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Mechanical Properties of Fiber Reinforced Concrete

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Abstract : *In this study, the results of strength properties of Polypropylene fiber reinforced have been presented. The compressive strength, split tensile strength and flexural strength of concrete samples made with different fiber amounts varying from 0%, 0.5%, 0.75% and 1% fiber by weight of cement were studied. The test samples added with 0.75% polypropylene fiber showed better results when added with other percentages of fiber.*

Keywords: *Compressive strength, Flexural strength, Split Tensile strength, Polypropylene fiber*

I. Introduction

The capability of durable structure to resist weathering action, chemical attack, abrasion and other degradation processes during its service life with the minimal maintenance is equally important as the capacity of a structure to resist the loads applied on it. Although concrete offers many advantages regarding mechanical characteristics and economic aspects of the construction, the brittle behavior of the material remains a larger handicap for the seismic and other applications where flexible behavior is essentially required. Recently, however the development of polypropylene fiber-reinforced concrete (PFRC) has provided a technical basis for improving these deficiencies.

Polypropylene fibers were first suggested as an admixture to concrete in 1965 for the construction of blast resistant buildings for the US Corps of Engineers. The fiber has subsequently been improved further and at present it is used either as short discontinuous fibrillated material for production of fiber reinforced concrete or a continuous mat for production of thin sheet components. Since then the use of these fibers has increased tremendously in construction of structures because addition of fibers in concrete improves the toughness, flexural strength, tensile strength and impact strength as well as failure mode of concrete. Polypropylene twine is cheap, abundantly available, and like all manmade fibers of a consistent quality

1.1 General Properties of Polypropylene Fibers

- The raw material of polypropylene is derived from monomeric C3H6 which is purely hydrocarbon. Its mode of polymerization, its high molecular weight and the way it is processed into fibers combine to give polypropylene fibers very useful properties as explained below [9]:
- There is a sterically regular atomic arrangement in the polymer molecule and high crystallinity. Due to regular structure, it is known as isostatic polypropylene.
- Chemical inertness makes the fibers resistant to most chemicals. Any chemical that will not attack the concrete constituents will have no effect on the fiber either. On contact with more aggressive chemicals, the concrete will always deteriorate first.
- The hydrophobic surface not being wet by cement paste helps to prevent chopped fibers from balling effect during mixing like other fibers.
- The water demand is nil for polypropylene fibers.

The orientation leaves the film weak in the lateral direction which facilitates fibrillations. The cement matrix can therefore penetrate in the mesh structure between the individual fibrils and create a mechanical bond between matrix and fiber.

1.2 Objectives Of The Study

The objective of the present study is to cast cubes of size 100mm x 100mm, prisms of size 500mm x 100mm x 100mm and cylinders of height 300mm and diameter 150mm with various fiber percentages. The study aims at understanding the strength aspects of concrete under the influence of polypropylene fiber.
The objectives of the study can be organized as:

- Casting the cubes, beams and cylinders with 0, 0.5, 0.75 and 1% polypropylene fiber by weight of cement.

- Testing the specimens for compressive strength, split tensile strength and flexural strength of cubes, beams and cylinders respectively at the age of 7, 28 and 56 days and comparing the results.

Summarized information about materials used in the present study and their properties are presented herein.

II. Experimental Details

Summarized information about materials used in the present study and their properties are presented herein.

- CEMENT: Portland Pozzolana cement conforming to IS: 1498-1991 was adopted in this work.
- COURSE AGGREGATE: Machine crushed angular granite metal passing through 20 mm sieve and retained on 10mm sieve has been used. It is free from impurities such as dust, clay particles and organic matter. The coarse aggregate conforms of IS: 383-1970.
- FINE AGGREGATE: Locally available river sand was used. The sand was dried before used to avoid problem of bulking.
- WATER: Locally available potable water with pH value of 7.65 was used in the present work and it conforms to IS: 3025-1986.
- POLYPROPYLENE FIBERS: Fine monofilament polypropylene fibers are used in the study. They are available in standard sizes of length 3mm, 6mm and 12 mm. In the present study, fibers of length 12 mm are used.

2.1 Test Data For Materials

- Specific gravity of cement : 3.12
- Specific gravity of coarse aggregate :2.80
- Fineness modulus of coarse aggregate :6.7
- Specific gravity of fine aggregate :2.68
- Fineness modulus of fine aggregate :2.60
- Water absorption of coarse aggregate : 1%
- Water absorption of fine aggregate :0.5%
- Free surface moisture for coarse and fine aggregate : Nil

2.2 Mix proportions

Stipulations for proportioning

- Grade designation : M30
- Type of cement: PPC
- Maximum nominal size of aggregate :20
- Type of aggregate : Crushed angular aggregate

Target average 28 day compressive strength of concrete: 38.25 N/sq.mm
Water cement ratio: 0.45
Cement: Fine aggregate: Coarse aggregate = 1:1.70: 3.06
The same mix was adopted for further studies throughout this work

III. Results And Discussion

3.1 Compressive Strength

Fig 1presents the variation of compressive strength of polypropylene fiber reinforced concrete with age (7, 28 and 56 days) for various percentages (0%, 0.5%, 0.75% and 1%) of polypropylene fiber by weight of cement.

It is observed that concrete at all the ages (7, 28 and 56 days) experienced an increase of compressive strength when polypropylene fiber of different percentages (0.5%, 0.75%, and 1%) were added. There is a very minor increase in the compressive strength at all ages. It is further observed that addition of 0.75% of polypropylene fiber resulted in the maximum increase in the compressive strength.

0% fiber	Age (Days)	Compressive strength
	7	24.1 N/mm²
	28	41.5 N/mm²
	56	43 N/mm²
0.5% fiber	Age (Days)	Compressive strength
	7	27.3 N/mm²
	28	41.67 N/mm²
	56	43.67 N/mm²

0.75% fiber	Age (Days)	Compressive strength
	7	28 N/mm²
	28	43 N/mm²
	56	44 N/mm²
1% fiber	Age (Days)	Compressive strength
	7	27.6 N/mm²
	28	42.3 N/mm²
	56	43.6 N/mm²

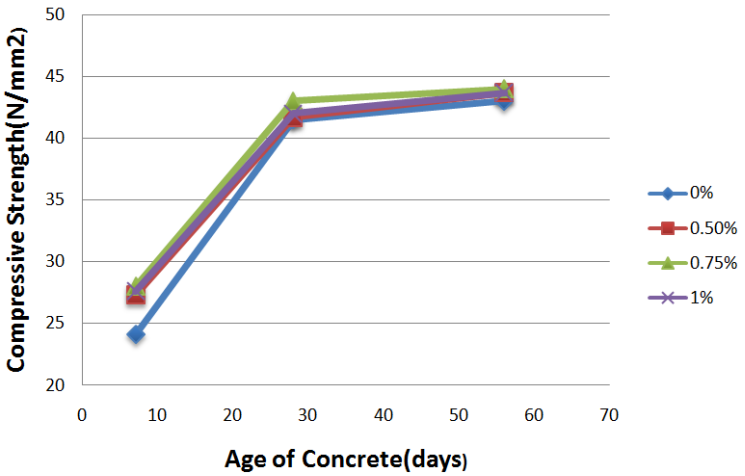

Fig 1. Variation of Compressive strength with fiber content

3.2 Split Tensile Strength

Fig 2 presents the variation of split tensile strength of polypropylene fiber reinforced concrete with age (7, 28 and 56 days) for various percentages (0%, 0.5%, 0.75% and 1%) of polypropylene fiber by weight of cement.

It is observed that concrete at all the ages (7, 28 and 56 days) experienced an increase of split tensile strength when polypropylene fiber of different percentages (0.5%, 0.75%, and 1%) were added. Addition of 0.75% of polypropylene concrete resulted in the maximum increase in the split tensile strength. Polypropylene fiber reinforced concrete with 0.75% fiber by weight of cement exhibited about 14% more strength compared to conventional concrete.

0% fiber	Age (Days)	Split Tensile Strength
	7	2.67 N/mm²
	28	3.1 N/mm²
	56	4.2 N/mm²

0.5% fiber	Age (Days)	Split Tensile Strength
	7	2.8 N/mm²
	28	3.25 N/mm²
	56	4.3 N/mm²

0.75% fiber	Age (Days)	Split Tensile Strength
	7	3.44 N/mm²
	28	3.53 N/mm²
	56	4.38 N/mm²

1% fiber	Age (Days)	Split Tensile Strength
	7	2.26 N/mm²
	28	3.11 N/mm²
	56	4.27 N/mm²

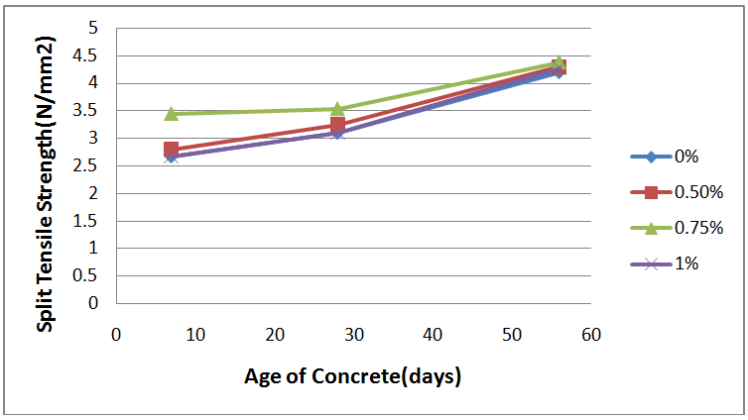

Fig 2. Variation of Split Tensile Strength with fiber content

3.3 Flexural Strength

Fig 3 presents the variation of flexural strength of polypropylene fiber reinforced concrete with age (7, 28 and 56 days) for various percentages (0%, 0.5%, 0.75% and 1%) of polypropylene fiber by weight of cement. It is observed that at all ages (7, 28 and 56 days) experienced an increase of flexural strength when polypropylene fiber of different percentages (0.5%, 0.75%, 1%) were added. Addition of 0.75% of polypropylene concrete resulted in the maximum increase in split tensile strength. Reinforced concrete with 0.75% fiber by weight of cement exhibited about 23% more strength compared to conventional concrete.

0% fiber	Age (Days)	Flexural strength
	7	4.61 N/mm²
	28	6.3 N/mm²
	56	7.4 N/mm²

0.5% fiber	Age (Days)	Flexural strength
	7	4.82 N/mm²
	28	7.42 N/mm²
	56	7.61 N/mm²

0.75% fiber	Age (Days)	Flexural strength
	7	5.65 N/mm²
	28	7.74 N/mm²
	56	7.92 N/mm²

1% fiber	Age (Days)	Flexural strength
	7	4.44 N/mm²
	28	6.64 N/mm²
	56	7.5 N/mm²

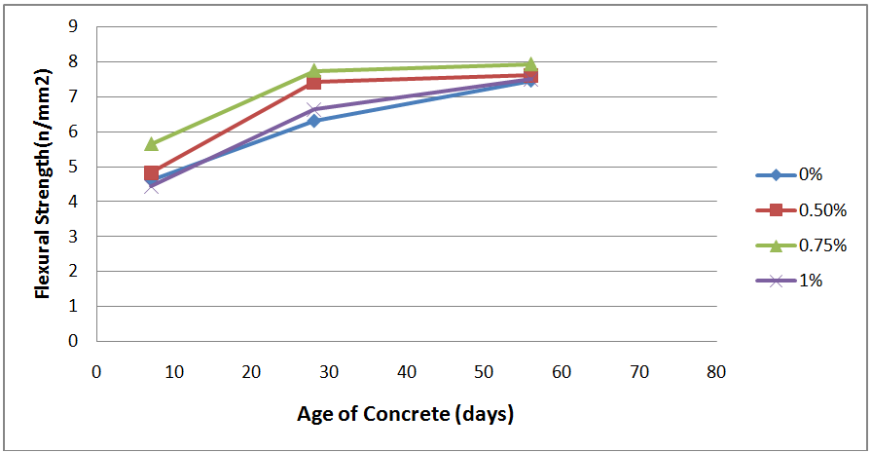

Fig 3. Variation of flexural strength with fiber content

IV. Conclusions

From experimental investigation was carried out on polypropylene fiber reinforced concrete at various ages (7, 28 and 56 days) and at various percentages (0.5, 0.75 and 1%) polypropylene fiber by weight of cement. The following points were concluded:

- It is observed that out of three trials of 0.5%, 0.75% and 1% of polypropylene fiber, addition of 0.75% of polypropylene fiber resulted in maximum increase in compressive strength. However, there is not much change in the compressive strength with change in polypropylene fiber percentage.
- It is observed that out of three trails of 0.5%, 0.75% and 1% of polypropylene fiber, addition of 0.75% of polypropylene fiber resulted in maximum increase of split tensile strength. There is 13.87 increase in split tensile strength (28 days) when reinforced with 0.75% polypropylene fiber compared to conventional concrete.
- It is observed that out of three trails of 0.5%, 0.75% and 1% of polypropylene fiber, addition of 0.75% of polypropylene fiber resulted in maximum increase in flexural strength. There is 22.9% increase in flexural strength of concrete (28 days) when reinforced with 0.75% polypropylene fiber compared to conventional concrete.

Overall it is observed that addition of 0.75% of polypropylene fiber by weight of cement resulted in the maximum increase of strength of concrete.

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