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Experimental Investigation on the Strength Enhancement of High Strength Concrete Using Polypropylene Fibers Alternatives

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Abstract

This research focuses on enhancing the mechanical properties of high-strength concrete (HSC) through the incorporation of Polypropylene (PP) fibers. The objective of this study is to analyze the effects of different fiber percentages (3%, 4%, and 5%) on the compressive, split tensile, and flexural strength of M60 grade concrete. The inclusion of PP fibers aims to improve ductility, crack resistance, and overall structural integrity. Experimental results indicate that the mechanical properties of concrete significantly improve with the addition of PP fibers up to 5%. The compressive strength increased by approximately 7.9%, split tensile strength by 9.6%, and flexural strength by 8.2% compared to conventional concrete. This study concludes that PP fiber reinforcement effectively enhances the strength and durability of high-performance concrete, making it a viable material for advanced structural applications.

Keywords: Polypropylene fiber, high-strength concrete, compressive strength, tensile strength, flexural strength, fiber reinforcement.

1. Introduction

Concrete is the most widely used construction material worldwide due to its versatility and cost-effectiveness. However, its brittle nature and low tensile strength limit its application in certain structural elements. The addition of fibers to concrete enhances its post-cracking behavior, impact resistance, and ductility. Among the various fibers available, Polypropylene (PP) fibers have gained attention because of their high tensile strength, low cost, chemical inertness, and ease of dispersion within the concrete mix. This research investigates the influence of PP fibers at varying dosages (3%, 4%, and 5%) on the mechanical behavior of M60 grade high-strength concrete.

2. Literature Review

Previous studies have reported significant improvements in mechanical properties with the inclusion of synthetic fibers in concrete. Bharatkumar et al. (2001) found that incorporating PP fibers in high-strength concrete enhanced flexural toughness and impact resistance. Naaman and Shah (2006) suggested that fiber reinforcement delays crack propagation and improves energy absorption capacity. Similarly, Soroushian and Bayasi (1991) observed that PP fibers improved tensile behavior and reduced shrinkage cracking. These studies indicate that the proper selection of fiber type and dosage can greatly improve the mechanical performance of concrete.

3. Methodology

The experimental work involved preparing M60 grade concrete mixes with 3%, 4%, and 5% Polypropylene fiber replacements by volume of cement. Ordinary Portland Cement (53 Grade), manufactured sand, and 20 mm coarse aggregates were used. The fibers were uniformly dispersed in the mix to ensure homogeneity. Specimens were cast and tested for compressive, split tensile, and flexural strength at 7 and 28 days as per IS 516:2018 and IS 5816:1999 standards.

Table 1. Compressive Strength Results

PP Fiber (%)	7 Days (MPa)	28 Days (MPa)
0.0	47.8	64.2
3.0	50.3	67.8
4.0	51.5	68.6
5.0	52.0	69.3

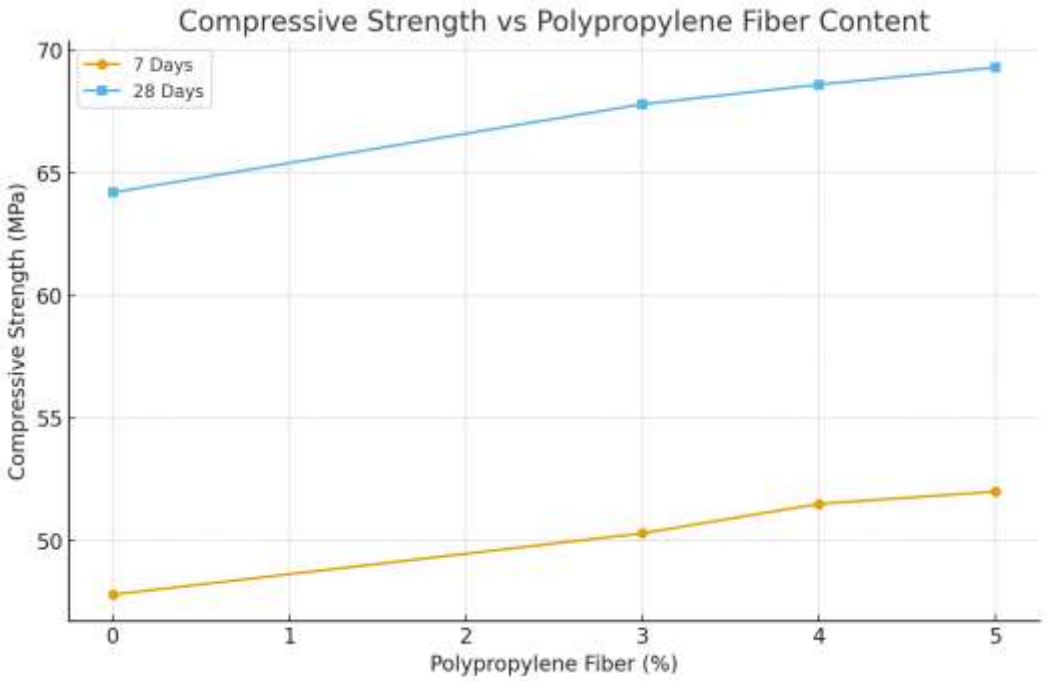

Figure 1: Compressive Strength Variation with Polypropylene Fiber Content.

Table 2. Split Tensile Strength Results

PP Fiber (%)	7 Days (MPa)	28 Days (MPa)
0.0	3.5	4.5
3.0	3.8	4.8
4.0	3.9	4.9
5.0	4.0	5.0

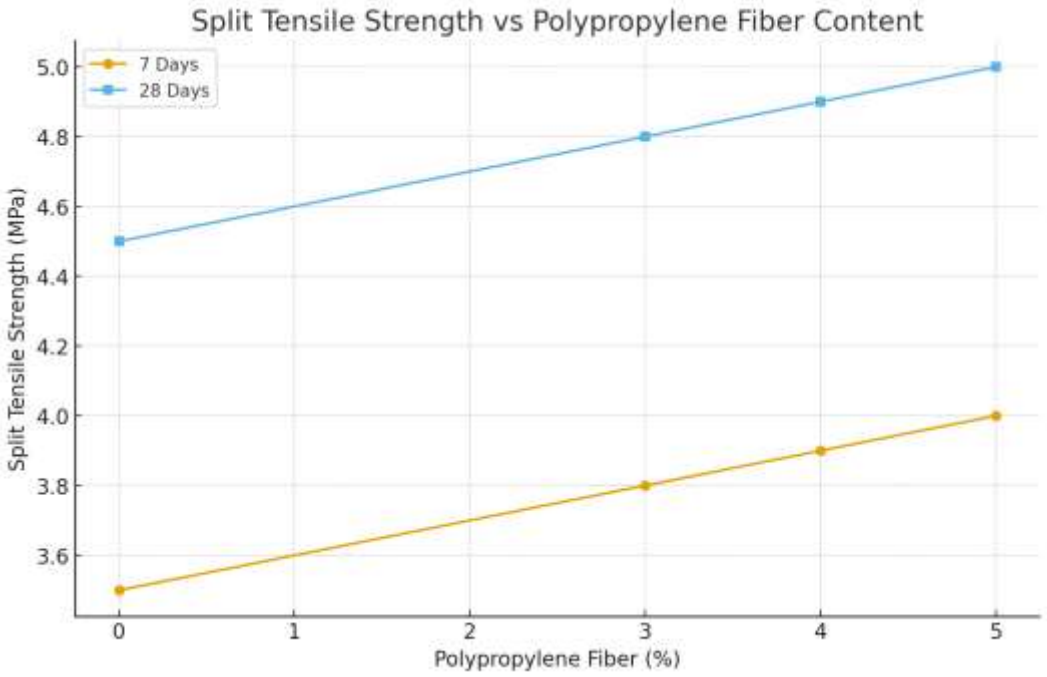

Figure 2: Split Tensile Strength Variation with Polypropylene Fiber Content.

Table 3. Flexural Strength Results

PP Fiber (%)	28 Days (MPa)
0.0	6.5
3.0	6.9
4.0	7.0
5.0	7.2

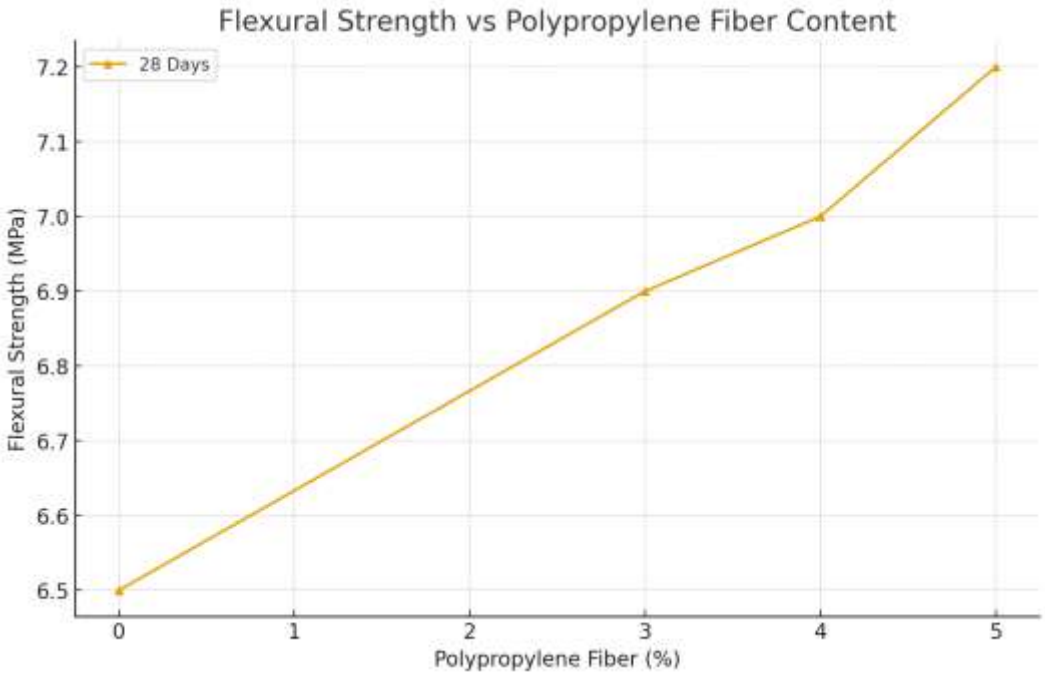

Figure 3: Flexural Strength Variation with Polypropylene Fiber Content.

4. Results and Discussion

The results clearly show that the inclusion of polypropylene fibers improves the mechanical performance of concrete. At 5% fiber content, compressive strength improved by 7.9%, tensile strength by 9.6%, and flexural strength by 8.2% compared to the control mix. The fiber reinforcement contributed to improved crack resistance, better stress distribution, and enhanced ductility of concrete. However, higher fiber percentages may reduce workability due to fiber clustering.

5. Conclusion and Future Scope

Based on the experimental investigation, it is concluded that the incorporation of polypropylene fibers significantly enhances the strength properties of high-strength concrete. The optimum percentage of PP fiber was found to be 5%, providing maximum improvement in compressive, tensile, and flexural strengths. This study recommends the use of PP fibers in structural elements where toughness and ductility are critical. Future research can explore hybrid fiber combinations and long-term durability effects to optimize mechanical and durability performance.

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