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Understanding the Effect of Adding Polypropylene Fibers to Concrete Beam

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Abstract: ***The main goal of this study was to make concrete stronger by finding the best amount of polypropylene fibers to mix in. Fiber-reinforced concrete is widely used in construction because it helps improve performance. In this project, we checked how adding different amounts of polypropylene fiber affects the strength of concrete-both its ability to handle pressure (compressive strength) and bending (flexural strength). We did this by making and testing concrete cubes of 150mm × 150mm × 150mm. After identifying the most effective fiber content through these tests, we used that same mix to make larger beam-like samples and tested them too. The results showed a clear improvement in strength after 28 days, and the ideal fiber content was found to be 1.5% of the cement volume.***

Keywords: polypropylene fiber, compressive strength, flexural strength and fiber reinforced concrete

1. Introduction

Most commonly used materials in construction because it's strong and long-lasting. But it is not very good at handling pulling forces, which can cause it to crack. To solve this problem, engineers have found that adding fibers to the concrete mix can make it stronger and more flexible. One popular option is polypropylene fiber. These are man-made fibers that are affordable, easy to mix in, and don't soak up water. When added to concrete, they help hold it together better, especially after it cracks. This makes the concrete tougher, more durable, and less likely to break under stress or changes in temperature.

Figure 1: Polypropylene fiber

Polypropylene fibers help control shrinkage cracks in concrete. They disperse throughout the concrete mix and help distribute tensile forces, reducing the cracking during the curing process. By reinforcing concrete, polypropylene fibers improve its toughness leading to longer-lasting structures. This added durability is especially beneficial in areas exposed to high loads or heavy traffic, such as industrial floors, pavements, and bridges. Compared to traditional steel reinforcement, polypropylene fibers are more cost- effective. They require less labor to install, are easier to mix with concrete, and reduce the overall project costs while improving performance.

2. Literature Review

Tara Rahmani, Behnam Kiani [1] In 2011, carried out a study to understand how adding different types of fibers-specifically polypropylene, glass, and steel-affects the durability of concrete. They looked at several factors such as compressive strength, flexural strength, and electrical resistivity. Fibers were added in varying amounts 1 to the concrete mixes. The results showed that all three fiber types helped improve the flexural strength of the concrete, making it about 10–30% stronger than regular, non-fiber concrete. Among them, concrete with polypropylene fibers had the highest electrical resistivity after 28 days, indicating better durability against moisture and corrosion. However, when it came to compressive strength, mixes with polypropylene and glass fibers saw a decrease. This was likely because the added fibers increased the air content in the concrete. Overall, the best performance was observed when the fiber content was around 1.5%, suggesting it was the most effective mix ratio in the study.

Kolli. Ramujee [2] In 2013, conducted a study focusing on how adding polypropylene fibers affects the strength of concrete. The research involved testing concrete samples with different fiber amounts-ranging from 0% (no fibers) to 2%. The key strength properties examined were compressive strength and splitting tensile strength. The results showed a clear trend: as strength of the the amount concrete when compared to t of polypropylene fiber increased, so did the mix without any fibers. Notably, the mix with 1.5% fiber content delivered the best overall performance among all the tested variations, suggesting it to be the most effective ratio in improving the concrete's strength.

Salahaldein Alsadey, Muhsen Salem [3] In 2016, carried out a study to determine the ideal amount of polypropylene fibers needed to maximize 2 the compressive strength of M25 grade concrete. Their research focused on comparing fiber-reinforced concrete with regular concrete that had no fibers added. The results showed that as the amount of polypropylene fiber increased, so did the compressive

strength-rising by about 4% to 12% compared to the control mix. Among all the samples tested, the concrete mix containing 2% polypropylene fiber delivered the best performance, making it the most effective mix in this particular study.

Haider A, Hayder H [4] In 2018 carried out a strength of concrete study focused on improving the mechanical by combining polypropylene fibers with high-performance cement, which was used as a partial replacement for regular cement. Their aim was to explore how this combination could enhance concrete's compressive, tensile, and flexural strength. The research involved concrete mixes with seven different amounts of polypropylene fibers and two levels of high-performance cement, alongside standard concrete samples without any additives. The test results showed a clear improvement when both polypropylene fibers and high-performance cement were used together. Specifically, flexural strength increased from 2.7 MPa to 14.5 MPa, tensile strength rose from 1.9 MPa to 7 MPa, and compressive strength improved significantly-from 30.1 MPa to 42.9 MPa. Overall, the concrete containing both additives displayed much better performance and strength compared to normal concrete.

Liang Wang [5] published a review focused on how polypropylene fibers affect 1 of concrete. The study looked at concrete mixes containing different the durability amounts of polypropylene fibers-specifically 0.15%, 0.3%, and 0.45%. Polypropylene fibers, being lightweight, strong, and resistant to corrosion, were found to be quite effective in improving concrete performance. The research highlighted that these fibers help reduce cracking in concrete, which in turn boosts its durability. This is because the fibers act as a barrier, preventing water and harmful chemicals from penetrating the concrete. Among the various mixes tested, the concrete with 0.45% fiber content showed the best overall performance. However, going beyond this percentage led to a drop in strength, suggesting that 0.45% is the ideal fiber content for durability without compromising concrete strength.

Haj Hajali Ahmed, Dr. Osama Mohammed [6] studied how adding different amounts of polypropylene fibers affects the properties of fresh concrete. The main goal of their research was effective fiber content within a range of 0.1% to 0.5% by volume. Their tests focused on key concrete properties such as to determine compressive strength and the most 3 split tensile strength. The results showed that adding polypropylene fibers reduced the workability of the concrete, meaning it became less easy to mix and pour. However, the fibers significantly improved the 1 splitting tensile at 28 days, with increases ranging from 25% to 42% compared to concrete without fibers. One exception was a drop in flexural strength at the 0.3% fiber level, which was attributed to poor quality control during laboratory testing rather than the fiber itself.

3. Objectives

1. To optimise which percentage replacement is much as efficient without affecting its strength
2. The main goal is to see how concrete behaves when we add polypropylene fibers to it
3. To determine the flexural behaviour of polypropylene fiber-added to concrete beams, containing the optimum determined, and compared against the conventional RC beam.

4. Materials

1. Cement: OPC 53 grade cement served as a binding agent in this mix. The relative density of the tests revealed the cement to be 3.14
2. Fine aggregate: fine aggregate material was passed through the 4.75 mm sieve and was retained on the 60-micron sieve. Sand exhibited a specific gravity of 2.6 as well as its ability to absorb water was 1%.
3. Coarse aggregate: The coarse aggregate used was 20 mm. It had a relative density of 2.75 and 1.16% water absorption.
4. Polypropylene fiber: The length of polypropylene fiber used was 12mm. The specific gravity is 0.91.and the Melting point was 165°C

5. Experiments

5.1 Compressive test

Cube specimen of size 150 mm X 150 mm X 150 mm. After that the specimen sample was placed such that, the load was applied perpendicular to the side of casting. At a constant rate, the load was applied in the compression testing machine. The specimen will be automatically unloaded and the failure load was noted.

Compressive strength = Load in N / Area in mm^2.

5.2 Flexural test

The beam specimen of size 100X100X500mm. Three-point test was carried out using a Flexural testing machine. Flexural strength formula is given by

If a >13 cm	If a<13cm
Strength = PL/bd2	Strength = 3Pa/bd2

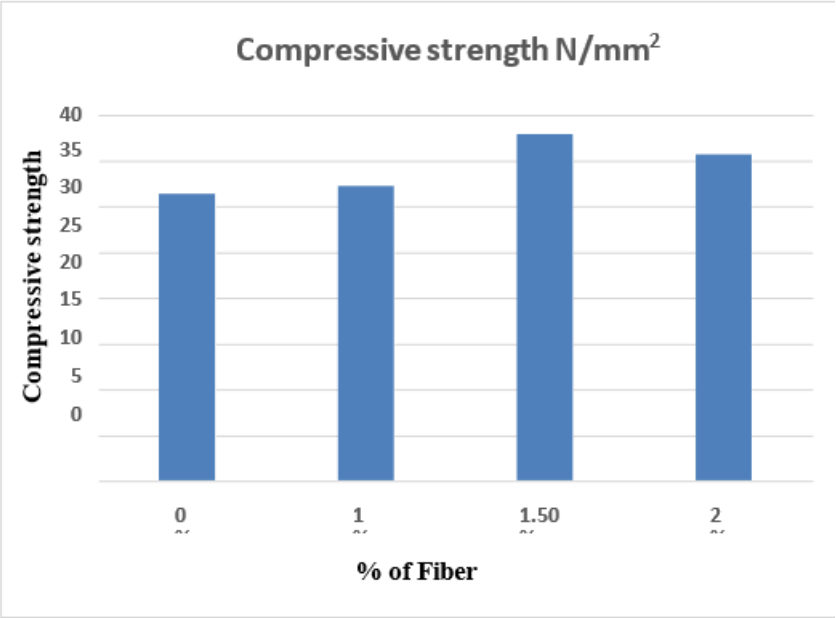
Were, P = ultimate load applied (N)

L, a = span length, failure point to reference line
b, d = width, depth of the specimen respectively (mm)

6. Experimental Result

6.1 Compressive strength test

%	Strength of polypropylene fiber (N/mm^2)
0	31.39
1	32.264
1.5	37.93
2	35.75

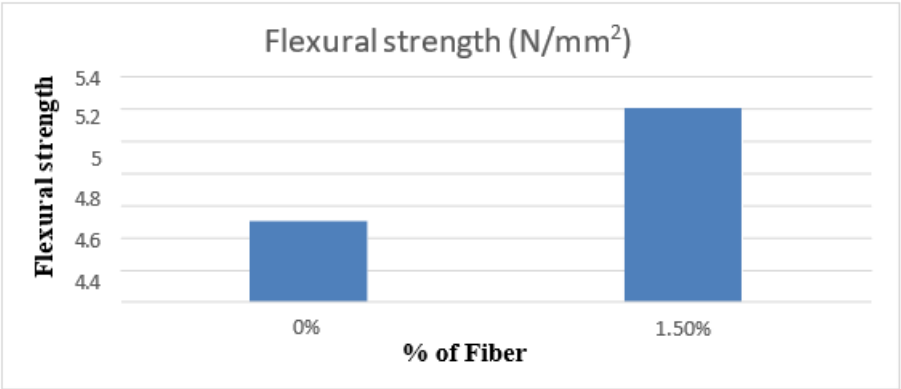


Compressive strength vs % of Fiber

6.2 Flexural Strength

Specimen size taken is 500mm*100mm*100mm.

%	Flexural strength of polypropylene fiber (N/mm²)	Average Flexural strength of polypropylene fiber (N/mm²)
0	4.5	4.5
1.5	5.2	5.2
	5.6	
	4.8	



Flexural strength vs % of Fiber

7 Conclusions

1. It is observed that 1.5% of fiber addition shows the optimum value for Polypropylene fiber.
2. We tested concrete with 1%, 1.5%, and 2% polypropylene fiber, and their compressive strengths were 32.26 N/mm², 37.93 N/mm², and 35.75 N/mm², respectively. All of these were stronger than the concrete without any fiber (the control cube)
3. The optimum percentage obtained in the compression strength will be taken for Flexural strength.
4. It was observed that polypropylene fiber showed higher strength compared with control specimens

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