Investigation on Compressive and Tensile Behavior of Fibrillated Polypropylene Fibers Reinforced Concrete

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ABSTRACT

Based on Experimental investigation for M-20 grade of concrete, this paper provides result data of the compressive strength, and split tensile strength of fibrillated polypropylene fiber reinforced concrete (PFRC) containing fibers of 0% and 0.25% volume fraction by weight of cement (V_f) of 15mm, 20mm and 24mm cut length without admixture. For compression test, the cube (15cmx15cmx15cm) and Cylinders (10cm diameter and 20cm length) were used. For splitting Test, Cylinders (10 cm diameter and 20 cm length) were used.

A result data obtained has been analyzed and compared with a control specimen (0% fiber). A result data also compared between three different fibers strength. A relationship between Compressive strength vs. days, and tensile strength vs. days represented graphically. Result data clearly shows percentage increase in7 and 28 days Compressive strength, and Tensile strength for M-20 Grade of Concrete.

Keywords - **Compressive strength, Control concrete, fibrillated polypropylene fiber, Split tensile strength, Workability.**

I. INTRODUCTION

Concrete is characterized by quasi-brittle failure, the nearly complete loss of loading capacity, once failure is initiated. This characteristic, which limits the application of the material, can be overcome by the inclusion of a small amount of short randomly distributed fibers (steel, glass, synthetic and natural) and can be practiced among others that remedy weaknesses of concrete, such as low growth resistance, high shrinkage cracking, low durability, etc.[1] Fiber Fiber reinforced concrete is the composite material containing fibers in the cement matrix in an orderly manner or randomly distributed manner. Its properties would obviously, depend upon the efficient transfer of stress between matrix and the fibers, which is largely dependent on the type of fiber, fiber geometry, fiber content, orientation and distribution of the fibers, mixing and compaction techniques of concrete, and size and shape of the aggregate. Fiber reinforced concretes (FRC) exhibit property improvement caused by the fibers. Fibrillated Polypropylene fibers have great influence on the spalling behavior of concrete under fire loading. Fibers of Fibrillated Polypropylene form a mesh or net type structure which binds the coarse aggregates in it, resulting in good workability and less bleeding of concrete. [5] They also lower the permeability of concrete Fibrillated Polypropylene fibers give very good impact resistance strength to the concrete matrix. This property is very well utilized in concrete pavement successfully. Fibrillated Polypropylene fibers actually inhibit the formation of cracks in concrete matrix, whereas steel mesh only has functional value after the concrete has cracked.[5] These materials are an excellent option for use as external reinforcing because of their light weight, resistance to corrosion, and high strength. Fibrillated polypropylene fibers are slit and expanded into an open network thus offering a larger specific surface area with improved bond characteristics. Polypropylene fibers are hydrophobic, that is they do not absorb water. Therefore, when placed in a concrete matrix they need only be mixed long enough to insure dispersion in the concrete mixture. The mixing time of fibrillated or tape fibers should be kept to a minimum to avoid possible shredding of the fibers. The type of polypropylene fiber recommended by manufacturers for paving applications is the collated fibrillated fiber.[5]The length of fiber recommended is normally tied to the nominal maximum size of aggregate in the mixture. Manufacturers recommend that the length of the fiber be greater than twice the diameter of the aggregate.[14] This would be consistent with past experiences with fibrillated polypropylene fibers and also with current theories on fiber dispersion and bonding". Hence this study explores the feasibility of fibrillated polypropylene fiber reinforcement; aim is to do parametric study on compressive strength and tensile strength study etc. with given grade of concrete, proportions and percentage of fibers.

II. EXPERIMENTAL PROGRAMME

MATERIAL USED AND MIXUTRE PROPORTION

In this experimental study, Cement, sand, coarse aggregate, water and fibrillated polypropylene fiber fibers were used.

Cement: Ordinary Portland cement of 43 grade was used in this experimentation conforming to I.S-8112- 1989

Coarse aggregates: Locally available, maximum size 20 mm, specific gravity 2.79

Sand: Locally available sand zone I with specific gravity 2.28, water absorption 2% and fineness modulus 2.92, conforming to I.S. – 383-1970.

Water: Potable water was used for the experimentation.

Polypropylene Fibers: Fibrillated 15mm, 20mm and 24mm cut length fibers were used.

Different cut lengths of polypropylene fibers with 0.25% volume fraction (vf) are shown below table.

Table 1 Different cut lengths of fibers used:

Notation	Cut Length of Polypropylene Fibers (mm)	Polypropylene Fibers by Weight of Cement Vf (%)
PF1	15	0.25
PF1	20	0.25
PF1	24	0.25

Table 2: *Concrete mix proportions.*
Concrete for M20 grade were prepared as per I.S.10262:2009 with w/c 0.5.
Mix proportion for M20 grade concrete for tested material as follows:

Material	*Quantity*
Cement	383 Kg/ m^3
Sand	672 Kg/ m^3
Coarse Aggregates	1100 Kg/ m^3
Water	192 Kg/ m^3
Polypropylene Fibers	0.25% by weight of cement
Slump	75-100 mm

III. WORKABILITY:

Tests on fresh concrete:

The consistency and workability of all the concrete mixtures was determined through slump tests. The slump tests were performed according to IS 1199-1959 [19]. The vertical distance between the original and displaced positions of the centre of the top surface of the concrete was measured and reported as the slump. Slump tests were carried out to determine the workability and consistency of fresh concrete [5]. The efficiency of all fiber reinforcement is dependent upon achievement of a uniform distribution of the fibers in the concrete, their interaction with the cement matrix, and the ability of the concrete to be successfully cast or sprayed. Essentially, each individual fiber needs to be coated with cement paste to provide any benefit in the concrete. Regular users of fiber reinforcement concrete will fully appreciate that adding more fibers into the concrete, particularly of a very small diameter, results in a greater negative effect on workability and the necessity for mix design changes. The slump changed due to the different type of fiber content and form. The reason of lower slump is that adding two different fibers can form a network structure in concrete, which restrain mixture from segregation and flow. Due to the high content and large surface area of fibers, fibers are sure to absorb more cement paste to wrap around and the increase of the viscosity of mixture makes the slump loss (Chen and Liu, 2000)

IV. EXPERIMENTAL METHODOLOGY

The tests have been performed to determine the mechanical properties were compressive strength and splitting tensile-strength of fiber reinforced concrete.

4.1 Compressive Strength Test:

For compressive strength test, both cube specimens of dimensions 150 x 150 x 150 mm and cylindrical specimens of length 200 mm and diameter 100 mm were cast for M20 grade of concrete. The moulds were filled with 0% and 0.25% fibers. Vibration was given to the moulds using table vibrator. The top surface of the specimen was leveled and finished. After 24 hours the specimens were demoulded and were transferred to curing tank where in they were allowed to cure for 7 days and 28 days. After 7 and 28 days curing, these cubes and cylinders were tested on digital compression testing machine as per I.S. 516-1959[18]. The failure load was noted. In each category, three cubes and three cylinders were tested and their average value is reported. The compressive strength was calculated as follows:
Compressive strength (MPa) = Failure load / cross sectional area.

4.2 Tensile strength test:

For tensile strength test, cylinder specimens of dimension 100 mm diameter and 200 mm length were cast. The specimens were demoulded after 24 hours of casting and were transferred to curing tank where in they were allowed to cure for 7 and 28 days. These specimens were tested under

compression testing machine. In each category, three cylinders were tested and their average value is reported [20].
Tensile strength was calculated as follows as split tensile strength:
Tensile strength (MPa) = 2P / π DL,
Where, P = failure load, D = diameter of cylinder,
L = length of cylinder.

V. EXPERIMENTAL RESULTS

5.1 Compressive Strength

5.1.1 Using cube Specimen:

Results of Compressive strength for M-20 grade of concrete on cube and cylinder specimen with 0% and 0.25% Polypropylene Fibers for cut length 15mm, 20mm and 24mm are shown in table3 and Figure1 below:

Table3: Results of Compressive strength using cubes specimen

Days	Average Compressive Strength (Mpa)			
	0%	0.25% (PF1)	0.25% (PF2)	0.25 % (PF3)
7	24.25	24.83	25.06	25.13
28	31.78	32.16	32.98	33.04

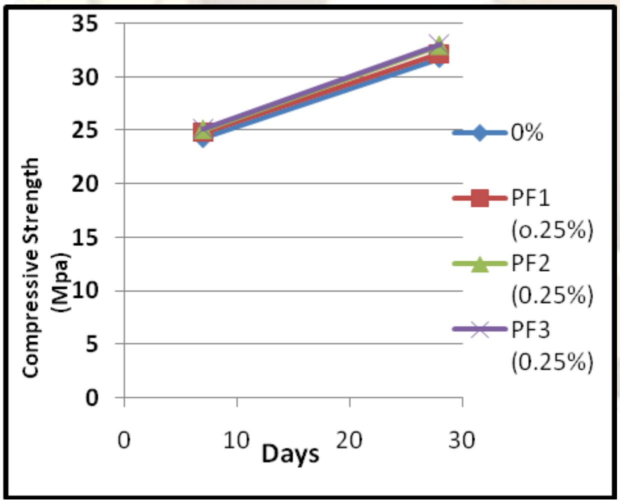

Figure.1 indicates the comparison of result of compressive strength using cube specimen of M20 grade of concrete with and without fibers. It was observed that, the compressive strength of concrete with 0.25% fibrillated Polypropylene Fibers increases very negligible amount. It gives highest value for longest fiber at same volume fraction.

5.1.2 Using cylindrical Specimen:

Results of Compressive strength for M-20 grade of concrete on cylinder specimen with 0% and 0.25% Polypropylene Fibers for cut length 15mm, 20mm and 24mm are shown in table4 and Figure2 below:

Table 4: Results of Compressive strength using cylinder specimen

Days	Average Compressive Strength (Mpa)			
	0%	0.25% (PF1)	0.25% (PF2)	0.25 % (PF3)
7	14.10	14.44	14.62	14.72
28	21.67	22.23	22.48	22.96

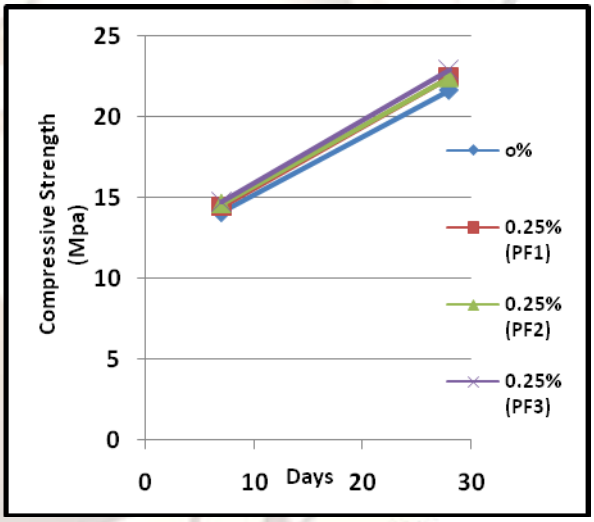

Figure 2: Compressive strength using cylinders

Figure.2 indicates the comparison of result of compressive strength using cylindrical specimens of M20 grade of concrete with and without fibers. It was observed that, by addition of 0.25% fibers has negligible effect on compressive strength of concrete at same volume fraction (Vf).

5.2 Tensile strength

Results of splitting tensile strength for M-20 grade of concrete with 0% and 0.25% Polypropylene Fibers for cut length 15mm, 20mm and 24mm are shown in table3 and Figur31 below:

Table5: Results of splitting tensile strength using cylinder.

Days	Average Splitting Tensile Strength (Mpa)			
	0%	0.25% (PF1)	0.25% (PF2)	0.25 % (PF3)
7	1.26	1.66	1.89	2.14
28	2.12	2.94	3.27	3.64

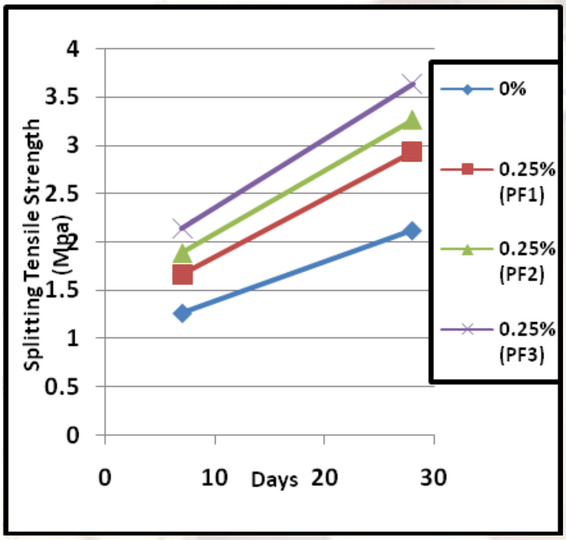

Figure 3: Comparison of Split tensile strength

Figure 3 indicates the result of Split tensile strength for M20 grade of concrete. It is observed that for addition of 0.25% PF3 fiber gives maximum tensile strength at 28 days. It gives highest value for longest fiber at same volume fraction.

VI CONCLUSSION

The study on the effect of fibrillated Polypropylene Fibers with different cut length can still be a promising work as there is always a need to overcome the problem of brittleness of concrete.

The following conclusions could be drawn from the present investigation-

1. It is observed that the compressive strength for M20 grade of concrete from three different cut length fibers at same volume fraction shows nearly same results with minor increase.

2. By addition of 0.25%, 24 mm cut length fibrillated Polypropylene Fibers shows maximum compressive strength.

3. With same volume fraction, change in length of fiber result nearly minor effect on compressive strength of Fiber Reinforced concrete.

4. It was observed that, the split tensile strength of fiber reinforced concrete was dependent on length of fiber used. By addition of longer length fiber, the split tensile strength increases. Used of 24 mm long fiber with same volume of fraction gives maximum split tensile strength over fiber 15 mm and 20 mm cut length.

5. Addition of steel fiber in the concrete effect the workability of concrete. Addition of 0.25% fibrillated Polypropylene Fibers reduces the slump value of fresh concrete. This problem of workability and flow property of concrete can be overcome by using suitable admixtures such as Superplasicizers.

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