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Experimental Study on the Effect of Polypropylene Fibers on Strength of M30 Grade Concrete

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ABSTRACT: Concrete is a different kind of material; it shows different properties at different stages starting from plastic state to its hardened state. Due to hydration process concrete starts forming cracks in its plastic state. We know that concrete is good in compression and weak in tension. The impact resistance of concrete is poor. And these weaknesses limit its usage. And this can be overcome by adding fibers as an additive to the concrete mix. Fiber Reinforced Concrete (FRC) is an addition of randomly distributed discontinuous fibers for the homogeneous concrete mix. A combination of high strength, stiffness and thermal resistance favorably characterizes the fibers. It will control the cracks by holding the concrete together and increases its compressive strength, and it will act as reinforcement to increase its tensile strength, and increases its impact strength. This paper presents Effect of Polypropylene Fibers on Strength of M30 Grade Concrete, an attempt has been made to find out strength related tests like Compressive Strength and Flexural Strength tests for 7 days and 28 days using Polypropylene Fibers with volume fraction of 0%, 0.25%, 0.5%, 0.75% and 1% and for aspect ratios of 250 and 667 considered for M30 Grade of concrete. Specimens were casted, cured and tested. The results of the tests showed that the strength properties are enhanced due to addition of fibers compared with plain concrete. Here optimum dosage for which the concrete shows its best results are also shown. It can be applied in construction of rigid pavements, sea shore, Pre cast, shotcrete, flat slabs, reduced cross section.

KEYWORDS: Aspect Ratio, optimum dosage, Fiber Reinforced Concrete, Polypropylene Fibers, Compressive Strength, Flexural Strength, Volume Fraction.

I. INTRODUCTION

Adding of different materials for the concrete and studying its behaviour is an old technique. As concrete is weak in tension, we provide reinforcement in tension zone, to overcome this challenge we provide fibers as an additive, these discrete, discontinuous fibers will lead to improve flexural strength [1]. So, as it improves failure time. In the initial stage due to hydration process the concrete starts developing cracks, it will lead to further cracking and failure, its durability will get reduced, here if those cracks were well controlled, then the cracking can also be reduced. Sudden loading on concrete can create an impact pressure, this will lead to bursting force [3], to reduce this action we add a material that will hold concrete together which will equally distribute the impact load [2].

1.1 Technology for Producing FRC

FRC can be produced using conventional concrete practice, though there are obviously some important differences. The basic problem is to introduce a sufficient volume of uniformly dispersed to achieve the desired improvements in its behaviour, while retaining sufficient workability in the fresh mix to permit proper mixing, placing and finishing. The performance of the hardened concrete is enhanced [5] more by fibers with a higher aspect ratio, since this improves the bonding of fiber-matrix. On the other hand, a high aspect ratio reduces the workability of the fresh mix [4]. In general, the problems of both workability and uniform distribution increase with increasing fiber volume, length and aspect ratio. In view of this, care must be taken in the mixing procedures. Most commonly, when using a transit mix truck or revolving drum mixer, the fibers should be added last to the wet concrete. The concrete alone, typically, should have a slump of 50-75 mm greater than the desired slump of the FRC. Alternatively, the fibers may be added to the fine aggregate during the addition of aggregate to the concrete mix. FRC can be placed adequately using normal concrete equipment. FRC has also got wide potential for application in situation where toughness is important in structures



requiring resistance to thermal shocks such as refractory linings, explosive stores. Pads for vertical take-off and air craft tank turning pads.

1.2 Scope of Present Investigation

The adequate and economic application of any material to field problems demands extensive knowledge of its performance under different loads. An extensive application of FRC can be seen in both industrial structures and civil engineering fields. Therefore, the thorough knowledge of the properties of FRC is quite essential. A lot of work has been carried out on FRC using low strength concrete like M20, M15, M25 etc. A little work has been done on FRC high strength concrete. Here in this work an attempt has been made to bring out certain characteristics of high strength FRC using M30, grades of concrete. The characteristics studied are compressive strength and flexural strength. The objective of the present paper is to study the effect of PPF on conventional concrete.

II. MATERIALS AND METHODOLOGY

- **Polypropylene fiber** the polypropylene film fibers type with fit in thermoplastic polypropylene gathering. The polypropylene filaments are warm soft; more be shaped. Polypropylene strands are genuinely hydrophobic. polypropylene filament has been utilized at minimal inside to oversee plastic shrinkage splitting concrete the fiber.
 - Supplier: Jogani Reinforcement (Mumbai)
 - Length: 6mm and 12mm (Aspect Ratio of 250 & 667)
 - Diameter: 0.024mm and 0.018mm
 - Specific gravity: 0.91
 - Density: 910 kg/m³
 - Code: IRC: SP:46-2013
- **Cement** the ordinary Portland cement (OPC 43) has used in this work, with specific gravity of 3.10, initial setting time of 45 minutes, final setting time of 450 minutes.
- **Fine aggregate** crushed stone sand of the portion from 4.75mm to 150 microns are used as fine aggregate.
- **Coarse Aggregate** the aggregate of 20mm down size obtained by regular assignment of and rock and manually smashing of the stone.
- **Mix design** was calculated using the IS: 10262:2019.
 - **Mix Proportion:**
 - Cement 387 kg/m³
 - Water 186 kg/m³
 - Fine Aggregate 719 kg
 - Coarse Aggregate 1108 kg
 - Water-Cement ratio 0.48

The methodology of the work consists of

- 1) Identifying the specification of material to be selected.
- 2) Collection of materials.
- 3) Identifying the properties of collected materials. Conduct basic tests on cement, fine aggregate, coarse aggregate [8].
- 4) Selection of concrete grade.
- 5) Preparation of mix design of M30 grade concrete [9].
- 6) Cubes and beams were casted with control mix using natural aggregate.
- 7) Preparation of test specimen by adding 0.25%, 0.5%, 0.75%, and 1.0% of polypropylene fibers in concrete (Aspect Ratio of 250 & 667 i.e., 6mm and 12mm).
- 8) Workability tests, compressive strength, flexural strength of concrete was conducted.
- 9) Addition of optimum percentage of fiber in concrete was determined.

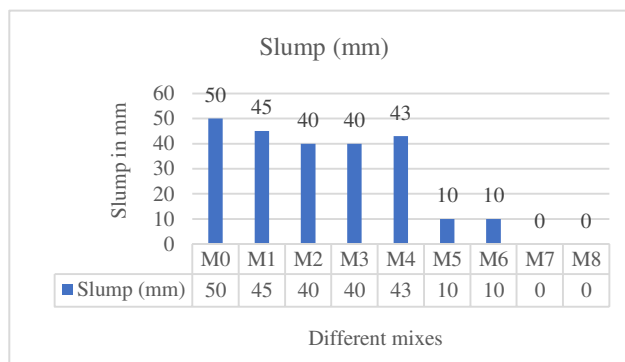
III. RESULTS AND DISCUSSION

The test results are shown in Tables 1 & 2 for the fresh concrete test conducted clearly indicates the difference of each test in assessing the workability of freshly mixed fibre reinforced concrete. For the assessment of fresh properties, slump test and compaction factor test were adopted in the study. However, the tables and the bar graphs below show

the results for the slump and compaction factor tests conducted on polypropylene fibres of different percentage of fibres. Slump values decrease with increases percentages of polypropylene fibres it means require superplasticisers to achieve better workability. Results were showed in table 1 and 2 and graphically represents in Graph 1 and 2.

Table 1: Slump test values

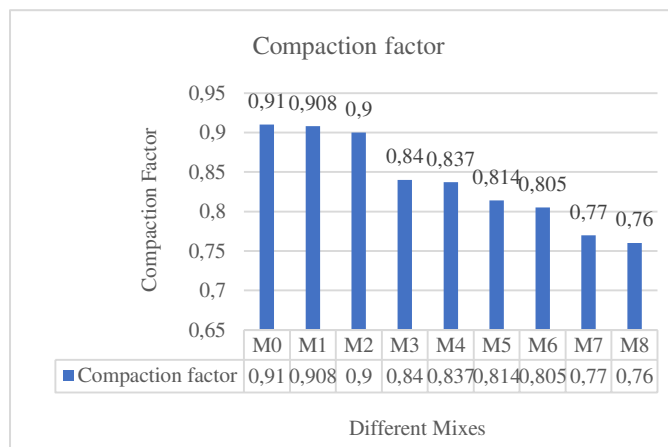
Mix designation	W/C ratio	% Fiber added	Fiber Length (mm)	Slump (mm)
M0	0.48	0	-	50
M1	0.48	0.25	6	45
M2	0.48		12	40
M3	0.48	0.50	6	40
M4	0.48		12	43
M5	0.48	0.75	6	10
M6	0.48		12	10
M7	0.48	1.0	6	0
M8	0.48		12	0



Graph 1: Slump test

Table 2: Compaction factor test values

Mix designation	W/C ratio	% Fiber added	Fiber Length (mm)	Compaction factor
M0	0.48	0	-	0.91
M1	0.48	0.25	6	0.90
M2	0.48		12	0.90
M3	0.48	0.50	6	0.84
M4	0.48		12	0.83
M5	0.48	0.75	6	0.81
M6	0.48		12	0.80
M7	0.48	1.0	6	0.77
M8	0.48		12	0.76



Graph 2: Compaction factor test

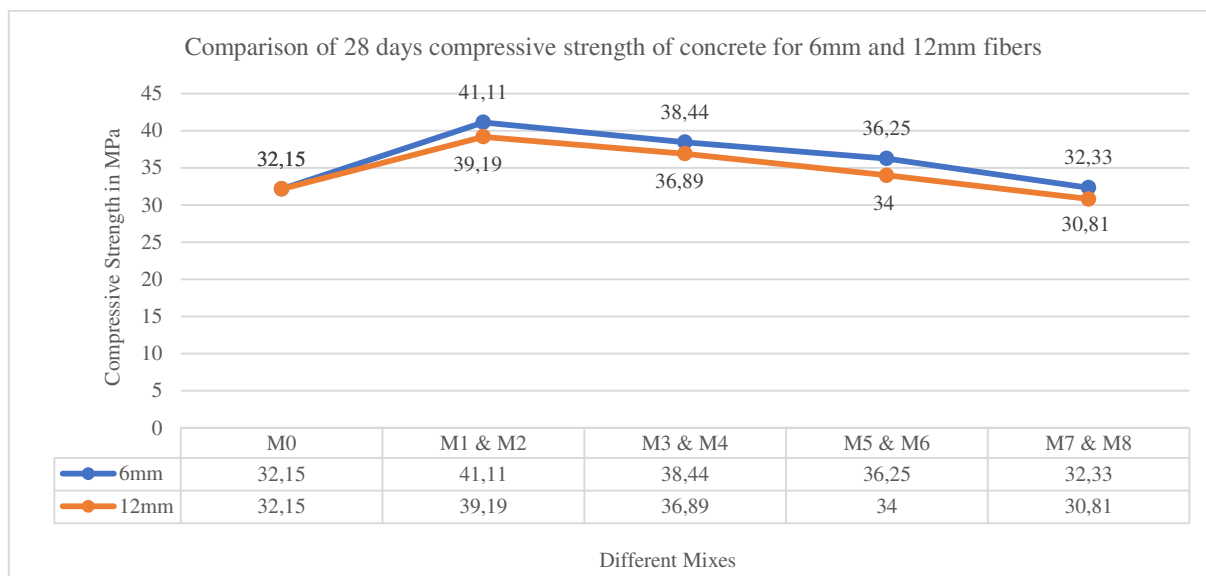
Compressive Strength of the concrete is a measure of its ability to resist static load, which tends to crush the specimen. This test was performed to find the differences of strength according the increasing percentage of fiber in the concrete. The compressive strength of concrete with different mix proportions were determined at the age of 28 days according to IS 516- 1959. Results were showed in Tables 3 and 4 and graphically represents in Graph 3 [10].

Table 3: 28 days Compressive strength test results for 6mm fibers.

Mix	Failure Load (kN)	Compressive strength (N/mm ²)	Avg. compressive strength (N/mm ²)	% Variation in strength w.r.t.M0
M0	720	32	32.15	-
	710	31.56		
	740	32.89		
M1	930	41.33	41.11	8.96
	925	41.11		
	920	40.89		
M3	870	38.67	38.44	6.29
	860	38.22		
	865	38.44		
M5	795	35.33	36.25	4.1
	800	35.56		
	852	37.87		
M7	670	29.78	32.33	0.18
	750	33.33		
	760	33.78		

Table 4: 28 days Compressive strength test result for 12 mm fibers.

Mix	Failure Load (kN)	Compressive strength (N/mm ²)	Avg. compressive strength (N/mm ²)	% Variation in strength w.r.t.M0
M0	720	32	32.15	-
	710	31.56		
	740	32.89		
M2	930	41.33	39.19	7.04
	850	37.78		
	865	38.44		
M4	840	37.33	36.89	4.74
	820	36.44		
	830	36.89		
M6	785	34.89	34	1.85
	760	33.78		
	750	33.33		
M8	680	30.22	30.81	-1.34
	690	30.67		
	710	31.56		



Graph 3: Comparison of 28 days Compressive strength of concrete for 6mm and 12mm fibers

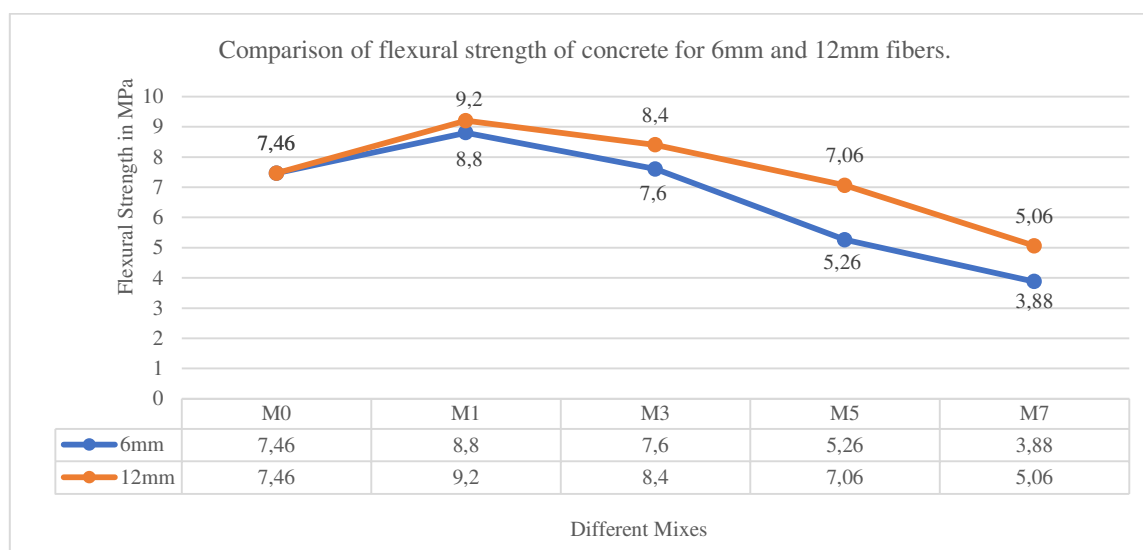
Flexural strength of concrete the enhancement in flexural strength as increase in in amount of fiber is achieved due to improvement in bond between the cement paste and fiber. Specimens subjected to three-point loading were tested according to IS 516-1959. Results were showed in table 5 and 6 and graphically represents in graph 4.

Table 5: Flexural strength test result values for 6mm fibers

Mix	Failure Load (kN)	Flexural strength (N/mm ²)	Avg. Flexural strength (N/mm ²)	% Variation in strength w.r.t.M0
M0	19	7.6	7.46	-
	18.5	7.4		
	18.5	7.4		
M1	22.5	9	8.8	1.34
	22	8.8		
	21.5	8.6		
M3	18.5	7.4	7.6	0.14
	19	7.6		
	19.5	7.8		
M5	13.5	5.4	5.26	-2.2
	13	5.2		
	13	5.2		
M7	9.5	3.8	3.88	-3.58
	9.8	3.92		
	9.8	3.92		

Table 6: Flexural strength test result values for 12mm fibers

Mix	Failure Load (KN)	Flexural strength (N/mm ²)	Avg. Flexural strength (N/mm ²)	% Variation in strength w.r.t.M0
M0	19	7.6	7.46	-
	18.5	7.4		
	18.5	7.4		
M2	23.5	9.4	9.2	1.74
	23	9.2		
	22.5	9		
M4	21	8.4	8.4	0.94
	21.5	8.6		
	20.5	8.2		
M6	18.5	7.4	7.06	-0.4
	17	6.8		
	17.5	7		
M8	12	4.8	5.06	-2.4
	13	5.2		
	13	5.2		



Graph 4: Comparison of flexural strength of concrete for 6mm and 12mm fibers

IV. CONCLUSION

The present study reports the effects polypropylene fibers can be still promising as polypropylene fibers reinforced concrete is used for sustainable and long-lasting concrete structures. Polypropylene fibers are widely used as a fiber reinforced concrete all over the world. Lot of research works are going on polypropylene fiber reinforced concrete. The polypropylene fibers are mostly used fiber for fiber reinforced concrete out of available fibers in market. According to other researchers, the addition of polypropylene fiber into concrete creates low workable or inadequate workability to the concrete. An effort was made to study the effect of use of fiber in concrete and draw a conclusion with respect to an optimum mix with the advantage it offers with respect to its properties. However, the slump test shows less workability of the concrete. This is due to the stiffening effects of the fibres. The slump results will not show the actual workability of the concrete. It was inferred that the problem of hindrance in flowability can be neutralized through nominal enhanced dosage of superplasticizer without compromising on other properties. This will enable a flowable concrete with fiber thereby increasing the compression test results up to 0.25%, later it will decrease, but the flexural test will increase with increases in percentage addition of fiber.

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