its brittle nature and poor tensile strength often lead to the development of cracks under tensile and flexural stresses, which can significantly affect the service life and durability of concrete structures. To overcome these limitations, the concept of fiber reinforcement has been introduced.

Fiber Reinforced Concrete (FRC) is a composite material that contains fibrous materials uniformly distributed within the concrete matrix, which act as crack arresters and enhance ductility, toughness, and post-cracking performance.

In the present study, an experimental investigation was carried out to evaluate the mechanical properties of M30-grade concrete by incorporating steel and glass fibers, both individually and in combination, to form dual fiber reinforced concrete. The main objective of this investigation was to study the effect of fibers on the compressive strength, split tensile strength, and flexural strength of concrete at different curing ages (7, 14, and 28 days) and to determine the optimum fiber dosage for achieving maximum performance. The experimental program involved casting and testing of concrete specimens such as cubes for compressive strength, cylinders for split tensile strength, and prisms for flexural strength.

Index Terms—Steel fiber, Glass fiber, Multi Fiber Reinforced Concrete.

I. INTRODUCTION

Concrete is the most widely used construction material due to its high compressive strength, durability, and ease of moulding into various shapes. It is the backbone of modern infrastructure, used in buildings, bridges, pavements, and other civil engineering structures. However, conventional concrete is

inherently brittle in nature and exhibits low tensile and flexural strength. Once cracks are formed, they propagate rapidly, leading to failure without significant warning. To overcome these drawbacks, the concept of Fiber Reinforced Concrete (FRC) has been introduced. Fibers are small, discrete materials that are uniformly distributed and randomly oriented throughout the concrete mass. They act as crack arresters and significantly improve the ductility, toughness, impact resistance, and post-cracking behaviour of concrete. The performance of FRC mainly depends on the type, aspect ratio, and volume fraction of fibers used.

This experimental study aims to investigate the effects of adding steel and glass fibers on the material properties of concrete, such as compressive strength, split tensile strength, and flexural strength. The results of this investigation are expected to provide insights into optimizing fiber content for achieving improved performance in structural applications. It contributes to the development of high-performance and durable concrete, suitable for modern infrastructure such as pavements, industrial floors, and earthquake-resistant structures. It helps identify an optimum mix proportion of steel and glass fibers that offers maximum strength without sacrificing workability. The findings from this study are expected to contribute valuable information for the development of high-performance and cost-effective concrete composites suitable for structural applications where strength, toughness, and durability are of critical importance.

II. LITERATURE REVIEW

- 1) Milind V. Mohod (2012), In this paper effect of fibers on the strength of concrete for M 30 grade have been studied by varying the percentage of

fibers in concrete. Fiber content were varied by 0.25%, 0.50%, 0.75%, 1%, 1.5% and 2% by volume of cement. Cubes of size 150mmX150mmX150mm to check the compressive strength and beams of size 500mmX100mmX100mm for checking flexural strength were casted. All the specimens were cured for the period of 3, 7 and 28 days before crushing. The results of fiber reinforced concrete for 3days, 7days and 28days curing with varied percentage of fiber were studied and it has been found that there is significant strength improvement in steel fiber reinforced concrete. The optimum fiber content while studying the compressive strength of cube is found to be 1% and 0.75% for flexural strength of the beam. It is observed that the workability of steel fibre reinforced concrete gets reduced as the percentage of steel fibres increases. While testing the specimens, the plain cement concrete specimens have shown a typical crack propagation pattern which led into splitting of beam in two piece geometry. But due to addition of steel fibres in concrete cracks gets ceased which results into the ductile behaviour of SFRC.

- 2) Zijjan Wang et.al (2023), Different types and amounts of steel fibers have varying effects on the improvement of concrete's mechanical properties. In order to identify the most suitable steel fiber types for the practical production of prefabricated pavements and derive a formula to predict and evaluate the mechanical properties based on steel fiber volume fraction, this study conducted experimental research on the physical mechanical properties of concrete using the method of equal volume substitution of coarse aggregate. The influence of steel fiber type and volume fraction on the microstructure and failure mechanism of steel fiber reinforced concrete (SFRC) was analyzed through electron microscopy scanning. The mechanical properties of plain concrete were used as benchmark. The results showed that when the steel fiber volume fractions were 0.6% and 1.5%, the bending and split tensile strengths of milled steel fibers were 3.1% higher than those of hooked-end steel fibers and the compressive strength of SFRC was significantly increased by 13.5%.
- 3) Wasim Abbass et.al (2018), Based on the reviewed study, the incorporation of steel fibers significantly enhances the mechanical performance of concrete by effectively mitigating its inherent brittleness and low tensile capacity. The use of hooked-end steel fibers with varying lengths and diameters demonstrated notable improvements in compressive, tensile, and flexural strengths across different concrete strength levels. The experimental results indicated that the inclusion of steel fibers led to an increase of approximately 10–25% in compressive strength and 31–47% in direct tensile strength, while flexural strength exhibited substantial improvement, particularly with higher fiber volume fractions and aspect ratios. The study further revealed that fibers with higher aspect ratios and longer lengths were more effective in enhancing flexural strength and post-cracking behavior, owing to improved crack-bridging and pull-out resistance mechanisms. Increasing the fiber volume fraction from 0.5% to 1.5% resulted in a pronounced increase in flexural strength, reaching up to 140% compared to plain concrete. Additionally, the effectiveness of steel fibers was influenced by the water-to-cement ratio, with medium to high-strength concrete exhibiting more pronounced benefits.
- 4) Ghanshyam Bhoi et al. (2022), Glass fiber reinforced concrete (GFRC) incorporates short, discrete glass fibers into the cementitious matrix to enhance tensile and flexural performance while controlling micro-cracks. Low-volume fractions of fibers (0.1–0.3 % by concrete weight) are particularly useful for improving crack resistance and durability without significantly affecting workability or compressive strength. The researchers prepared concrete mixes with 0%, 0.1 %, 0.2 %, and 0.3 % glass fiber content. Cylindrical and prismatic specimens were tested to evaluate: Compressive strength, Split tensile strength, Flexural strength, Tile wet transverse strength, Water absorption. The primary aim was to assess whether small quantities of glass fibers could meaningfully improve tensile-related properties and durability indicators. These findings suggest that small fiber additions (0.1–0.3 %) provide an economical and effective

means of improving concrete's tensile performance and crack resistance.

- 5) Kritesh KumarKumar et al. (2022), The study on the effect of glass fiber on concrete investigates how adding glass fibers alters both mechanical strength (compressive, tensile, flexural) and durability characteristics compared to plain concrete. Researchers prepared concrete mixes with varying glass fiber contents (e.g., 0%, 0.25%, 0.5%, 0.75%, 1.0% and higher by volume or weight) and conducted standard tests for compressive strength, split-tensile strength, crack resistance, and durability indicators such as water absorption, chloride penetration, and resistance to cracking under aggressive conditions. Results consistently show that glass fiber reinforcement improves tensile and flexural strength, enhances crack resistance and toughness. Overall, the inclusion of glass fibers helps produce concrete with better mechanical performance and durability behaviour than plain concrete when properly proportioned.
- 6) Emad A.H. Alwesabi,et.al (2022), In their experimental investigation examined how hybridizing steel fibers (MSF) with polypropylene fibers (PF) influences the compressive toughness and related mechanical properties of fibre-reinforced concrete (FRC). The study varied PF and MSF contents across several mixes and measured effects on density, voids, water absorption, compressive strength, compressive toughness, and toughness index. Results showed that hybrid FRC specimens outperformed mono-fiber mixes, with the 0.1 % PF + 0.9 % MSF hybrid achieving the highest compressive toughness approximately 106.5 % greater than the control mix and also exhibited superior compressive strength and reduced voids and water absorption, indicating a synergistic effect of combined fibers. However, replacing MSF with PF beyond optimal levels tended to reduce both compressive strength and toughness. The authors concluded that appropriately proportioned steel–polypropylene hybrid fibers can significantly enhance compressive toughness and overall performance of concrete compared with single fiber additions, providing useful insights for improving concrete ductility and crack resistance in structural applications.

- 7) Muhammad Asharib Shahid,et.al(2022), In this study, researchers aimed to develop a high-performance hybrid fiber-reinforced concrete (HPHFRC) by combining glass fibers (GF) and Kevlar fibers (KF) in various proportions to improve mechanical performance for use in structural rehabilitation applications. The work involved preparing eight concrete mixes with total fiber content fixed at 1.5% by cement mass, casting specimens, and testing them for compressive strength, flexural strength, splitting tensile strength, energy absorption, and toughness according to standard ASTM methods. Results showed that all hybrid mixes exhibited significantly enhanced mechanical properties compared to plain concrete and single-fiber mixes, with the hybrid containing 0.75% GF and 0.75% KF achieving the highest overall improvements e.g., increases in compressive strength (~13.4%), flexural strength (~61.1%), and splitting tensile strength (~127.8%), as well as major gains in toughness and energy absorption. The study concluded that hybridizing glass and Kevlar fibers produces a synergistic effect, resulting in concrete with substantially better strength, ductility, and energy-absorbing capacity, making it a promising material for bridge and structural rehabilitation.

III. SUMMARY OF THE LITERATURE REVIEWS

The reviewed studies show that fiber reinforcement significantly improves the mechanical behavior and durability of concrete. Steel fibers enhance compressive, tensile, and flexural strength, improve ductility, and effectively control crack propagation, with optimum performance generally observed at fiber contents between about 0.6% and 1.5%. However, increased steel fiber content reduces workability.

Glass fibers, even at low dosages (0.1–0.3%), mainly improve tensile and flexural strength, crack resistance, and durability, while having little effect on compressive strength.

Hybrid fiber systems (steel–polypropylene, glass–Kevlar) exhibit synergistic effects, leading to superior toughness, energy absorption, and post-cracking performance compared to single-fiber concretes. Keep total hybrid fiber content $\leq 1.5\text{--}2.0\%$ to avoid loss of workability and fiber balling. Use superplasticizers to

maintain workability. Select fiber aspect ratio and type based on the target property (strength, toughness, or crack control).

Overall, fiber-reinforced concrete offers enhanced strength, ductility, and durability, provided that fiber type and dosage are properly optimized.

IV. CONCLUSION

The preparation of the concrete mix was carried out in accordance with IS 10262: 2019 – Guidelines for Concrete Mix Proportioning and IS 456: 2000 – Plain and Reinforced Concrete – Code of Practice. The objective was to produce a workable and uniform mix with consistent strength and durability for the experimental study. All materials were weighed by mass to ensure accuracy. The materials were batched separately as per the designed mix proportions. The water–cement ratio was maintained as 0.432 throughout the experiment. Care was taken to prevent moisture variation in Msand and aggregates by oven-drying and adjusting the water content accordingly. Five concrete mixes were prepared:

- CC – Conventional Concrete
- 0 % Steel + 0.3% Glass
- 0.25% Steel + 0.3 % Glass
- 0.5% Steel + 0.3% Glass
- 0.75% Steel + 0.3 % Glass

Concrete specimens including 150 mm cubes, 150 × 300 mm cylinders, and 100 × 100 × 500 mm flexural beams were cast for each mix. After demoulding, all specimens were cured in water for 7 and 28 days. The results align with earlier investigations that highlighted the benefits of Multi fiber systems over single-fiber concrete, especially in improving tensile and flexural behaviour while reducing concrete brittleness. Therefore, the present study not only validates existing literature but also reinforces the suitability of multi-fiber reinforced concrete as a reliable material for structural applications requiring improved strength, toughness, and durability. In conclusion, the experimental results establish that Multi Fiber - reinforced concrete, especially with 0.5% steel and 0.3% glass fibers, offers substantial improvements in all key mechanical properties. The study also demonstrates that multi-fiber reinforced concrete reduces the brittle nature of conventional concrete and enhances its resistance to crack

propagation, making it more suitable for structural applications. Overall, multi-fiber reinforced concrete is a promising construction material for applications where improved strength, durability, and crack resistance are critical. This mix can be recommended for use in pavements, slabs, industrial floors, and other structural elements where enhanced tensile and flexural performance is required.

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