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Assessment on mechanical properties of concrete with polypropylene fiber

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Abstract. Concrete is a versatile material that must meet certain strength criteria to maintain structural integrity. Although concrete has several advantages in terms of mechanical qualities and construction costs, its brittle nature is a drawback in those applications that require flexibility. However, the recent creation of concrete with polypropylene fiber-reinforced (PFRC) has provided a technical framework for addressing these issues. Polypropylene fibres have a tendency to bind the concrete mix. This reduces the rate of bleeding by slowing the settlement of coarse material. A slower rate of bleeding equals a slower rate of drying, which means less shrinkage breaking in the plastic. Polypropylene fibres act as crack stoppers in hardened concrete. The impact of polypropylene (PP) fibres on compressive strength, tensile strength, flexural strength, and workability for M 25 Grade concrete in both fresh and hardened states is investigated in this study. Polypropylene fibres were introduced at a percentage of 0.5%, 1%, 1.5 %, and 2% in this investigation, and the findings were tabulated.

Key words: Fiber Reinforced concrete, Polypropylene fiber, concrete with fiber, PP fibre, Concrete

1. Introduction

Fiber dispersion is one of the ways for improving concrete's structural properties. Synthetic polypropylene fibres are obtained as a by-product of the textile industry. Polypropylene fiber, often known as PP or polypropylene, is a synthetic fiber made from 85 percent propylene that is utilized in a range of applications. The properties of concrete can be greatly enhanced by addition of fibres. Despite the fact that steel fibres will account for the majority of concrete applications, there are a variety of other fibres available such as PP and PVA. The main issue with steel fibres, however, is that they have a lower workability and are prone to corrosion. Corrosion will have a significant impact on the lifetime of the concrete, and PP fibre may be the greatest solution for these issues, providing long-term durability of concrete [6]. Effect of Hybrid Fibre (Steel – Polypropylene) on Carbonation depth and crushing strength of concrete was investigated by Hao Bao et al.,[11] by varying length to diameter ratios. Arash et al., examined how mechanical properties of self-compacting concrete effected by adding polypropylene fibres [12]. PP fibres are of white in colour and 12 mm in length. A significant improvement in the strength was observed at 0.1 % of Fiber content.

Anthony N Ede et. al [1] investigated the impact of micro synthetic polypropylene fiber with the main focus of improving concrete mechanical properties. By observing Concrete Properties with Destructive and Non-Destructive tests, it was noted that the optimum percentage of PP Fiber lies within 0.25% to 0.5%. Qin. Y et. al [2] observed the compression behaviour and destructive characteristics of concrete with waste polypropylene fiber. A notable improvement in the Compression behaviour of concrete was observed with the waste fabric PP fiber in concrete. AM Alhozaimy et. al [3] investigated the effect of Pozzolanic materials on mechanical Characteristics of Polypropylene fiber reinforced concrete. ASM Akid et al., also investigated the effect of Fly ash and Polypropylene fiber on fresh,



hardened and durability characteristics of concrete [8]. The effects of introducing low volume fractions (0.3 %) of estimated fibrillated polypropylene fibres in concrete on compressive, flexural, and impact strength with various dosages of binder were investigated experimentally. They discovered that polypropylene fibres have no influence on compressive and flexural strength, but that they do improve flexural strength and impact resistance. Effect of curing on mechanical properties of polypropylene reinforced concrete was observed by MV Mohod et. al [4] in Performance of Polypropylene fiber reinforced concrete. Concrete properties were analysed under different curing environments with varying percentages of PP Fiber ranges from 0.5% to 2%. It was concluded that the optimum dosage of Polypropylene fiber is 0.5 % to represent the better performance. TAH Ahmed et. al [5] investigated PP Fiber Influence on concrete properties. Fresh and Hardened parameters were observed by varying fiber dosage at 0.1%, 0.3% and 0.5%. a notable improvement in the performance of concrete was observed at 0.5% Fiber dosage. Alan E. Richardson et al [7] investigated the effect of various dosages of monofilament PP fiber on compressive strength of concrete, Polypropylene fiber are Translucent and offers good heat resistance. Because of having a very low density, these are light in weight and shows good resistance to fatigue as well. The toughness and flexibility characteristics of PP fiber will play a significant role in improving the performance of concrete. According to the literature review, only few researchers focused their effort on fibres with an Aspect Ratio of 625 (L/D Ratio).2.

2. Objectives and Methodology

After detailed literature survey, these are the selected objectives:

- Determining Fresh Properties of Fiber Reinforced concrete in terms of workability with Fiber Aspect Ratio 625.
- Investigating the effect of PP Fiber on Hardened properties such as Compressive, Tensile and Flexural Strength of concrete.
- Suggesting optimum Fiber volume fraction for concrete to minimise failures.

The main methodology involves the Collection of literature survey followed by testing of raw materials. Later mix proportioning is done by using IS 10262 – 2019 method. In Next phase, casting if specimens is done for investigating Compression, Split and Flexural behaviour of concrete. Results and Discussions were carried out in final phase.

3. Experimental Programme

3.1 Materials

Cement: Cement was one of the most influential components in concrete production. Optimising the cement content has a noteworthy impact on the properties of concrete. Cement of OPC 53 Grade was utilized confirming to IS 12269 – 1987.

Coarse aggregates: This project uses aggregates with a size range of 10-20 mm. confirming to IS 383-1970 [9].

Fine aggregates: Aggregate of size less than 4.75 mm confirming to zone II are used as Fine Aggregate and are confirmed to IS 383-1970. The material properties are tabulated in Table 1.

Polypropylene Fiber: Polypropylene fibre of Size 25 mm in length and 0.04 mm in diameter are used in this work. The Properties are listed in Table 2. The fibres are purchased form Vrock Constructive Solutions, Hyderabad.

Chemical Admixture: For greater workability, Master Glenium B233 was employed.

Table 1. Preliminary test results of materials.

	Specific gravity	Bulk density	Water absorption
Cement	3..10	-	-
Coarse aggregate	2.65	1700 kg/m ³	0.5%
Fine aggregate	2.45	1602 kg/m ³	1%

Table 2. Properties of Polypropylene fiber.

Property	Limits
Density	0.946 g/cm ³
Specific gravity	0.9
Water absorption	0.03%
Aspect Ratio	625

3.2 Mix proportioning and Casting of Specimens

The Concrete of grade M 25 is Prepared according to the Code IS 10262 – 2019 [10]. The details are Shown in Table 3. For each trial, 6 Cubes, 4 Cylinders, and 2 Beams were casted and confirmed to Indian Standards. The specimens are tested at 7 days and 28 days after they have been cured. The Detailed mix designations are shown in Table 4.

Table 3. Material proportion for M 25 Grade

Material	Quantity (Kg/m ³)
Cement	328
Fine Aggregate	618
Coarse Aggregate	1296
Water	148
W/C Ratio	0.45

Table 4. Mix Designations.

Mix	Cement (%)	FA (%)	CA (%)	Water (%)	SP (%)	PP Fiber (%)
Control Mix	100	100	100	100	0.3	0
MPF 1	100	100	100	100	0.3	0.5
MPF 2	100	100	100	100	0.3	1
MPF 3	100	100	100	100	0.3	1.5
MPF 4	100	100	100	100	0.3	2

4. Results and Discussions

Conventional concrete specimens are water cured at standard temperature. The mechanical characteristics of the cubes (150 mm x 150 mm x 150 mm), cylinders (150 mm diameter and 300 mm height), and beams (150 mm x 150 mm x 700 mm) are examined according to Indian Standards code of testing.

4.1 Fresh Properties of Concrete

The Slump cone test is utilized to assess the workability of fresh concrete. The consequences of Slump cone tests on different blends are displayed in Table 5 and Figure 1. Here the slump results depict that the workability is in a decreasing manner with the increase in the fiber content.

Table 5. Workability of Concrete (Slump Cone Test)

Mix	Slump (in mm)
Control Mix	85
MPF 1	80
MPF 2	75
MPF 3	74
MPF 4	72

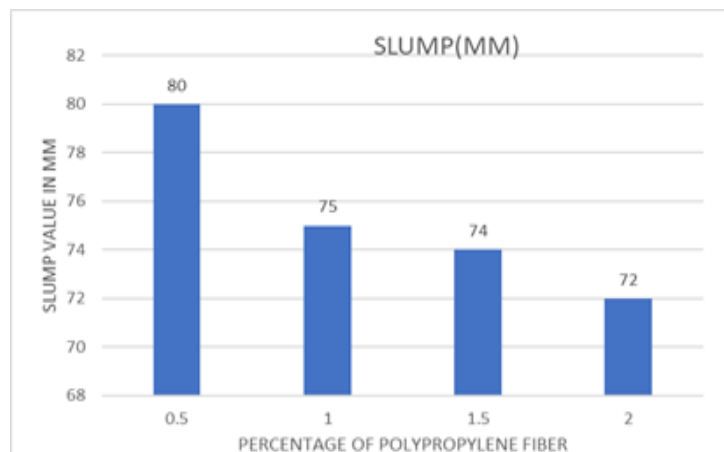


Figure 1. Variation of Slump.

4.2 Hardened Properties:

4.2.1 Compressive Strength of concrete

Crushing load is applied on the cube surface to get compressive strength. It also treated as crushing strength of concrete. The compressive strength test results at an age for 7 and 28 days are presented below. Before testing in the CTM, the specimens were surface dried to draw out moisture content. The following is a summary of the detailed test results are shown in Table 6 and Figure 2.

Table 6. Variation of Compressive strength (N/mm²)

Mix	7 Days	28 Days
Control Mix	21.1	32.5
MPF 1	22.4	34.5
MPF 2	23.6	36.0

MPF 3	21.8	33.6
MPF 4	20.8	32.1

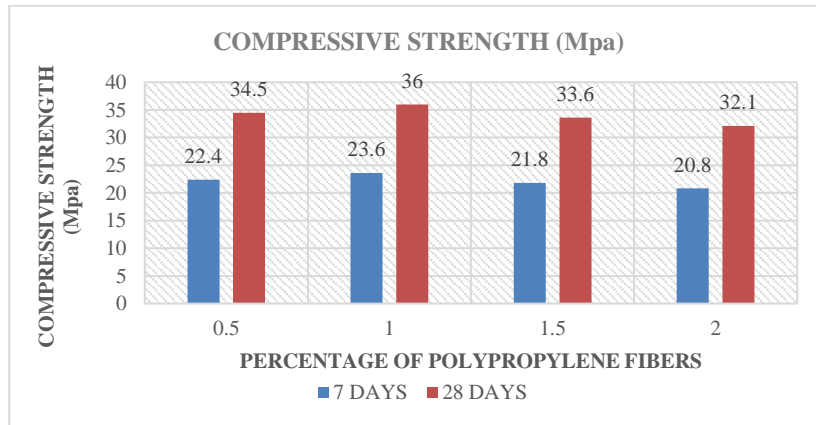


Figure 2. Variation of Compressive Strength (7 & 28 Days)

4.2.2 Split Tensile Strength

Tensile strength is one of the essential qualities of concrete. cylindrical specimens with a height of 300mm and a diameter of 150mm were tested to determine Split Tensile strength of concrete. Each of specimens were tested for 7 days of curing and 28 days of curing of concrete. The following table 7 and Figure 3 summarizes the test results in detail.

Table 7. Split Tensile strength of Concrete (N/mm²)

Mix	7 Days	28 Days
Control Mix	2.45	2.9
MPF 1	2.58	3.1
MPF 2	2.72	3.7
MPF 3	3.05	3.50
MPF 4	2.97	3.41

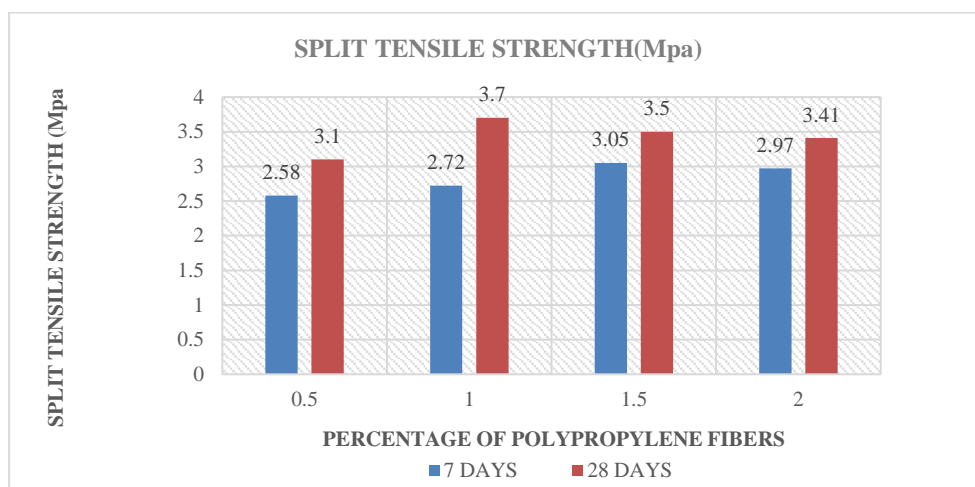


Figure 3. Variation of Split Tensile Strength (7 & 28 Days)

4.2.3 Flexural Strength

The rupture modulus is the most important feature of flexural members. The key aspect in today's building activities is to improve concrete flexural strength criterion. Table 8 represents the result of flexural performance of concrete.

Table 8. Variation of Flexural Strength (N/mm²)

Mix	7 Days	28 Days
Control Mix	3.98	5.4
MPF 1	4.10	5.45
MPF 2	4.25	5.59
MPF 3	3.78	5.23
MPF 4	3.61	5.05

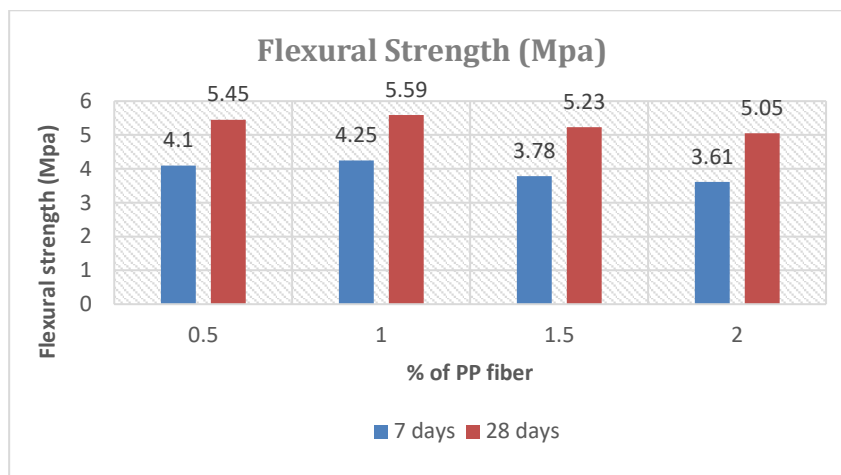


Figure 4. Variation of Flexural Strength (7 & 28 Days)

From the above results (Figure 4), we can observe a significant improvement in the Strength Parameters. The fiber played an important role in resisting failure by improving the bonding of concrete. Concrete Mix with 1% Fiber have shown better performance in Compressive, Split Tensile and Flexural Strength criterion.

5. Conclusions

- 1 In the present investigation the fresh and Hardened Properties are Successfully achieved their desired values.
- 2 The material polypropylene fiber is a good admixture to the reinforced concrete that satisfies all the requirements and it can be used for all constructional purposes.
- 3 Using Master Glenium B233 as a superplasticizer shows better workability and uniformity in Concrete mixing at a dosage of 0.3%.
- 4 Maximum compressive strength of 36.0 Mpa for M25 Grade had occurred for Trail 2 i.e., 1% PP Fiber.
- 5 Split tensile strength of 3.7 Mpa had occurred for Trail 2 i.e., 1% PP Fiber which was maximum among all the dosages.
- 6 Maximum flexural strength of 5.9 Mpa for M25 Grade had occurred for Trail 2 i.e., 1% PP Fiber.
- 7 By adding the polypropylene fiber of 1% in concrete, the compressive strength was increased at a rate of 29.8% and flexural strength is of 4.92% and split tensile strength is of 3.21%.
- 8 The Load carrying capacity and Flexural resistance of concrete can be improved by Using polypropylene fiber at a dosage of 1%.

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