SAHYADRI International Journal of Research, Vol. 3, Issue 2, 2017
ISSN: 2456-186X, Published Online December, 2017 (http://www.sijr.in/)

Research Paper

Experimental study on hardened properties of concrete by using polypropylene fibre as additive

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Abstract

This paper describes a study of behavior of polypropylene fibre reinforced concrete in the modern construction industry. The study of the influence of addition of polypropylene fibres at increasing dosage from 0.5% to 2.5% of total weight of cement was carried out. Its use in concrete makes effective utilization of tensile and flexural strength of the material along with reduction of plastic shrinkage cracking and thermal cracking. Experiment was done using M-30 mix and Compression test; Split Tensile test and Flexural Strength test were carried out at 7 and 28 days as per standard procedures by relevant codes. The result was compared with conventional concrete and it was observed that concrete with 1.5% by weight of polypropylene fibre as additive, showed highest strength of concrete with decreased self weight. The strength decreased gradually with further increase in percentage of polypropylene fibre.

Keywords: Polypropylene fibre, compressive strength test, split tensile test, flexural test.

1 Introduction

The consumption of concrete is increasing day by day all over the globe since it is the most important building material. Combination of high strength along with stiffness and thermal resistance effectively results in the use of fibres. The compressive strength and splitting tensile strength increases with the increase in percentage of polypropylene fibres [1]. Researchers have comparatively studied the use of polypropylene, recron and steel fibres in concrete and have found good results with polypropylene fibres [2]. It was studied by researchers that the increase in compressive strength is due to percentage of fibre and aggregate bonding and is not due to cement paste bonding. The fibres act as anchors between the cement paste and the fine and coarse aggregates which help in increasing the durability of concrete [3]. Concrete is a widely used construction material. It also replaces the old construction materials such as brick and stone masonry [4]. Polypropylene is lightest fibre and its bulk density is less; so it will have a positive effect on the strength of concrete. The properties of concrete such as compressive strength and split tensile strength are higher than that of the conventional mix. The study showed that polypropylene fibre could be very conveniently used in structural concrete and will result in considerable amount of decrease in micro cracking of concrete [5]. In recent years due to high pollution and climatic changes, there is a greater need in finding more environmental friendly practices out of which the use of polypropylene fibre with concrete can be one of the best solutions. This study is based on behaviour of polypropylene fibre. There was no mechanical mixer; neither any type of chemical admixture was used in the study.

Figure 1: Micrograph of polypropylene fibre.

The use of polypropylene reinforced concrete results in the improvement of all properties related with cracking, such as tensile strength, flexural strength, shear strength, stiffness, ductility, and the resistance to freeze-thaw damage, impact and fatigue. The property of fibres has following effects on the behaviour of hardened concrete.

a. There will be greater increase in tensile strain and ultimate strain in fibre added concrete than the plain concrete.

b. The fibres provide a well-defined post-cracking behavior to the concrete.

c. It offers high increase in ductility and greater energy absorbing capacity (higher toughness) to the concrete before undergoing failure. Figure 1 shows a micrograph of polypropylene fibre.

The concrete is good in compression but weak in tension because concrete is a brittle material. So, in order to improve their properties, polypropylene fibre is used. Effects of Polypropylene fibre on compressive, tensile and flexural performance of cubes, cylinders and beams were investigated in this study. The objective of the study is:
a. To add the polypropylene fibre at 0.5%, 1%, 1.5%, 2%, and 2.5% of weight percent of cement for M30 grade concrete and to study its effect on concrete.
b. To find optimum percentage of polypropylene fibre as additive in concrete that results concrete to gain more strength.

2 Experimental procedure

Various tests were conducted on cement, fine aggregate and coarse aggregate as per the suitable code provisions and the experimental results are tabulated in Tables. Mix design of concrete for M-30 grade was carried out as per IS 10262:2009 and the results are tabulated in Tables 1,2 and 3.

Table 1: Test results on coarse and fine aggregate.

Test	Coarse Aggregate	Limit	Fine Aggregate	Limit
Fineness modulus	7.2	6.5 to 8	2.44 (zone 2)	2.2 to 2.4
Specific gravity	2.69	2.75	2.58	2.75
Water absorption	0.37%	0.60%	1.69%	2%

Table 2: Test results on Cement.

Sl. No.	Test	OPC 43 Grade cement
1	Fineness	9%
2	Specific Gravity	3.15
3	Standard consistency	31%
4	Initial setting time	34 min
5	Final setting time	486 min

Table 3: Mix Proportion for M-30 grade concrete

Grade of concrete	Cement	Fine aggregate	Coarse Aggregate	W/C ratio
M 30	1	1.576	2.8	0.45

One trial each for 7 and 28 days curing was taken for compressive and split tensile strength test. And one trial each 7 and 28 days was taken for flexural strength test. The concrete materials were weighed and kept ready as per calculations. The Polypropylene fibre is soaked in water prior to addition with the concrete in order to soak in water so that it does not absorb water from the mix. First thorough dry mixing of concrete materials is carried out followed with addition of water as per design. Then polypropylene fibre is added and mixed thoroughly until uniform composite is obtained. Mechanical concrete mixer along with super-plasticizer is preferable in order to obtain a better homogeneous mix. The concrete mix is then poured into moulds kept ready followed with ramming with standard rod in layers and leveling the surface after placing moulds on vibrating table. Later all the moulds are placed in a level surface floor without disturbance.

The specimens of concrete are taken out of moulds after twenty four hours, numbered for identification and then placed for curing. Corresponding to 7 and 28 days of curing, the cubes, cylinders and beams are taken and then tested in testing machines and the results are tabulated. Once after all the trials are completed, graph is plotted to find out the optimum results. Then variation in results is studied comparing with the normal concrete. With the variation in results, the conclusion is then reported.

3 Results and discussion

The results obtained on the addition of fibre in concrete cured for 7 and 28 days are given in Tables 4 and 5. Table 4 shows variation of density with increasing fibre content and Table 5 shows variation of compressive strength with increasing fibre content.

Table 4: Variation in density for 7 and 28-days with increasing of fibre content.

% of fibre added	7-days		28-days	
	Density (kN/m^3)	Increase or decrease in density (%)	Density (kN/m^3)	Increase or decrease in density (%)
0	24.12	0	24.49	0
0.5	24.1	-0.083	24.32	-0.699
1	24.05	-0.291	24.25	-0.99
1.5	23.9	-0.92	24.2	-1.2
2	23.7	-1.772	24	-2.04
2.5	23.65	-1.987	23.46	-4.4

Table 5: Variation in compressive strength for 7 and 28 days with increasing fibre content.

% of fibre added	7-days		28-days.	
	Compressive Strength (MPa)	Increase or Decrease in compressive Strength (%)	Compressive Strength (MPa)	Increase or Decrease in compressive Strength (%)
0	48.44	0	52	0
0.5	52.15	7.11	57.04	8.83
1	55.7	13.03	62.07	16.22
1.5	61.33	21.01	68.3	23.86
2	58.96	17.84	65.19	20.23
2.5	40.3	-20.198	45.33	-14.71

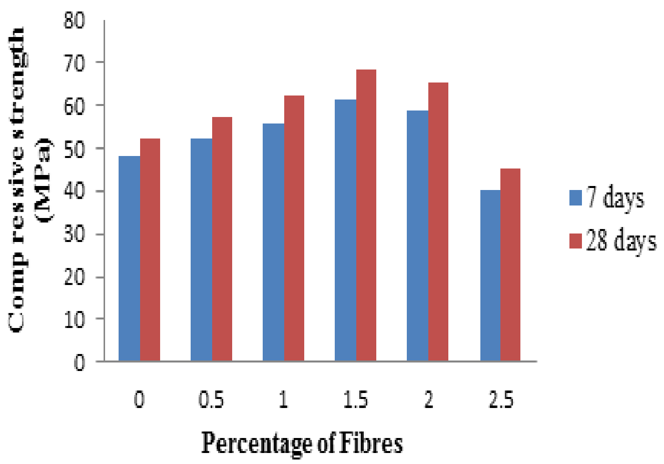

Figure 2: Variation in compressive strength with increasing fibre content.

Figure 2 shows variation in compressive strength with increasing fibre content. The dependence of density on increasing fibre content for 7 and 28 days curing is given in Table 6. Variation of split tensile strength with increasing fibre content for 7 and 28-days curing is given in Table 7.

Table 6: Variation in density for 7 and 28-days curing with increasing fibre content.

% of fibre added	7-days		28-days	
	Density (kN/m^3)	Increase or Decrease in density (%)	Density (kN/m^3)	Increase or Decrease in density (%)
0	24.24	0	24.4	0
0.5	23.86	-1.592	24.02	-1.582
1	23.64	-2.538	23.74	-2.78
1.5	23.45	-3.368	23.64	-3.214
2	23.39	-3.634	23.42	-4.184
2.5	23.14	-4.753	23.3	-4.721

Table 7: Variation in split tensile strength for 7 and 28-days curing with increasing fibre content.

% of fibre added	7-days		28-days	
	Split tensile strength (MPa)	Increase or Decrease in split tensile strength (%)	Split tensile strength (MPa)	Increase or Decrease in split tensile strength (%)
0	3.4	0	3.87	0
0.5	3.44	1.162	3.91	1.023
1	3.49	2.578	4.1	5.6
1.5	3.54	3.954	4.15	6.746
2	3.02	-12.582	3.54	-6.779
2.5	2.69	-26.394	3.35	-15.522

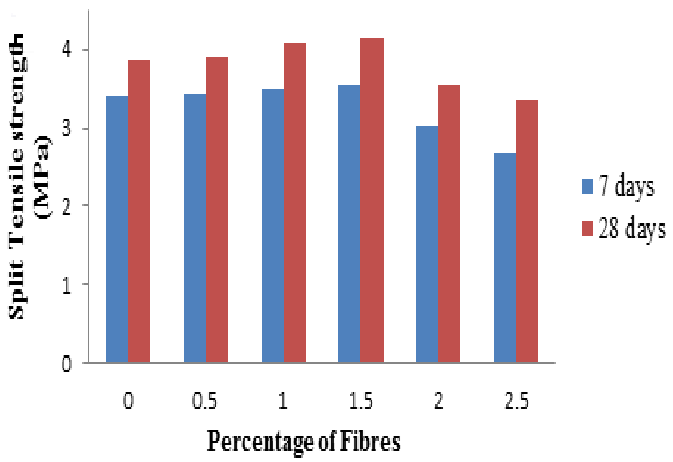

Figure 3: Variation in split tensile strength for 7 and 28 days curing with increasing fibre content.

Figure 3 shows variation in split tensile strength with increasing fibre content for 7 and 28 days curing. Variations in flexural strength for 7 and 28 days curing is given in Table 8.

Table 8: Variation of flexural strength with fibre content for 7 and 28 days curing.

% of fibre added	7-days		28-days	
	Flexural Strength (MPa)	Increase or Decrease in Flexural Strength (%)	Flexural Strength (Mpa)	Increase or Decrease in Flexural Strength (%)
0	5.16	0	6.22	0
0.5	5.33	3.189	6.4	2.812
1	5.69	9.314	6.76	7.988
1.5	6.4	19.375	7.11	12.517
2	5.33	3.189	6.22	0
2.5	5.16	0	5.16	-20.542

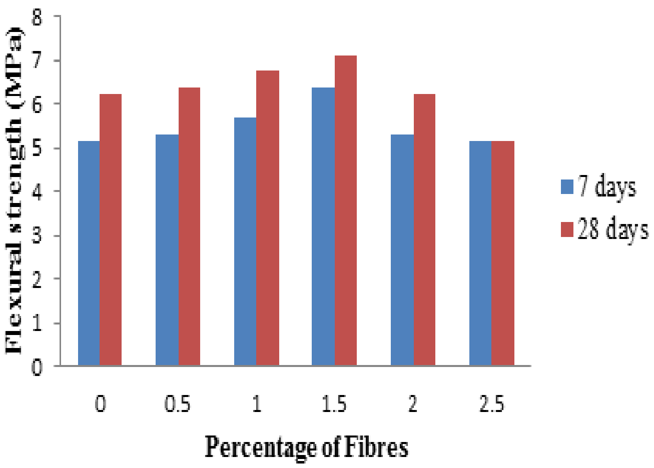

Figure 4: Variation of flexural strength with increasing fibre content for 7 and 28 days curing.

Figure 4 shows variation of flexural strength with increasing fibre content for 7 and 28 days curing.

Figure 5: 1.5% fibre-added concrete cubes after compressive strength tests.

Shown in Figure 5 are 1.5% fibre-added concrete cubes after compressive strength tests. Also shown in Figure 6 are 1.5% fibre-added concrete cylinders after split tensile tests.

Figure 6: 1.5% fibre-added concrete cylinders after split tensile test.

4 Conclusion

The specimen with 1.5% polypropylene fibre as additive was found to be good, which has compressive strength of 23.86% more than that of conventional concrete. Better split tensile strength was observed which showed upto 6.75% increase in strength than normal concrete. Further, on adding the polypropylene fibre, the flexural strength increased by 12.52% over that of the conventional concrete. The density of concrete decreases with fibre addition compared to normal concrete specimen. Hence, when it is used in construction, it can reduce the self weight of different concrete elements in a building considerably, thus reducing the total dead load on the footing.

Further, it is observed that the concrete with polypropylene fibre has higher yield point than normal concrete. It does not fail suddenly as in the case of flexural testing on beam with normal concrete due to its brittle nature; instead, fibre added concrete behaves like a ductile member and then undergoes failure after yield point. This study indicates that the mechanical properties of concrete are enhanced by addition of the polypropylene fibre (1.5% by weight of cement) as an additive.

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