International Journal of Application or Innovation in Engineering & Management (IJAIEM)
Web Site: www.ijaiem.org Email: editor@ijaiem.org
Volume 6, Issue 8, August 2017 **ISSN 2319 - 4847**

Experimental Study on the Performance of PolypropyleneFiber Reinforced Concrete

Chetan C Patil[1], P. Shivananda[2]

[1]Research Scholar, School of Civil Engineering, REVAUniversity, Bengaluru, Karnataka, India

[2]Professor, School of Civil Engineering, REVAUniversity, Bengaluru, Karnataka, India

ABSTRACT

The present trend in concrete technology is towards increasing the strength and durability of concrete to meet the demands of the modern construction. Concrete is the most popular artificial material on earth, which is the single most widely used material.In this paper the effect of polypropylene fiber was studied with different percentages by conducting compression and split tensile test. Test results after 7 days and 28 days curing were recorded for the analysis. The study is mainly focused on the experimental work and it is expected to answer the question whether addition of polypropylene fibers will increase the compression and tensile strength.Laboratory test results showed that optimum dosage of polypropylene fibers for better compression and tensile strength was found to be 1.5% hence these fibers can be effectively used.

Key Words: Polypropylene fibers, Compressive Strength, Tensile strength, ductility

1. INTRODUCTION

The fracture of concrete as a result of fatigue is the most predominant cause of structural failure due to its low tensile strength. In an attempt to improve the tensile strength, the incorporation of fibers in concrete has been considered.Polypropylene fibers are new generation chemical fibers. Polypropylene fibers are manufactured in large scale and have fourth largest volume in production after polyesters, polyamides and acrylics [1]. Subsequently, the polypropylene fiber and is nowbeing used as short discontinuous fibrillated material for production of fiber reinforced concrete [1]. Further, the application of these fibers in construction increased largely because addition of fibers in concrete improves the tensile strength, flexural strength, toughness, impact strength and also failure mode of concrete.[1]

From the previous literatures we know that the use of fiber such as polypropylene and steel can have sufficient fire protection on the concrete structures [7, 8]. But minimal or even negative effects of polypropylene fibres on the residual performance of the heated concrete may also occur [9]. The initial moisture state of the concrete and the rate of heating may be the main parameters determining the effect of polypropylene fibres [10]. Therefore, there is necessity to quantify this claim in terms of the fibre dosage, the strengthof the concrete and most important is to know the residual mechanical properties of FRC under exceptional actions such as high temperature from fire. Following are some of the important properties of polypropylene fibers.

2. LITERATURE REVIEW

Over the years, in order to increase concrete's flexural behavior, ductility and energy absorption many researches were made and ongoing. As a result of past research FRC has been introduced which resulted in increased tensile strength, fatigue strength, and impact strength.

Nagabhushanam (1989) investigated the flexural fatigue strength of fibrillated polypropylene fiber reinforced concrete. The test program included the evaluation of flexural fatigue strength and endurance limit. The test results indicatedthat there is an increase in flexural fatigue strength.

Johnston and Zemp (1991) investigated the flexural performance under static loads for 9 mixtures. The results indicated that increasing in fibre content from 0.5% to 1.5% had a significant beneficial effect on the first crack strength despite the required W/C to meet workability requirements.

Bayasi and Ceilk (1993) investigated the effect of silica fume on the flexural strength of synthetic fiber-reinforced concrete. Two types of fibresviz, polypropylene fibres and polyester fibres were used with the amount of fibres ranged

from 0 to 0.6% by volume. Silica fume was used as partial replacement of OPC at 0, 5, 10 & 25%. The results indicated that polyester and polypropylene fibres have an inconsistent effect on the flexural strength but significantly increased the flexural toughness and the post-peak resistance of concrete.
Priti A. patelstudied that the compressive, split tensile and flexural strength will improve on addition of 1.5 % of polypropylene fiber in the concrete [5].

VinodKumar and Dr. M. Muthukannan have done experimental Investigations on Hybrid fibers using steel, glass and polypropylene fibres in different combinations to study the mechanical properties of Hybrid Fiber Reinforced Concrete as compared to the conventional concrete.

Kumar conducted experimental work on M15, M20 and M25 grade fly ash concrete reinforced with 0%, 0.5% and 1% polypropylene fibers. From the experiments it was concluded that compression strength increase for all the three grades used upto 1% addition of polypropylene fiber content.

Mehul and Kulkarni conducted experiments using fibrillated polypropylene fiber of length 12mm and diameter 34 micron and low density of 0.9 kN/m3, in percentages of 0.5%, 1% and 1.5% in high strength concrete. They found that the compressive strength of concrete increased with addition of fibers [2].

3. MATERIAL PROPERTIES AND MIX PROPORTIONS

3.1 Physical Properties of Cement

Various tests were conducted to determine the physical properties of cement as per BIS and the results are listed in Table 1.

Table 1: Test results for cement

Properties	Values
Specific Gravity	3.12
Normal Consistency	34%
Initial Setting Time	29 mins
Final Setting Time	600 mins
Fineness of Cement	8%

3.2 Test Results for Aggregates

Table 2: Test results for aggregate

Properties	Fine Aggregate	Coarse Aggregate
Specific Gravity	2.64	2.76
Fineness modulus of sand	2.91	8.26
Moisture Content	1.06%	2.60%

3.3 Mix Proportion Selected

The concrete mix is designed as per IS method to determine the relative proportions to produce the concrete which will have desirable workability, strength and durability.

Table 3: Mix Proportion

Cement	Fine Aggregate	Coarse Aggregate	Water
513	674.74	1300.81	186
1	1.31	2.5	0.36

4. THE EFFECTS ON THE CONCRETE PROPERTIES

Some of the present test methods used now may not accurately describe the behavior of fiber reinforced concretes in the field. Based on the studies done the effects of polypropylene fibers on fresh and hardened concrete are described here.

4.1 Influence on the Properties of Fresh Concrete

Polypropylene fibers tend to hold the concrete mix together. This slows the settlement of coarse aggregateand thus reduces the rate of bleeding. A slower rate of bleeding means a slower rate of drying andthus less plastic shrinkage cracking. According to tests by Zollo [12] polypropylene fibers reducedshrinkage of plain concrete specimens by about 75 percent.When polypropylene fibers are used in concrete as secondary reinforcement,they are added in such low levels (0.1 to 0.2 percent by volume) that the reduction in workabilityis small, despite significantchanges in slump. Because fibers affect the slump of concrete muchmore than they do its actual workability. Polypropylene fiber reinforced concrete is reported to respond well to vibration. It flows satisfactorily when kept moving, and segregation is reduced. Special attention should be given to good vibration. To improve workability even more air entraining agents can be increased.

4.2 Effects on the Properties of Hardened Concrete

In hardened concrete, polypropylene fibers will mitigate the cracks. Like any secondary reinforcement, by increasing bond with concrete, cracks will be minimised and it will not allow any cracks to spread wider.The fibers thus form a sort of three dimensional reinforcement that distributes tensile stresses more evenly throughout the concrete. Flexural strength and tensile strength are also improved, each about 10 percent. The compressive strength of concrete that has undergone its potential drying shrinkage is about the same for concrete with or without polypropylene fibers. The ductility of concrete is said to be improved, too, because of polypropylene's low modulus of elasticity.

5. MATERIALS USED FOR THE STUDY

The materials used are cement, coarse aggregate sand as fine aggregate, water and polypropylene fibres.

- Cement: Ordinary Portland cement of 53 Grade
- Fine Aggregate (sand): Locally available zone II sand with specific gravity 2.6 confirming with code book IS 393-1970.
- Coarse Aggregate: Crushed stone of 10mm size having specific gravity 2.76 confirming code book IS 393- 1970.
- Water: Potable water for Experiments.
- Polypropylene fibers

6. EXPERIMENTAL PROGRAM

Experimental work is carried out to study the variations in compressive strength and split tensile strength after addition of polypropylene fibers. In this study M-30 grade concrete was used and percentages of fiber added was chosen on the basis of previous work and extensive literature study, percentages of fibers used is 0.5, 1.0, 1.5, 1.2. Specimens were tested after 7 days and 28 days curing period for both compression strength and split tensile strength.

6.1 Compressive Strength Test

Compressive strength of concrete is one of the most important properties of concrete which is a qualitative measure of concrete. Cubes of 150X150X150 mm size were tested for compressive strength and test results after 7 days and 28 days curing were recorded. The setup is shown in Fig.1

Figure1 Compressive strength test

6.2 Split tensile strength test

Tensile strength is one of the basic and important properties of concrete which is required for the design of concrete structural elements. Split tensile strength test is an indirect method of testing tensile strength of concrete. In the present study cylinders of 150mm diameter and 300mm height were used and test results after 7 days and 28 days curing were recorded. The test setup is shown in the Fig.

Figure 2 Splitting tensile test

7. RESULTS AND DISCUSSIONS

7.1 Compressive Test Results

Table 4shows the results from the compressive test for cubes which have been cured for 7 days and 28 days. The graphical representation from the results in Table 4 is shown in Fig 3

Table 4: Compressive Strength Test Results

Fiber Dosage	Compression Strength (N/mm2)	
	7 days curing	28 days curing
0%	28.4	41.4
0.50%	29.82	42.72
1%	34.64	46.52
1.50%	40.12	50.23
2%	39.78	49.13

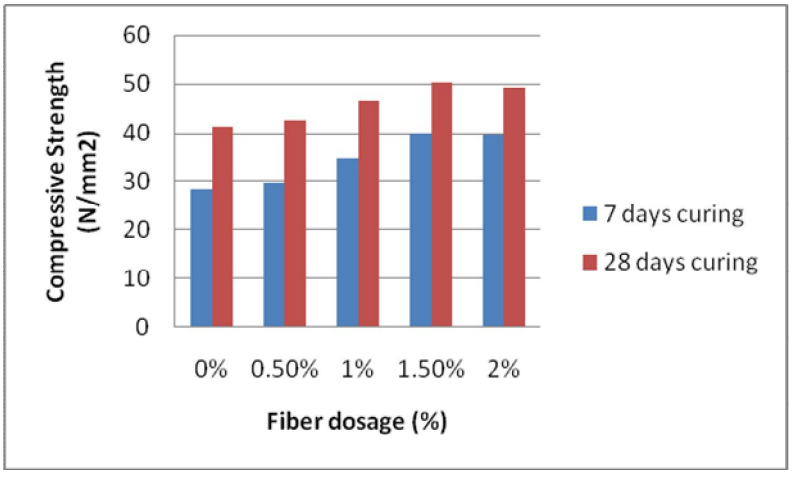

Figure 3 Graphical Representations of Compressive Strength Test Results

7.2 Split Tensile Strength Test Results

Table 5shows the results from the split tensile test for cylinders which have been cured for 7 days and 28 days. The graphical representation from the results in Table 5 is shown in Fig 4

Table.5: Split Tensile Test Results

Fiber Dosage	Split Tensile Strength(N/mm2)	
	7 days curing	28 days curing
0%	2.76	3.63
0.50%	2.81	3.82
1%	2.92	3.94
1.50%	3.13	4.32
2%	2.99	4.03

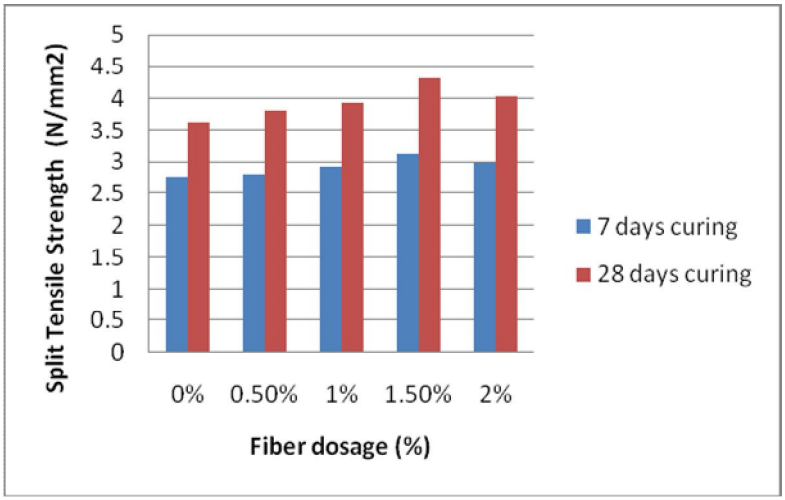

Figure 4 Graphical Representation of Split Tensile Strength Test Results

8. CONCLUSION

From the experimental work done using polypropylene fibers in concrete it can be concluded that, optimum dosage of fiber for improved compressive and split tensile strength is 1.5 due to increased bond between concrete and fibers. At 2 percent dosage strength reduced by 5 percent. With the addition of fibers crack width reduced in FRC beams hence polypropylene fibers can be used as a reinforcing material with a known dosage.

REFERENCES

[1] Peng Zhang and Qingfu Li (2013) 'Fracture Properties of Polypropylene Fiber Reinforced Concrete Containing Fly Ash and Silica Fume', Research Journal of Applied Sciences, Engineering and Technology 5(2): 665-670, 2013.
[2] Mehul J. Patel, S. M. Kulkarni (2012-2013) 'Effect of Polypropylene Fibre on The High Strength Concrete', Journal of Information, Knowledge And Research in Civil Engineering Volume 2, Issue 2, Page 127.
[3] Thirumurugan.S, Siva Kumar.A (2013), 'Compressive Strength Index of Crimped Polypropylene Fibers in High Strength Cementitious Matrix' World Applied Sciences Journal, 2013, 24 (6), 698-702
[4] Gencel, Ozel, Brostow and Martinez (2011) 'Mechanical Properties of Self-Compacting Concrete Reinforced with Polypropylene Fibres', Materials Research Innovations 2011 VOL 15 NO.
[5] Priti A. Patel., Dr.Atul K. Desai., and Dr.Jatin A. Desai., "Evaluation Of Engineering Properties for Polypropylene Fibre Reinforced Concrete", International Journal of Advanced Engineering Technology, Vol. 3, Issue 1, January-March 2012, pp. 42-45.
[6] VinodKumar.M, Muthukannan.M. 2014 Experimental Investigation on Mechanical Properties of Hybrid Fiber Reinforced Concrete, In Proceedings of International Conference ACECIM'14, SRM University, Ramapuram, pp. 597-.602.

[7] A. Nishida & N. Yamazaki (1995)." Study on the Properties of High Strength Concrete with Short Polypropylene Fibre for Spalling Resistance". Proceedings of the International Conference on Concrete under Severe Conditions (CONSEC'95). Sapporo, Japan. August.E&FN Spon, London, pp: 1141-1150.

[8] P. Kalifa, G, Chene& Ch. Galle (2001)."High-Temperature Behaviourof HPC with Polypropylene Fibres from Spalling to Microstructure".Cement& Concrete Research. 31, pp: 1487-1499.

[9] Y.N. Chan, X. Luo W. Sun (2000)."Compressive Strength and Pore Strucutre of High Performance Concrete after Exposure to HighTemperature up to 800 C".Cement& Concrete Research. 30, pp: 247-251.

[10] X. Luo, W. Sun & S.Y.N Chan (2000)."Effect of Heating and Cooling Regimes on Residual Strength and Microstructure of Normal Strengthand High Performance Concrete".Cement& Concrete Research. 30, pp: 379-383.

[11] V. Prabhakaran, M. Lingaeswari (2017).)."Experimental Study on Polypropylene Fiber Reinforced Concrete with Mineral Admixtures". International Journal of Civil Engineering and Technology.Volume 8, Issue 5, May 2017, pp. 01–07

[12] Zollo, Ronald F., "Collated Fibrillated Polypropylene Fibers in FRC," presented at ACI International Symposium on Fiber Reinforced Concrete, Detroit, Michigan, September 23, 1982.