

An Experimental Study on Mechanical Properties of Concrete by Using Polypropylene Fibers

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Abstract: This paper outlines an experimental study that measures the effects of polymer fiber on Mechanical properties of concrete. Polypropylene Fiber Reinforced Concrete is an embryonic construction material. Poly propylene is a 100 % synthetic textile fiber. The present study was to evaluate the mechanical properties of concrete by using PP fibers. Specimens were prepared with various combinations of 0.6%, 0.8 %, 1.0 %, 1.2 %, 1.5 %, and 2.0 % of Polypropylene fibers by volume fraction for all proportions. This paper presents the experimental methodology and experimental result related to Compressive strength of cubes for 3 days, 7 days, and 28 days, 56 days, 90 days. Split tensile strength, flexural strength of Concrete at 28 days of curing was evaluated. Fiber-reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. FRP reinforcements offer a number of advantages such as corrosion resistance, non-magnetic properties, high tensile strength, lightweight and ease of handling.

Keywords: PP FIBERS, Fiber-reinforced concrete (FRC), Fibre-reinforced polymer (FRP)

1. Introduction

Concrete is strong in compression, as the aggregate efficiently carries the compression load. However, it is weak in tension as the cement holding the aggregate in place can crack, allowing the structure to fail. Reinforced concrete adds steel reinforcing bars, steel fibers, polymer fibers, glass fibers, or plastic fibers to carry tensile loads. Fiber-reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. While concrete brittleness to a large extent can be compensated with steel reinforcements on a structural scale in Fiber Reinforced Concrete resulting in improved structural durability, safety as well as improved performance in infrastructure sustainability

1.1 Polypropylene fibers

Polypropylene fibers in concrete not only optimum utilization of materials are achieved but also the cost reduction is achieved. Addition of polypropylene fibers decreases the unit weight of concrete and increases its strength. Poly propylene is a 100 % synthetic textile fiber. The monomer of polypropylene is propylene. Improve mix cohesion, Improve freeze-thaw resistance, Improve resistance to explosive swelling in case of a severe fire. Improve impact resistance Increase resistance to plastic shrinkage during curing.

Polypropylene fibers are Non-Magnetic, rust free, Alkali resistant, safe and easy to use. Polypropylene twine is cheap, abundantly available and is of consistent quality. Polypropylene fibers are chemically inert and hence, any chemical that will not attack the concrete constituents will not have any effect on the fiber also.



Figure 1: Sample of PP fiber

2. Methodology

The physical properties of materials used in the experiments are determined with the standard test procedures as per Indian Standard (IS) Codes. Test results are tabulated as given below,

Table 2.1: Properties of Cement

S.No	Property	Values
1	Fineness of Cement	225 m ² /kg
2	Specific Gravity	3.11
3	Normal Consistency	33 %
4	Setting Time	
	i) Initial Setting time ii) Final setting time	40 minutes 6 hours

Table 2.2: Properties of Fine Aggregate

S.No	Property	Values
1	Specific Gravity	2.583
2	Fineness modulus	2.8
3	Bulk Density	
	I. Loose State II. Compacted State	17.9 KN/m ³ 19.5 KN/m ³
4	Grading of Sand	Zone – II

Table 2.3: Properties of Coarse Aggregate

S.No	Properties	Value
1	Specific Gravity	2.68
2	Bulk Density	14.13 KN/m ³
3	Water Absorption	0.49%
4	Flakiness Index	13.19%
5	Elongation Index	20.49%
6	Crushing Value	14.72%
7	Impact Value	6.08%
8	Finesness Modulus	6.26

Table 2.4: Properties of Polypropylene fibers

Fibre length	6 mm
Density	0.91gm/cc
Melting point	160-170°C
Resistance to acid & alkali	94.40%
Fibre type	Monofilament
Crack elongation	15%
Young's modulus	5 Gpa
Tensile Strength	600 Mpa

Based on these material properties, the Mix Design is prepared for Normal Concrete Mix IS: 10262-2009 method is used and the mix proportions and mix details are obtained as follows,

Table 2.5: Mix Proportion

	Water	Cement	Fine aggregate	Coarse aggregate
Proportion by Weight	160kg	400kg	661.51kg	1220.19kg
Proportion by Ratio	0.4	1	1.65	3.05

Cube, cylinder and beam specimen are cast as per IS: 516-1978. In this process, once the wet concrete mixture is prepared of required standard the concrete is filled in cube moulds (150X150X150 mm) for compressive strength test. For Tensile strength the cylinders (300X150 mm) were casted and also for flexural strength the prisms (750X150X150 mm) were casted. The specimen are removed after 24 hours and immersed in water tank for 3, 7, 28, 56 and 90 days. Then the specimen were removed from curing tank and tested immediately under Compression Testing Machine / Flexural Testing Machine. The type and number of specimens cast are as shown in Table 2.6.

Table 2.6: Number of Specimens Cast

S. No	Proportion	Cubes	Cylinders	Prisms
1	CC	15	3	3
2	0.6% PP	15	3	3
3	0.8% PP	15	3	3
4	1.0% PP	15	3	3
5	1.2% PP	15	3	3
6	1.5% PP	15	3	3
7	2.0% PP	15	3	3

Tests adopted for measurement of workability of the concrete mix in the present investigation are, 1. Slump Test, 2.Compacting Factor Test.

Table 2.7: Workability

Cases	Slump	Compaction Factor
CC	24mm	0.74
PP Fibers	50mm	0.85

3. Results and Discussions

3.1 Compressive Strength

The cube specimens were tested in Compression Testing Machine (CTM) after specified curing period for different percent of 0.6%, 0.8 %, 1.0 %, 1.2 %, 1.5 %, and 2.0 PP fibers for conventional concrete mix (CC). The compressive strengths after respective curing periods are noted in Table 3.1.

Table 3.1: Compressive Strength Results

Composition	Compressive Strength (N/mm ²)				
	3 Days	7 Days	28 Days	56 Days	90 Days
CC	22.66	30.81	58.22	64.14	67.11
0.6 % PP	24.44	33.70	62.81	70.00	72.51
0.8 % PP	25.11	34.44	63.62	70.22	72.96
1.0 % PP	25.11	34.29	64.00	70.59	73.40
1.2 % PP	26.14	35.11	66.44	73.70	74.00
1.5 % PP	25.92	35.99	70.36	73.77	75.10
2.0% PP	25.70	35.92	67.10	73.62	74.58

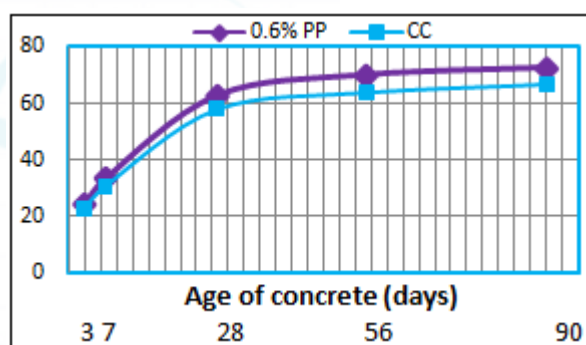


Figure 3.1: Graph showing Compressive Strength Development of 0.6% PP Fibers

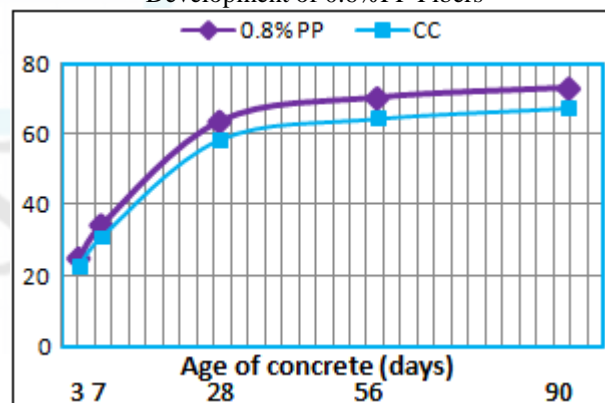


Figure 3.2: Graph showing Compressive Strength Development of 0.8% PP Fibers

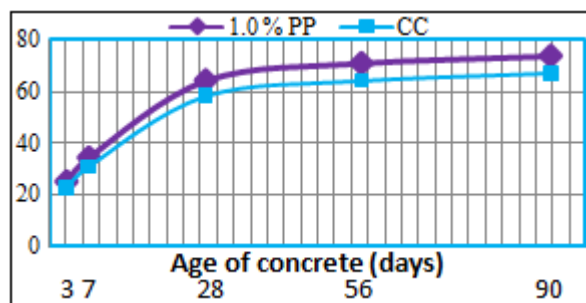


Figure 3.3: Graph showing Compressive Strength Development of 1.0% PP Fibers

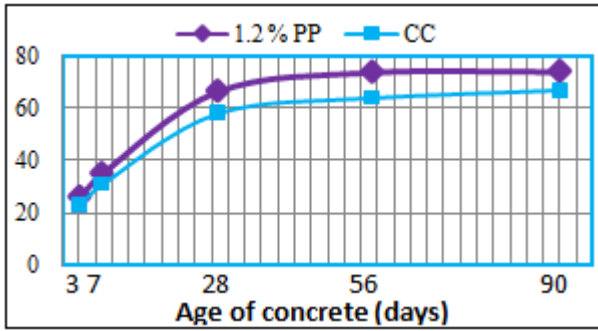


Figure 3.4: Graph showing Compressive Strength Development of 1.2% PP Fibers

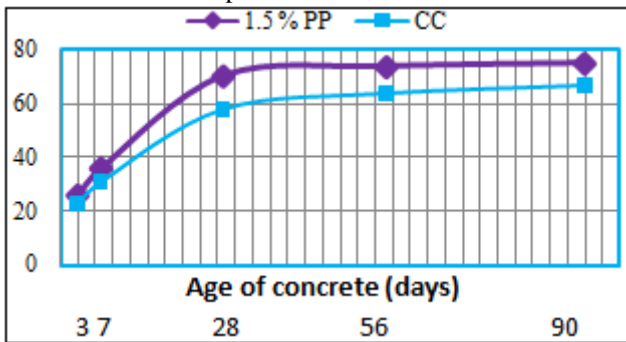


Figure 3.5: Graph showing Compressive Strength Development of 1.5% PP Fibers

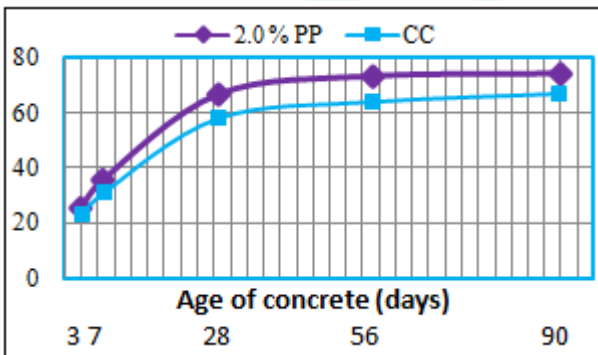


Figure 3.6: Graph showing Compressive Strength Development of 2.0% PP Fibers

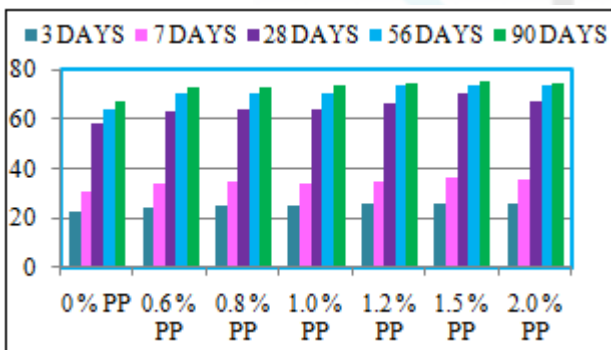


Figure 3.1: Graph showing Compressive Strength Development of Different Mixes of PP Fibers

3.1.2 Discussions on Compressive Strength Results

The compressive strength of specimen with 1.5 % PP fibers is significant increasing in strength comparatively to other variations of PP fibers. Compressive strength of specimen with 1.5 % Polypropylene fibres at 7,28,56,90 days is increased by 16.81 %, 20.85 %, 15.01 %, 11.90 % with 1.2 % PP fibres at 3 days strength is increased by 15.35% when

compared with Conventional concrete. Among all the variations of PP fibers the percentage strength increased by 1.5 % PP fibres is more because of more reinforcement strength when compared with others. After the 1.5 % Polypropylene fibres, 1.2 % PP fibers show favorable results.

3.2 Tensile Strength

The cylinder specimens were tested in Compression Testing Machine (CTM) after specified curing period for different percent of 0.6%, 0.8 %, 1.0 %, 1.2 %, 1.5 %, and 2.0 PP fibers for conventional concrete mix (CC). The Tensile strengths after respective curing periods are noted in Table 3.2.

Table 3.2: Tensile Strength Results

Composition	Tensile Strength (N/mm ²)
	28 Days
CC	2.82
0.6 % PP	3.39
0.8 % PP	3.46
1.0 % PP	3.53
1.2 % PP	3.60
1.5 % PP	4.21
2.0% PP	4.12

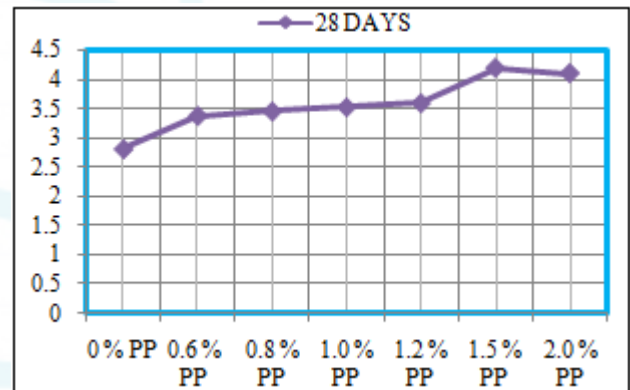


Figure 3.2: Graph showing Tensile Strength Development of Different Mixes of PP Fibers

3.2.1 Discussions on Tensile Strength Results

The Tensile strength of specimen with 1.5 % PP fibers is significant increasing in strength comparatively to other variations of PP fibers. Tensile strength of specimen with 1.5 % PP fibres at 28 days is increased by 49.29 %. Similarly by using 0.6%,0.8%,1.0%,1.2%,2,0% PP fibres tensile strength increased by 20.21 % ,22.69 % ,25.17 % ,27.65 % ,46.09 % at 28 days strength is when compared with Conventional concrete. Among all the variations of PP fibers the percentage tensile strength increased by 1.5 % PP fibres is more because of more reinforcement strength when compared with others. After the 1.5 % PP fibres, 2.0 % PP fibers shows favorable results.

3.3 Flexural Strength

The cube specimens were tested in Universal Testing Machine (UTM) after specified curing period for different percent of 0.6%, 0.8 %, 1.0 %, 1.2 %, 1.5 %, and 2.0 PP fibers for conventional concrete mix (CC). The flexural

strengths after respective curing periods are noted in Table 3.3.

Table 3.3: Flexural Strength Results

Composition	Flexural Strength (N/mm ²)
	28 Days
CC	8.37
0.6 % PP	9.15
0.8 % PP	10.17
1.0 % PP	10.12
1.2 % PP	12.88
1.5 % PP	14.51
2.0% PP	14.38

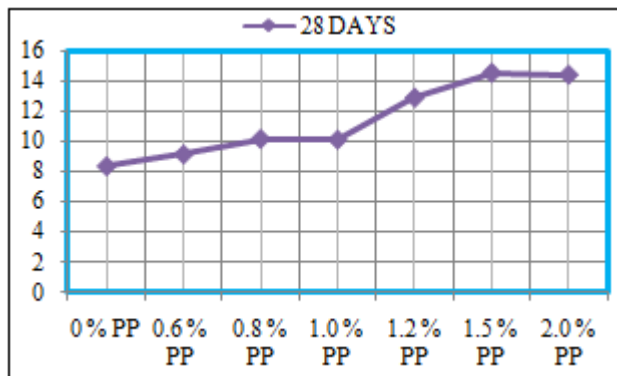


Figure 3.3: Graph showing Flexural Strength Development of Different Mixes of PP Fibers

3.3.1 Discussions on Flexural Strength Results

The Flexural strength of specimen with 1.5 % PP fibers is significant increasing in strength comparatively to other variations of PP fibers. Flexural strength of specimen with 1.5 % PP fibres at 28 days is increased by 73.33 %. Similarly by using 0.6%,0.8%,1.0%,1.2%,2.0% PP fibres Flexural strength increased by 9.31 % ,16.12 % ,21.52 % ,53.88 % ,71.80 % at 28 days strength is when compared with Conventional concrete. Among all the variations of PP fibers the percentage Flexural strength increased by 1.5 % PP fibres is more because of more reinforcement strength when compared with others. After the 1.5 % PP fibres, 2.0 % PP fibres show favorable results.

4. Conclusions

- 1) The Compressive strength of concrete is increased by 20.85 % with PP fibers
- 2) The Tensile strength of concrete is increased by 27.74 % with PP fibers
- 3) The flexural strength of concrete is increased by 73.33 % with PP fibres
- 4) There is significant change in the Flexural strength with variation of PP fibers when compared to Conventional concrete.
- 5) Among different various percentages of PP fibers, 1.5% PP fibers show good results to use with concrete.
- 6) Flexural strength of polymer fiber concrete is much higher than conventional concrete.
- 7) Bond strength between polymer fibers and concrete is high.
- 8) Polypropylene fiber concrete is lighter in weight than conventional concrete.

- 9) Polymer fiber reinforced concrete is the most effective type of concrete withstands the adverse environmental conditions such as corrosion and other distress due to poor quality, execution and maintenance works.
- 10) Use of polypropylene fiber concrete composites increases the structural stability of a structure due to better flexural, bond, and compressive strengths.

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