International Journal of Applied Engineering Research
ISSN 0973-4562 Volume 10, Number 9 (2015) pp. 22627-22638

http://www.ripublication.com

Split Tensile Strength of Polypropylene Fiber Reinforced Fly ash Concrete

Dr.T.Ch.Madhavi[1], Mohan Reddy[2], K.Anjenayulu[3], A.Nagi Reddy[4], G.Karunakar Reddy[5]
1Professor and Head, Department of Civil Engineering, SRM University, Ramapuram, Chennai-89, tchmadhavi@yahoo.com
2,3,4,5 SRM University, Ramapuram

Abstract

Addition of polypropylene fibres to concrete helps in strengthening concrete and in protection of concrete against micro cracks. In this paper the 28 days split tensile strength of concrete cylinders cast using M30 grade concrete with partial replacement of cement with fly ash and reinforced with polypropylene fibres are presented. The polypropylene and flyash are added to the concrete of various proportion. Fly ash is used as Partial replacement of cement by 30%, 40%, 50%, and 60% and polypropylene fibers are used in 0.2%, 0.4%, 0.6% and 0.8% content. From the test results, it was observed that split tensile strength of concrete increases gradually by addition of Polypropylene fiber from 0.2% to 0.4 %. Beyond 0.4%, addition of polypropylene fibers decreased the Split tensile strength.

Key words: Concrete, Polypropylene Fibres, flyash, Split Tensile Strength.

Introduction

Now a days concrete plays an important role in construction industry. Concrete is a composite construction matrix made with cement, coarse and fine aggregates, water and admixture. Generally, Concrete can be designed and manufactured with high compressive strength. But its tensile strength has always been lower. To improve this property it is usually reinforced with materials that are good in carrying tension (often steel).

Concrete has many advantages such as high compressive strength, good fire resistance, high water resistance, low maintenance, and long service life. However, there are some disadvantages with regard to the strength and durability aspects such as compressive strength, split tensile strength, flexural strength, micro cracks, plastic and drying shrinkage cracks, chloride penetration etc . Also, concrete has low strain of fracture and formwork requirement. Concrete develops micro cracks during curing and these cracks propagate rapidly under applied loads forming larger cracks resulting in low tensile strength of concrete.

Hence to overcome this problem, fibers are included in concrete. The addition of fibers in the matrix has many important effects such as improved mechanical characteristics viz., superior fatigue and fracture strength, toughness, impact resistance, flexural strength, Improved fatigue resistance is one of the primary reasons for the extensive use of Polypropylene Fiber Reinforced Concrete (PFRC) in pavements, bridge decks, offshore structures and machine foundation, where the composite is subjected to cyclically varying load during its lifetime.

Fibers are usually used in concrete to control cracking due to plastic and drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibers produce greater strengths such as impact strength, abrasion and shatter resistance in concrete. Generally, fibers do not increase the flexural strength of concrete, and so cannot replace moment resisting or structural steel reinforcement. Indeed, some fibers actually reduce the strength of concrete

Advantages of Polypropylene

- Improve mix cohesion and pumpability over long distances
- Improve freeze-thaw resistance.
- Improve resistance to explosive spalling in case of a severe fire.
- Improve impact resistance.
- Increase resistance to plastic shrinkage during curing.

Experimental Investigations

In the present work, polypropylene fibers are used to improve the tensile strength of concrete. Hence, Split tensile strength test is conducted on concrete cylinders of 150 mm diameter and 300mm heights as per IS: 516 – 1959.

Mix design

A mix ratio of 1 : 1.1 : 2.0 is adopted with a w/b ratio of 0.36.

Materials

Cement

Ordinary Portland cement of 53 grade available in local market is used in the investigation. The cement used has been tested for various properties as per IS: 4031 and found to be confirming to the specifications of IS: 12269. The specific gravity of cement was 3.15 and the normal consistency is 35%.

Coarse Aggregate

Crushed angular granite metal of 20 mm and 12.5 mm size from a local source was used as coarse aggregate. The specific gravity of coarse aggregate used was 2.45.

Fine Aggregate

River sand conforming to Zone-III was used as fine aggregate. The specific gravity of the fine aggregate was 2.55.

Flyash

Fly ash has a high amount of silica and alumina in a reactive form. These reactive elements complement hydration chemistry of cement. The specific gravity of flyash is 2.2.

Polypropylene Fibre

A synthetic carbon polymer, is produced as continuous mono – filaments, with circular cross section that can be chopped to required length (or) tape of rectangular cross section (Fig. 1). Polypropylene fibres are tough but with low tensile strength and modulus of elasticity. Polypropylene fibers possess plastic stress-strain characteristics. Furthermore, their ability to cause interference with the capillary forces by which water bleeds to the surface of concrete reduces the risk of plastic settlement due to water evaporation. Micro synthetic fibres also increase resistance to spalling in fire situation. Specific gravity is 0.9.

Figure 1: Polypropylene fibers

Experimental Setup

The specimens for testing the polypropylene fibre reinforced concrete are prepared by direct pouring of concrete into moulds. For each concrete mixture, three specimens were cast in cylinder moulds of 150 x 300 mm. The cylinders were kept for 24hr in the mould at room temperature and then demoulded. The cylindrical specimens were kept in a curing tank for 28 days at room temperature until the time of testing. The specimens are then tested at 28 days.

The specimens are tested in a 200t compression testing machine. The cylinder is kept horizontally and load is applied with uniform rate. The load is applied until no greater load can be sustained. The maximum load resisted and the failure patterns are noted.

Figure 2: Split Tension Test

Results

Direct tension test of concrete is seldom made because of difficulties in mounting the specimens and uncertainties as to the secondary stresses induced by the holding devices. An indirect test for tensile strength of concrete developed originally in Brazil has been standardized by ASTM and is in general use. Accordingly, 3 specimens of cylindrical shape of diameter 150 mm and length 300 mm were tested under a Compression Testing Machine of 200t capacity under a compressive load across the diameter along its length till the cylinder splits.

The tension develops in a direction at right angles to the line of action of the applied load. The Split Tensile strength was calculated as follows:

Split Tensile strength (MPa) = $2P / \pi DL$

Where, P = Failure load,

L = Length of cylinder, and

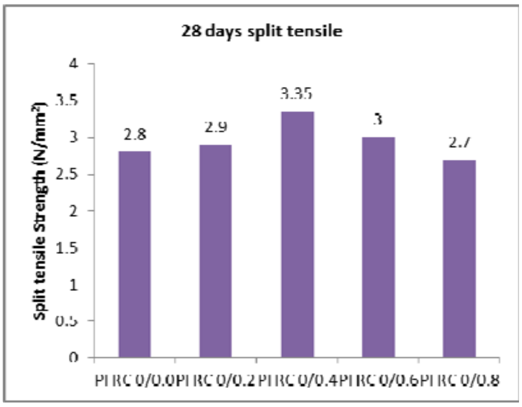
D = Diameter of cylinder

Results of tested cylindrical specimens for M30 grade of concrete are shown in Table 1.

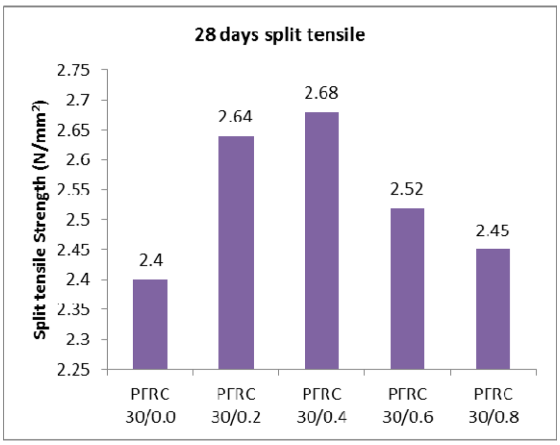
Table 1: Split tensile strength (N/mm^2)

Fibers → / Fly ash ↓	0%	0.2%	0.4%	0.6%	0.8%
0%	2.80	2.90	3.35	3.00	2.70
30%	2.40	2.64	2.68	2.52	2.45
40%	2.07	2.31	2.54	2.40	2.10
50%	1.80	1.83	2.12	2.05	2.00
60%	1.40	1.65	2.00	1.83	1.32

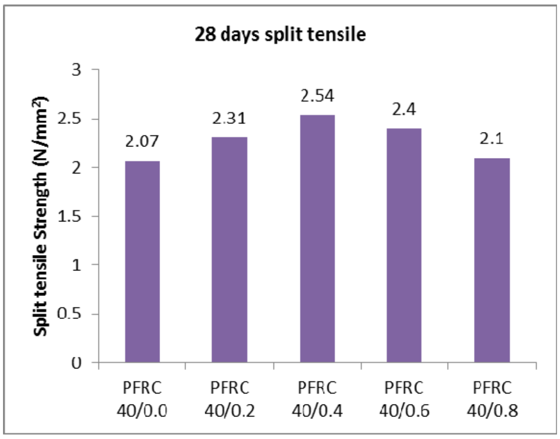
a) Effect of fibers



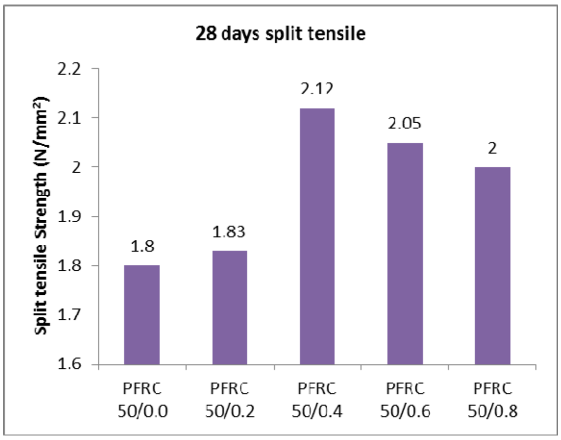
a) 0% Fly ash and fibers varying from 0 to 0.8%



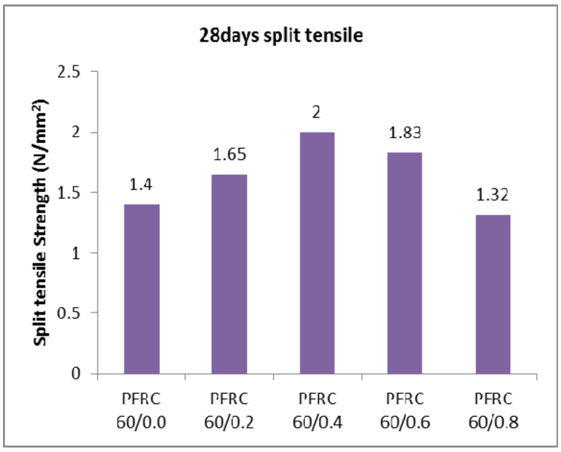
b) 30% Fly ash and fibers varying from 0 to 0.8%



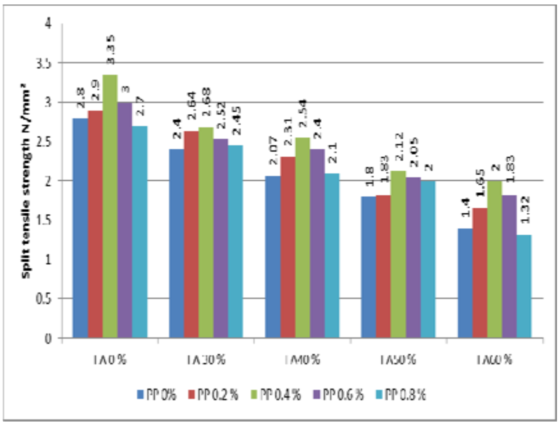
c) 40% Fly ash and fibers varying from 0 to 0.8%



d) 50% Fly ash and fibers varying from 0 to 0.8%



e) 50% Fly ash and fibers varying from 0 to 0.8%



f) Comparative results

Figure 3: Effect of fiber content on Split tensile strength of concrete

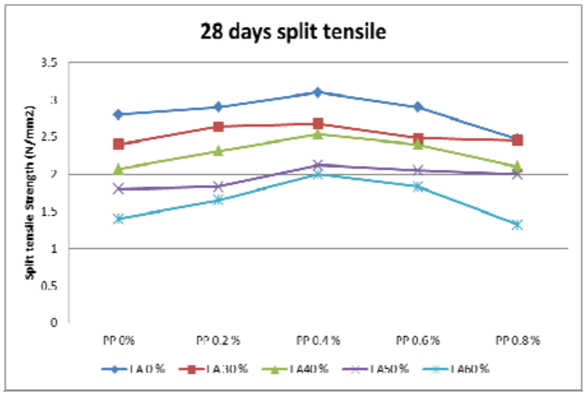


Figure 4: Effect of Fiber Content on Split Tensile Strength of Concrete

Fibers → **Fly ash ↓**	**0%**	**0.2%**	**0.4%**	**0.6%**	**0.8%**
0%	-	3.57	19.64	7.14	-3.57
30%	-	10	11.67	5	2.08
40%	-	11.59	22.71	15.94	1.45
50%	-	1.67	17.78	69.44	11.11
60%	-	17.86	42.86	30.71	-5.71

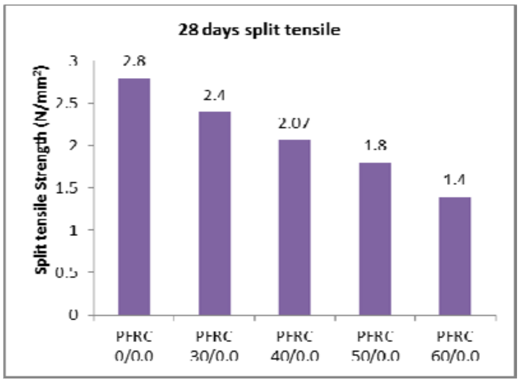
With addition of polypropylene content in fractions of 0.2%, 0.4%, 0.6% and 0.8%, the split tensile strength increased by 10%, 11.67%, 5% and 2.08% respectively when 30% fly ash content is used and increased by 11.59%, 22.71%, 15.94%, 1.45% respectively when 40% fly ash content is used.

When 50% fly ash content was used, the increase in split tensile strength is 1.67%, 17.78%, 69.44%, 11.11% for fiber fractions of 0.2%, 0.4%, 0.6% and 0.8% respectively while when 60% fly ash content was used, the increase in split tensile strength is 17.86%, 42.86%, 30.71% but for 0.8% fiber content there is a slight decrease of 5.71% in the split tensile strength.

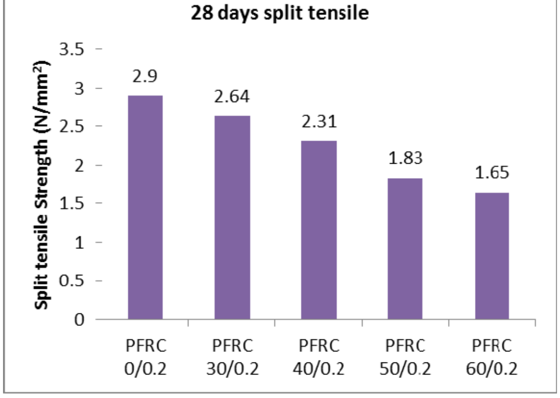
Thus it can be concluded from the graphs that the presence of polypropylene fibers increased the split tensile strength of concrete. As the fiber content increased, the split tensile strength increased for 0.2% and 0.4% fiber content but with further addition, the strength decreased. For 0.2% and 0.4% fiber content, the split tensile strength increased to a maximum of 17.86% and 42.86% respectively when 60% of cement is replaced by fly ash.

As the fiber content increased, the split tensile strength increased up to 0.4 % and beyond 0.4%, there is decrease in the split tensile strength of concrete for all mixes. The worst effect is observed at 0.8% fiber content. Hence it is advisable to use less than 0.4% fiber content for optimum increase in strength and not to adopt percentages as high as 0.8%.

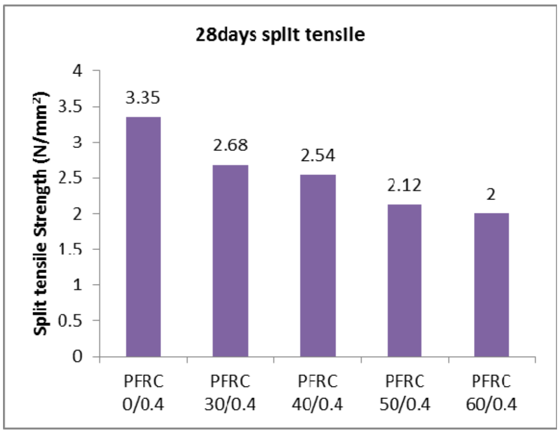
b) Effect of fly ash



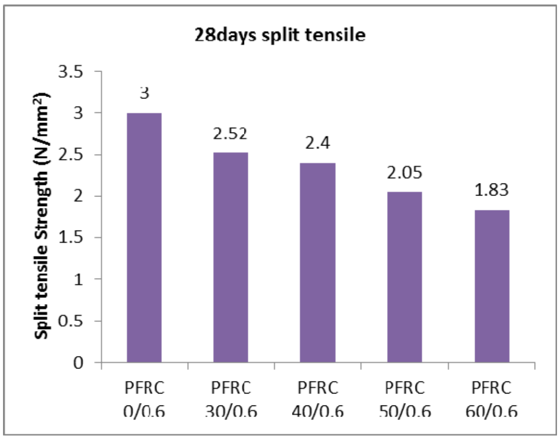
a) 0% Fibers and fly ash varying from 0 to 60 %



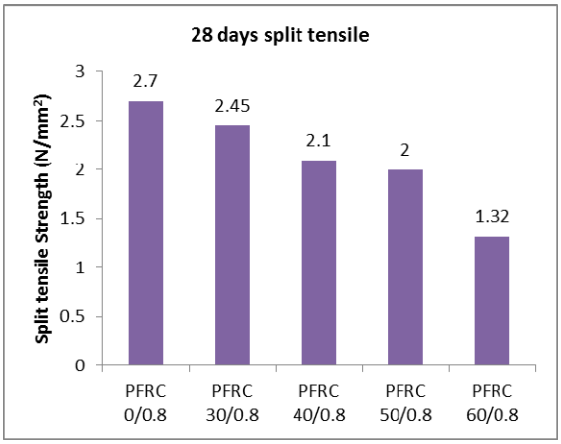
b) 0.2% Fibers and fly ash varying from 0 to 60 %



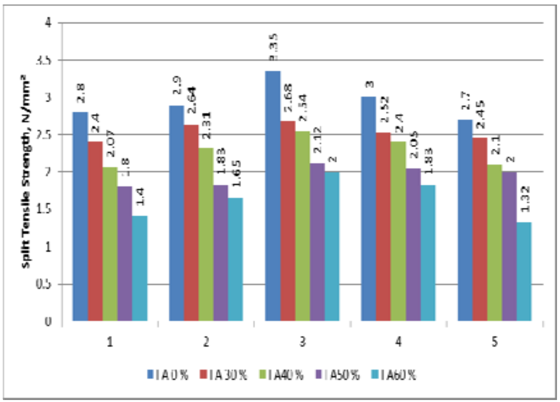
c) 0.4% Fibers and fly ash varying from 0 to 60 %



d) 0.6% Fibers and fly ash varying from 0 to 60 %



e) 0.8% Fibers and fly ash varying from 0 to 60 %



f) Comparative results

Figure 4: Effect of Fly Ash Content on Split Tensile Strength of Concrete

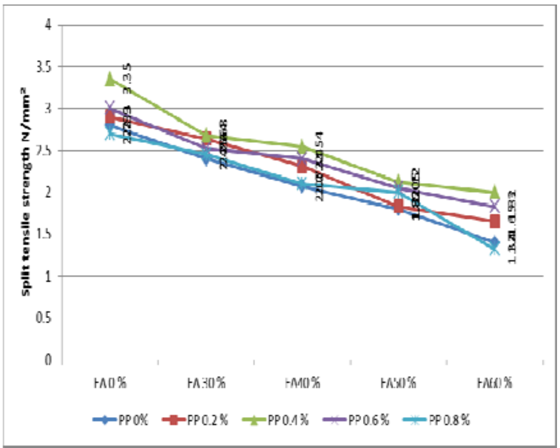


Figure 5: Comparison of Strength For Different Mix Proportions of Concrete and Fibers

Table 3: % Increase/Decrease of Split Tensile Strength With Increasing Fly Ash Content

Fibers → **Fly ash ↓**	**0%**	**0.2%**	**0.4%**	**0.6%**	**0.8%**
0%	-	-	-	-	-
30%	-14.3	-8.90	-20	-16	-9.3
40%	-26.1	-20.4	-24.2	-20.0	-22.2
50%	-35.7	-36.9	-36.7	-31.6	-25.9
60%	-50	-43.1	-40.3	-39.0	-51.1

The comparative results for split tensile strength of concrete cylinder with varying fly ash and polypropylene content is shown in Fig.5.

As the fly ash content increased in the percentages of 30%, 40%, 50%, 60% the split tensile strength decreased by 8.9%, 20.4%, 36.9% and 43.1% respectively for 0.2% fiber content and by 20%, 24.2%, 36.7% and 40.3% respectively for 0.4% fiber content.

When 0.6% fiber content was added for concrete with fly ash content of 30%, 40%, 50%, 60%, the split tensile strength continued to decrease by 16%, 20%, 31.6% and 39% respectively while for 0.8% fiber content the decrease was 9.3%, 22.2%, 25.9% and 51.1% respectively.

From the curves, it is evident that with addition of fly ash, the split tensile strength decreased. The loss of strength is 14.3% for 30% fly ash content and 50% for fly ash content of 60%. However, when 40 % fly ash was added with 0.4% fiber content the optimum strength is achieved.

Conclusion

From test results the Split tensile strength of concrete mixes made with and without fly ash and polypropylene fiber was determined at 28 days and from the observations the following conclusions are drawn.

- The split tensile strength increases with addition of polypropylene fibers.
- The split tensile strength increased with addition of fiber content of upto 0.4%.
- When higher volume fractions of fibers were included (0.6% and 0.8%), the strength started decreasing.
- With addition of fly ash content the split tensile strength of concrete was decreasing at 28 days age.

Acknowledgements

We are thankful to BHAVINI, DAE for supporting this project and encouraging us to carry out this research work at SRM University.

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