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Effect of Polypropylene Fiber on Properties of Concrete

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Abstract

Plain concrete has low tensile strength, less ductility, destructive and brittle failure. In order to improve these properties of plain concrete, an attempt has been made to study the effect of addition polypropylene fiber in ordinary portland cement concrete. In the this experimental investigation fibers in different percentage 0 to 0.7% has been studied for the effect on strength properties of concrete by carrying compressive strength test and flexural strength test at 28 days for M25 grade of concrete. Test results show that the addition of polypropylene fiber to concrete exhibit better performance than the plain concrete. The results have shown improvement in compressive strength and flexural strength with the addition of polypropylene fiber in ordinary portland cement concrete The fiber content is vary from 0.1%, 0.3%, 0.5% and 0.7% by weight of concrete.

Keywords: Polypropylene Fiber, Compressive Strength, Flexural Strength.

Introduction

Concrete is the most widely used construction material which has several desirable properties like high compressive strength, stiffness and durability under normal usual environmental factors. While at the same time concrete found to be brittle and weak in tension. It is well known that concrete mixed with other material was applied for resistance purpose.

Fiber reinforce concrete is a family of composite materials that combine the high compressive strength properties of cement mortars with significantly increased impact, flexural and tensile strengths imparted by the fiber reinforcement.

Without any fiber in the concrete there was development of the cracks due to plastic shrinkage, drying shrinkage and other reasons of changes in volume of concrete. The development of these micro cracks causes elastic deformation of concrete. The presence of fibers provides crack arresters. When the first crack occurs in the matrix, the strong fibers pick up the load. That support is stronger than the matrix itself, so the next crack must occur elsewhere. More loading adds only new cracks, immediately arrested, rather than causing first cracks to propagate. Failure develops as a gradual, like - plastic yielding.

In the present work, polypropylene fiber, 9 mm long and 18 micrometre in diameter are used for the preparation of standard M25 grade concrete.

A preliminary test program has been carried out to study the strength characteristics of fiber reinforced concrete with the addition of polypropylene fiber to concrete. The fiber content is vary from 0.05%, 0.15%, 0.25% and 0.35% by weight of concrete.

Review of literature

M. Tamil Selvi et al (2013)[5] is study the durability properties of M30 grade of concrete reinforced individually with 4% of steel and polypropylene fibers, respectively, as well as with hybrid fibers consisting of 2% steel and 2% polypropylene fibers respectively and to evaluate their strength at 7, 28, and 90 days. They conducted the rapid chloride permeability test, water absorption test, compressive strength and split tensile strength at 7, 28, 56 and 90 days and the test results show that the addition of steel and polypropylene fibers to concrete exhibit better performance.

Hybrid Polypropylene and steel (crimped) fibers show 22%, 10%, 3% and 9% increase in compressive strength at 7 days, 14 days, 21 days and 28 days respectively when compared to conventional concrete of M30 grade.

Hybrid Polypropylene and steel (crimped) fibers show 7%, 15%, 0% and 5% increase in split tensile strength of cylinders at 7 days, 14 days, 21 days and 28 days respectively when compared to conventional concrete of M30 grade.

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Priti A. Patel et al (2012)[7] done an experimental investigation explored properties such as compressive strength, flexural strength, split tensile strength and shear strength of polypropylene fiber reinforced concrete. Conventional concrete has two major drawbacks: low tensile strength and a destructive and brittle failure. In an attempt to increase concrete ductility and energy absorption, researcher introduced polypropylene fiber reinforced concrete (PFRC). Their study is part of a research program on evaluating the performance of polypropylene fiber reinforced concrete.

The fiber volume fraction V_f 0%, 0.5%, 1%, 1.5% and 2 %. No significant change is found for compressive strength when compared to the plain concrete but flexural, split tensile and shear strength improves greatly.

Roohollah Bagherzadeh et al (2012) [8] has been studied the influence of polypropylene fibers in different proportioning and fiber length to improve the performance characteristics of the lightweight cement composites. In this study they used fibers in two different lengths (6mm and 12mm) and fiber proportions (0.15% and 0.35%) by cement weight in the mixture design. Hardened concrete properties such as compressive strength, splitting tensile strength, flexural strength, water absorption, and shrinkage were evaluated at 7- and 28-day.

In their study all reinforced lightweight concrete specimens display improvement in their mechanical strength. Among all fiber specimens, only the Polypropylene fiber with 12 mm length and proportion 0.35 % performed better in all respects compared to the physical and mechanical properties of reinforced lightweight concrete.

Slamet Widodo (2012)[9] conducted the research work to evaluate the effects of polypropylene fiber addition on fresh state characteristics of SCC mixes, and investigate the effects of polypropylene fiber on some hardened properties of SCC. In their research work they were added polypropylene fiber of 0%, 0.05%, 0.10%, and 0.15% volume fraction in concrete mixes.

They observed that the compressive strength of concrete specimens improved proportionally with the addition of polypropylene fiber up to 0.05 percent by concrete volume, and then tend to decrease after 0.10 percent of polypropylene addition in the concrete mix.

They also observed that the splitting tensile strength of concrete specimens improved proportionally with the addition of polypropylene fiber up to 0.10 percent by concrete volume, and then tend to decrease after 0.15 percent of polypropylene addition in the concrete mix.

According to the evaluation of fresh and hardened properties of Self-Consolidating Concrete (SCC), they concluded that polypropylene fibers allowed to be added into the concrete mixes up to 0.10 percent by concrete volume.

Experimental programme

Materials

Cement, sand, coarse aggregate, water, polypropylene fibers were used in experimental work.

Cement

The cement used was Ordinary Portland cement of 43 Grade available in local market. The cement used has been tested for various properties as per IS: 4031 and found to be confirming to various specifications of I.S-8112- 1989. The specific gravity of cement was 3.05, Fineness of cement 4.0%, Normal consistency 36% and initial and final settings of OPC 43 grade cement was 50 min and 550 min respectively.

Aggregate

Crushed stones passing through 20mm and retained on 10 mm sieve used as coarse aggregate. Fineness Modulus, Specific gravity, Water absorption and free moisture content of coarse aggregate is 7.10, 2.95, 0.3% and nil respectively. Natural river sand available in the local market used as fine aggregate. Locally available sand was confirming to zone III with specific gravity 2.55, water absorption 0.5% and fineness modulus 2.50, conforming to I.S. – 383-1970.

Polypropylene Fiber

Polypropylene fiber, a synthetic carbon polymer, is produced as continuous mono – filaments, with circular cross section. Polypropylene with18 μm diameter, 9 mm length, and aspect ratio 500 which having 0.91 g/cm^3 density were used. Polypropylene fibers are tough but with low tensile strength and modulus of elasticity. They have plastic stress-strain characteristics

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Mix Proportions

Table 1 Mix Proportions

PP fiber (%)	0	0.05	0.15	0.25	0.35
Cement (kg/m^3)	428	428	428	428	428
Water (Lt/m^3)	189.11	189.11	189.11	189.11	189.11
FA (kg/m^3)	504.173	504.173	504.173	504.173	504.173
CA (kg/m^3)	1286.46	1286.46	1286.46	1286.46	1286.46

Test Specimens

Cubes of 150 X 150 X 150 mm cast in cast iron mould for compression strength testing. Prisms are cast in 700 X 150 X 150 mm mould size for the flexural strength testing. Fresh concrete was placed into the moulds and compacted using vibrator table for 30s. Top surface was levelled smoothly using trowel and after that the moulds were securely placed in the room temperature for 24 h. The specimens were systematically placed in curing tanks after 24 hours for 28 days.

Test on Concrete

Compressive Strength

Compressive strength of a concrete is a measure of its ability to resist static load, which tends to crush it. This test was performed to find the increase and differences of strength according the increasing percentage of fiber in the concrete. The compressive strength of concrete with different mixture proportions was determined at the age of 28 days according to IS 516-1959. The experimental test result is given in Table 3.

Table 2- Compressive strength test result at 28 days for Polypropylene fiber

Type of Concrete	Days	Compressive Strength N/mm^2
0% Polypropylene Fiber	28	36.44
0.05% Polypropylene Fiber	28	36.89
0.15% Polypropylene Fiber	28	38.10
0.25% Polypropylene Fiber	28	37.90
0.35% Polypropylene Fiber	28	37.33

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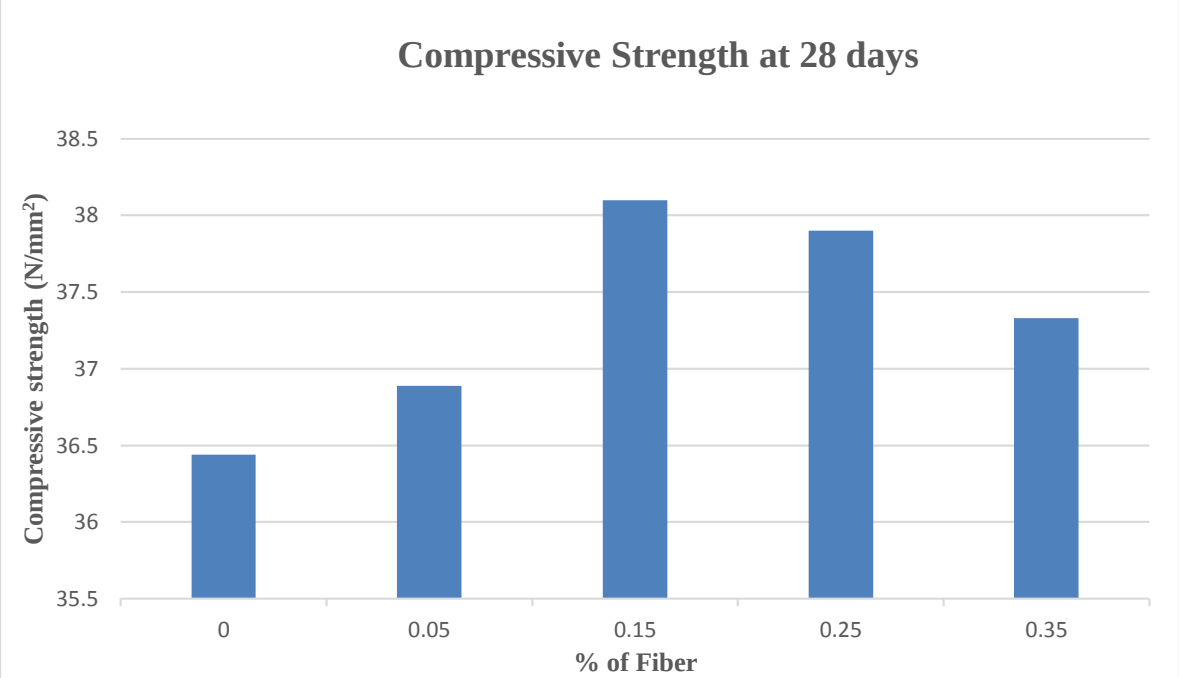

Flexural strength

Flexural strength of a concrete is a measure of its ability to resist bending. Flexural strength can be expressed in terms of 'modulus of rupture'. The flexural strength is evaluated at different fiber concrete mixes after 28 days of curing subjected to three point load according to IS 516-1959. The experimental test result is given in Table 4

Table 3- Flexural Strength test result at 28 days for Polypropylene Fiber

Type of concrete	Days	Flexural Strength N/mm²
0% Polypropylene Fiber	28	4.25
0.05% Polypropylene Fiber	28	4.56
0.15% Polypropylene Fiber	28	5.91
0.25% Polypropylene Fiber	28	6.42
0.35% Polypropylene Fiber	28	6.22

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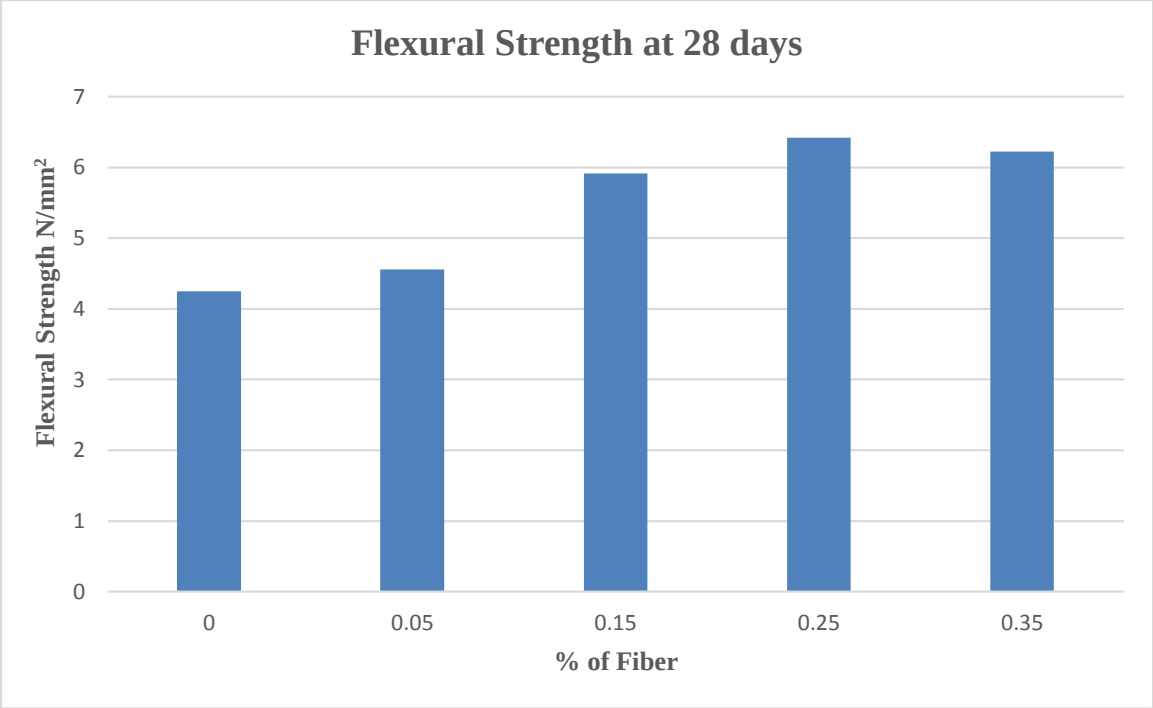

Results and discussions

Compressive strength

Table 2 gives the test results of compressive strength at 28 days. Compressive strength increases with increasing percentage of fibers. It can be observed that 28 days compressive strength is increased by 1.23% with addition of 0.05% of fiber compared to normal M-25 concrete. It can be observed that 28 days compressive strength is increased by 4.55% with addition of 0.15% of fiber compared to normal M-25 concrete. It can be observed that 28 days compressive strength is increased by 4% with addition of 0.25% of fiber compared to normal M-25 concrete. Also it can be observed that 28 days compressive strength is increased by 2.44% with addition of 0.35% of fiber compared to normal M-25 concrete. 0.5% addition of fibers into the concrete shows maximum benefits in compressive strength.

Flexural strength

Table 3 gives the test results of flexural strength at 28 days. Flexural strength increases with increasing percentage of fibers. It can be observed that 28 days flexural strength is increased by 7.29% with addition of 0.05% of fiber compared to normal M-25 concrete. It can be observed that 28 days flexural strength is increased by 43.52% with addition of 0.15% of fiber compared to normal M-25 concrete. It can be observed that 28 days flexural strength is increased by 51.05% with addition of 0.25% of fiber compared to normal M-25 concrete. Also it can be observed that 28 days flexural strength is increased by 46.35% with addition of 0.35% of fiber compared to normal M-25 concrete. 0.25% addition of fibers into the concrete shows maximum benefits in flexural strength.

Conclusions

The addition of fibers into the concrete mixture marginally improves the compressive strength at 28 days but there is 51.05% increase in flexural strength with the addition of 0.25% fiber in concrete. It is observed from the experimental results and its analysis, that the compressive strength of concrete and flexural strength of concrete increases with addition of fibers. The 0.35% addition of fibers into the concrete shows better result in compressive strength and the 0.25% addition of fibers into the concrete shows better result in flexural strength.

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