

Effects of Polypropylene Fibers on Normal Strength Concrete

¹A. Annadurai, ²A.Ravichandran,

¹Assistant Professor, Department of Civil Engineering, Sathyabama University,
Chennai-119, India

annadurai_1972@yahoo.co.in

²Director, Christ College of Engineering and Technology, Pondicherry-10, India

Abstract

The present study investigated the effect of polypropylene fibers in the Normal strength concrete. Polypropylene fibers were added in the Normal strength concrete of grade M25 with the volume fraction of 0.5%, 1% and 1.5%. The mechanical properties such as compressive strength, splitting tensile strength and flexural strength of normal strength concrete and polypropylene fiber reinforced concrete have been investigated. The results shown that the addition of polypropylene fiber in normal strength concrete has a little effect on the compressive strength, splitting tensile strength increased up to 1% but it was very less value, and Modulus of rupture was increased with increase in fiber volume fraction up to 1%, The strength effectiveness was 45.83% compared with Normal Strength Concrete.

Key words: Concrete, Polypropylene fiber, Strength, Cracks.

Introduction

Concrete is known to be a brittle material when subjected to tensile stresses and impact loads, concrete members are unable to withstand such loads and stresses that are usually encountered by concrete structural members. Usually, concrete members are reinforced with continuous reinforcing bars to withstand tensile stresses and to compensate for the lack of ductility and strength. The addition of steel reinforcement to concrete significantly increases its strength, but to produce a concrete with homogenous tensile properties and better micro cracking behavior, fibers are advantageous [1-2]. The introduction of fibers in concrete has brought a solution to develop a concrete having enhanced flexural and tensile strength, which are a new form of composite material. At the micro-level, fibers inhibit the initiation and growth of cracks Polypropylene is a relatively modern product with a large molecule built up by a repetition of small, simple chemical units until a polymer chain is formed.

Polypropylene fibers as a secondary reinforcement, now days are being used extensively throughout the world in all types of constructional concrete Firstly, they have been proven as an effective method of controlling troublesome shrinkage in concrete [3-4]. In this study Mechanical properties of normal strength concrete with polypropylene fiber were studied from 0 to 1.5% Volume fractions.

Experimental Programs

Materials

Ordinary Portland Cement (OPC) 53 grade is used for this study program, locally available River sand was used as fine aggregate. The specific gravity and water absorption were found to be 2.73 and 2.5% respectively; 20 mm size graded coarse aggregate was used, the specific gravity and water absorption were found to be 2.85 and 1.0% respectively. The aggregates properties were confirmed to the requirement as per IS: 383 – 1970. Polypropylene is a Mono filament fiber, which are produced from 100% virgin mono-polymer polypropylene, comply with the requirements of ASTM - C1116 and are developed as a crack - controlling additive for cementations materials. It is available as monofilament 20 mm in length for concrete reinforcement and 6 mm and 12 mm in length for plaster and mortar. Polypropylene fibers are true monofilaments that totally disperse into the concrete mixing when added at the batch plant or at the job site. Fibers used in the study were given in Figure 1. Properties of fibers are given in Table 1. Mix design was carried out using IS 10262 recommended guidelines [5]. The proportions of materials are shown in Table 2.



Figure 1: Polypropylene fibers

Table 1: Technical Properties of Polypropylene fiber

Appearance	Natural White
Specific gravity	0.91 g/cm ³
Diameter (din 53816)	40 microns and higher
Tensile strength	350 MPA
Melting range	160°C - 165°C
OPU	0.5% (Method, Henkel)
Crimp waves /cm	0 crimps/cm
Thermal conductivity	Low
Electrical conductivity	Low
Salt, acids and alkaline resistance	High

Table 2: Mix proportions for 1m³ of concrete

cement	383 kg
Fine aggregate	760.54 kg
Coarse aggregate	1096 kg
water	191.6 kg

Casting of specimen

The specimens were cast for this study by using Cube mould of size 150 mm, the 150 mm diameter, 300 mm length cylinder mould, and the 100 x100 x 500 mm prism mould for testing of compressive strength, Splitting tensile strength and Flexural strength. First Ordinary concrete of Grade M25 specimens were cast next the polypropylene fiber specimens were prepared by using 0.5%, 0.1%, and 1.5 % of fiber by volume of the mix. In this mixing process first the coarse and fine aggregate was mixed thoroughly in dry form for 1min. The cement was added next after dry mixing for 1min then water was added and mixed for 2 min. after this process the calculated amount of fibers were added to the wet concrete. The mixture was mixed for another three minutes to confirm that the fibers were uniformly distributed into the concrete. The concrete was placed into the moulds with proper compaction. The moulds were demoulded after 24 hours, and the specimens were allowed to cure in the curing tank. In this study each parameter three specimens were cast. The entire test was carried out after the specimens were cured for 28 days.

Testing procedure

Compression testing machine of capacity was 200 T used at Concrete Technology Laboratory in Department of Civil Engineering. For testing the compressive strengths of cube of specimens at 28 days from casting were conducted as per the Code

provision of IS 516–1959 (reaffirmed 1999). The splitting tensile strengths of cylinder specimens, was conducted in accordance with ASTM C 496, and flexural strength of prisms at 28 days from casting in accordance with ASTM C 78 [5-6].

Test Results and Discussion

Compressive Strength

The compressive strength of cube for Normal strength concrete and polypropylene fiber concrete with various volume fractions are shown in Table.3. Addition of polypropylene fiber in Normal strength concrete improved the compressive strength of concrete in 0.5% volume fraction only; the strength effectiveness was 4.27%. After that the compressive strength was decreased. The effects of polypropylene fibers in concrete compared with the compressive strength of Normal strength of plain concrete were plotted as bar chart as shown in Figure 2.

Table 3: Compressive strength results

S. No.	Volume fraction V_f (%)	Average Ultimate Load (kN)	Compressive Strength N/mm^2	Strength Effectiveness (%)
1	0.0.	642.5	28.56	
2	0.5	670	29.78	4.27
3	1.0	593	26.35	-7.73
4	1.5	563	25.02	-12.39

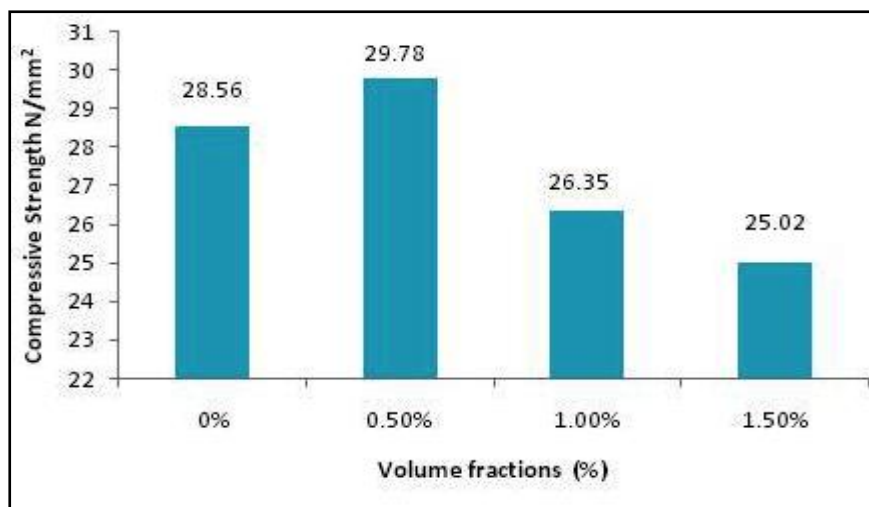


Figure 2: Effects of fiber in compressive strength

Splitting tensile strength

Test results of splitting tensile strength of concretes are shown in Table 4. The splitting tensile strength of concrete is increased by adding of polypropylene fiber up to 1.0% volume fraction, the strength effectiveness is 4.83% compared with normal strength concrete. Effects of fiber in concrete were as shown in Figure. 3.

Table 4: Splitting tensile strength results

S. No.	Volume fraction V_f (%)	Average Ultimate Load KN	Splitting tensile Strength N/mm ²	Strength Effectiveness (%)
1	0.0.	205	2.9	
2	0.5	210	2.97	2.41
3	1.0	215	3.04	4.83
4	1.5	208	2.94	1.37

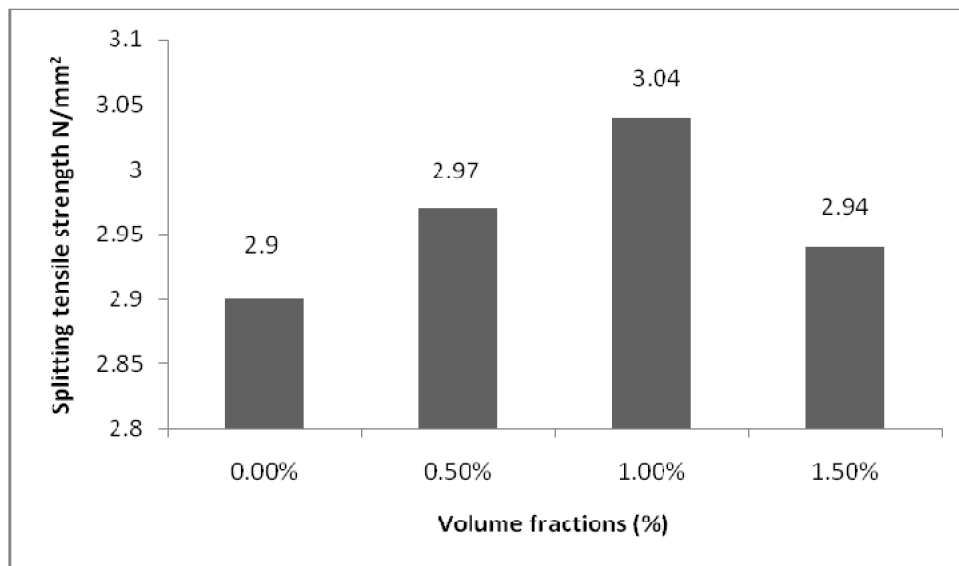


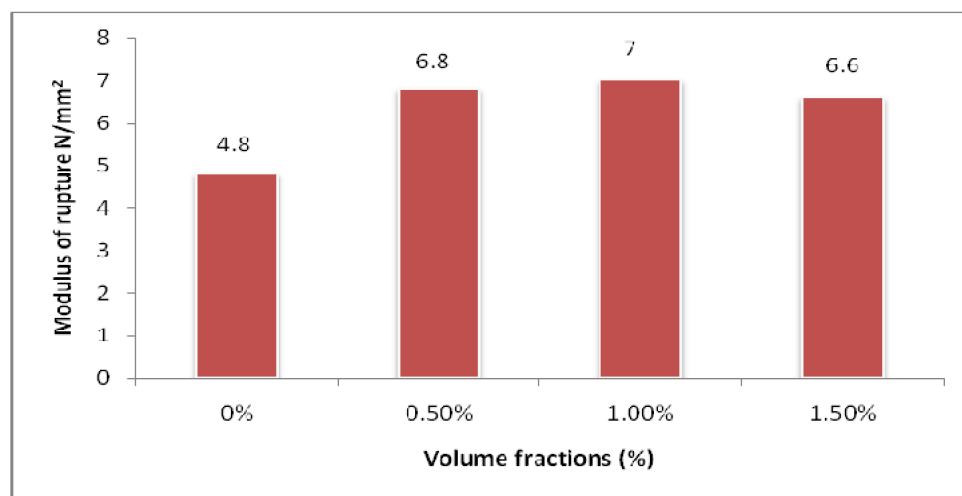
Figure 3: Effects of fiber in splitting tensile strength

Flexural strength

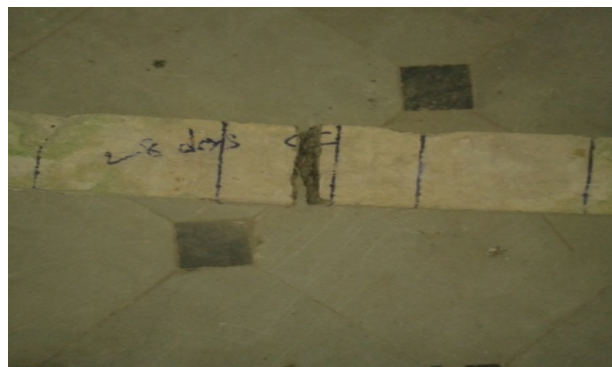
The modulus of rupture of normal strength concrete, polypropylene fiber reinforced test results are shown in Table 5. It Indicate that the 1.0% volume fraction of polypropylene fiber reinforced concrete gave more strength, strength effectiveness is 45.83% compared with the normal strength concrete. The results were plotted as bar chart for comparison shown in Figure 4.

Table 5: Flexural strength results

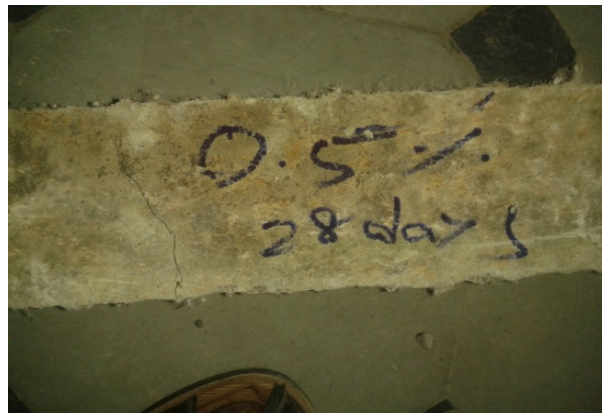
S. No.	Volume fraction V_f (%)	Average Ultimate Load (kN)	Modulus of rupture N/mm^2	Strength Effectiveness (%)
1	0.0	12	4.8	
2	0.5	17	6.8	41.6
3	1.0	17.5	7	45.83
4	1.5	16.5	6.6	37.5

**Figure 4:** Effects of fiber in Flexural strength**Crack patterns of specimens**

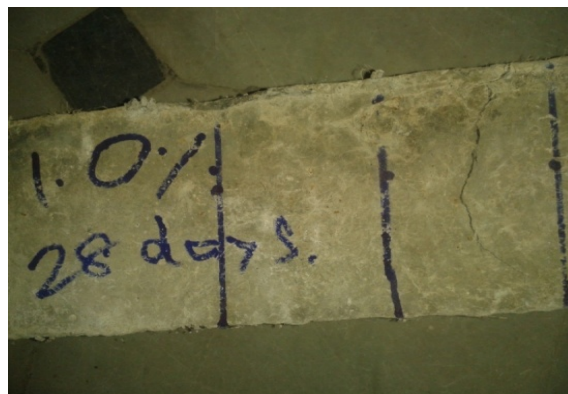
Plain normal strength concrete was failed suddenly and the specimen was broken into two pieces at ultimate load, Polypropylene fiber concrete specimens were withstand the load even after initial cracks were formed and brings about a reduction in crack width and number of cracks as shown in Figure 5.



Plain concrete sample after testing



Volume Fractions- 0.5% Polypropylene Specimen after testing



Volume fractions-1.0 % Polypropylene specimen after testing



Volume fractions-1.5% Polypropylene specimen after testing

Figure 5: Crack patterns of Specimens

Conclusions

The aim of this study has been to investigate the properties of concrete by adding polypropylene fiber.

The testing on compressive strength of polypropylene fiber concrete strength was increased in 0.5% of volume of fraction after that the strength was decreased.

The splitting tensile strength testing strength of polypropylene fiber concrete strength was increased up to 1.0%, and decreased in 1.5 % of volume of fraction.

The testing on flexural strength of polypropylene fiber concrete strength was increased up to 1.0% of volume of fraction after that flexural strength was decreased, but addition of fibers increased the modulus of rupture compared with normal strength concrete.

Polypropylene fiber concrete brings about a reduction in crack width and number of cracks. Polypropylene fiber concrete is a reliable and effective technique for strengthening of flexural members.

As per the test results understand that the flexural strength of polypropylene fiber concrete beam is much more than the strength of conventional concrete beam.

References

- [1] Roohollah Bagherzadeh, 2012, "An Investigation on Adding Polypropylene Fibers to Reinforce Lightweight Cement Composites (LWC)" *Journal of Engineered Fibers and Fabrics* Volume no 7, issue-4 Page No: 13 to 21
- [2] N. Banthia, M. Sappakittipakorn, 2007, "Toughness enhancement in steel fiber reinforced concrete through fiber hybridization" *Cement and Concrete Research* 37, 1366-1372.
- [3] Machine Hsie, "Mechanical properties of Polypropylene hybrid fiber – reinforced concrete" *Materials Science and Engineering A* 494, 153-157
- [4] Saeid Kakooei, 2012, "The effects of Polypropylene fibers on the properties of reinforced concrete structures" *Construction and building materials* 27, 73-77
- [5] I.S. 10262 "Concrete Mix Proportioning – Guidelines" BIS. New Delhi.
- [6] M.S. Shetty, "Concrete Technology Theory and Practice", Reprint-2005 Publishers S.Chand and Company Ltd., New Delhi.
- [7] A. Annadurai, A. Ravichandran, 2012, "Investigation on Mechanical Properties of Hybrid fiber reinforced high strength concrete" *International Journal of Engineering Research and Technology*. Vol-1(02), ISSN 2278-0181
- [8] A. Ravichandran, K. Suguna and P.N. Ragunath, 2008, "Mechanical properties of High – Strength Concrete with Hybrid fiber reinforcement" *International Journal of Applied Engineering Research* ISSN 0973 -4562 Volume 3, Number (6). PP.829-836.
- [9] Saje, D., Bandelj, B., Sustersic, J., Lopatic, J., and Saje, F. 2011, "Shrinkage of Polypropylene Fiber-Reinforced High-Performance Concrete" *volume no 3 issue 7P.No. – 941 to 952*