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Behaviour of Polypropylene Fibre on the Mechanical Charateristics of Fibre Reinforced Concrete using Polypropylene Fibers

Sukhvir Singh Grewal, Suryakant Jaryal

Abstract: ***Concrete as a building material, used most extensively has revolutionized the construction industry by its properties like high strength and workability. However, the engineering structures are surrounded by the combustible materials, making them prone to the blast impact loading as well as fire. Concrete structures which are subjected to the conditions of high temperature, are susceptible to physical and chemical changes leading to their degradation. The fire can cause the damage to the structure as well as human lives. The need of the hour is to study the impact of fire on the concrete structures as it is mostly used as the construction entity in buildings and other structures. In our research paper, the use of Polypropylene fibers (PPFs) in concrete and their impact on various attributes of concrete like Compression stréngth, split tensile and flexurál strength has been studied. The impact of PPFs on concrete at different temperatures has also been analyzed. The results have shown that the compression strength got raised due to the inclusion of PPFs in the concrete by 9.08%, splitting tensile by 59.25% and flexural strength by 27.36% after 4 weeks of curing. The addition of PPFs to the concrete has also resulted in an increase in strength then the conventional concrete at temperatures of 400^{o}C and 800^{o}C.***

KEYWORDS: ***Annealing furnace, Concrete, Fire resistant, Polypropylene fibers, spalling***

I. INTRODUCTION

Fire poses a serious threat to the durability and safety of concrete structures. The exposures of a concrete structure to the high temperatures adversely affect its physical as well as mechanical performance leading to loss of property, environment as well as people. Thus, it is necessary to probe the impact of the fire on the concrete structures. The performance of the concrete is affected by various factors such as the heating and cooling rates, exposure to high temperatures, fire exposure duration, maximum temperature to which the concrete was exposed, aggregate-mortar bond etc. All these factors have a certain impact on the resistance of the concrete structures towards fire. Fire can prove catastrophic and can damage a building severely, the temperature in a building with fire can reach up to 1200^{o} C and can have impact severely on the load bearing capacity of the structure.

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***** Correspondence Author
Er.Sukhvir Singh Grewal*, M.tech Scholar, civil Engg. from Desh Bhagat University, Mandi Gobindgarh, Punjab, India. Email: sukh.grewal91@gmail.com
Er. Suryakant jaryal, Assistant Professor,civil engg. Mandi Gobindgarh, Punjab, India**.** Email: jaryalsuraj@yahoo.in

The fire in a building can affect the inhabitants badly and can result in the loss of human lives. The fire accidents also cause environmental pollution by releasing very harmful pollutants into the atmosphere.
The desire of reducing the fire accidents in the structures has always been a matter of concern and various steps have been taken to maximize the fire resistance ability of the concrete structures. The ability of a building to withstand the higher temperatures depends upon the type of construction material used and the fire extinguishing equipment's installed in the structure. In order to keep the structures well maintained with safety against the fire, the type of material used plays indispensible role and the decision of building material to be used should be carried out at the initial stages with proper planning. Thus, it becomes a necessity to check the stability of concrete against fire and its resistance at higher temperatures and proper steps should be taken to raise the fire resistance of concrete structures as concrete is frequent extensively used material in modern manufacture industry. Different types of admixtures have been accumulated in the industry to increase the fire resistance of concrete structures. The various admixtures used include glass fibers, steel fibers, asbestos fibers etc. their impact on the various concrete properties has been investigated. The impact of these admixtures has shown a better resistance at higher temperatures and prevents the concrete structure from getting damaged. The inclusion of these fibershas resulted in the increase of the load bearing capacity by making a strong bond inside the concrete and prevents the cracks from further widening at higher temperatures.

II. MATERIALS

Ordinary Portland Cement (OPC) of 53-G conforming to IS: 8112-1989 was used during this study. Fine particles pássing through 1.18 mm sieve confirming to IS: 383-1970 was used in this research.
Coarse particles(OPC) having size 10 mm-20 mm were used, also confirming to IS: 383-1970.
Polypropylene fibers were obtained from the local market and were available in different lengths. In this study, PPFs of 12 mm length with a density of 0.9-0.91kg/m^{3} and a melting point of 175^{o}C.
The PP fibers show a hydrophobic reaction with water. The PP fibers used in the study increased the strength(compressive, flexural and tensile) and also increased the resistance towards fire.

III. METHODOLOGY

Concrete of M25 grade was used for experimental investigation with a w/c percentage of 0.5 with a cement content of 394.5kg/m^3.

Polypropylene fibers were added as 0.5% fine aggregate replacement in the concrete.

Concrete samples were casted in steel moulds of size 150 mm^3 for compression test, 500mm x 100mm x 100mm (beams) for flexural test and 150mm x 300mm (cylinders) for splitting ténsile test.

The sámples were castéd as per IS: 10262-2009 and samples were kept for watering period of 1 and 4 weeks. The experimental procedure included the following tests:

- Fire test
- Compression strength test
- Flexurál test
- Splitting tensile test

After the curing period is over, the samples were heated in the annealing furnace for about one hour at different temperatures of 400°C and 800°C. The fire tests were performed first followed by the cooling down of samples and then the tests for compression strength, flexurál strength and split tensile stréngth were performed. The comparison of conclusion wasdone with the conventional concrete samples and the un-burnt sample for the fire test. The tests were demonstrated on the sample at 1 and 4 weeks of curing.

IV. RESULTS AND DISCUSSION

In this study, the tests like compression strength test, flexural test, splitting tensile test and fire test were performed on the concrete specimens. The tests were conducted on both reference samples as well as samples with PPFs. The results obtained from these tests are discussed below:

Table. 1 shows strength of compressive, split tensile and flexural of conventional and polypropylene concrete at different 1 and 4 weeks.

Sr.No.	Tests	Conventional concrete		Polypropylene concrete	
		1 week	4 weeks	1 week	4 weeks
1	Compressive test	21.5	32.15	23.43	35.07
2	Split tensile test	1.75	2.43	2.8	3.87
3	Flexural test	4.73	6.03	6.53	7.68

1. The compressive strength tests were done in the laboratory after 1 and 4 weeks of watering. The strength for conventional concrete was 21.5 N/mm^2 and 32.15N/mm^2after 1 and 4 weeks respectively. While as for PP reinforced concrete, it was 23.43N/mm^2 and 35.07N/mm^2 after 1 and 4 weeks of watering respectively. The consequences show that the addition of PP fibers to concrete increases the compressive strength to a certain extent.

The comparison of results of compressíve strength of normal concrete and PP fiber reinforced concrete is shown in the figure 1.

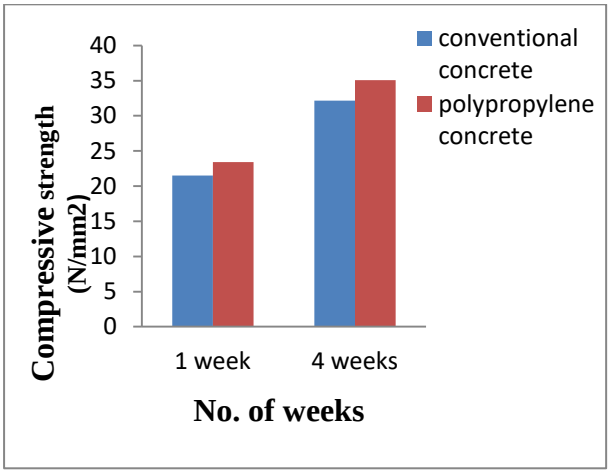

Fig.1 Graph showing compressive strength of normal concrete and PPF reinforced concrete.

The split tensíle strength test was also performed in the laboratory and the split tensile strength in conventional concrete after 1 and 4 were 1.75N/mm^2 and 2.43N/mm^2 respectively while weeks as in PP fiber reinforced concrete it was 2.80N/mm^2 and 3.87 N/mm^2 after 1 and 4 weeks respectively.

The results reveal that the addition of PP fibers also increased the split tensile strength a certain limit. Fig.2 shows the comparison of split tensile strength in conventional concrete and PP fiber reinforced concrete.

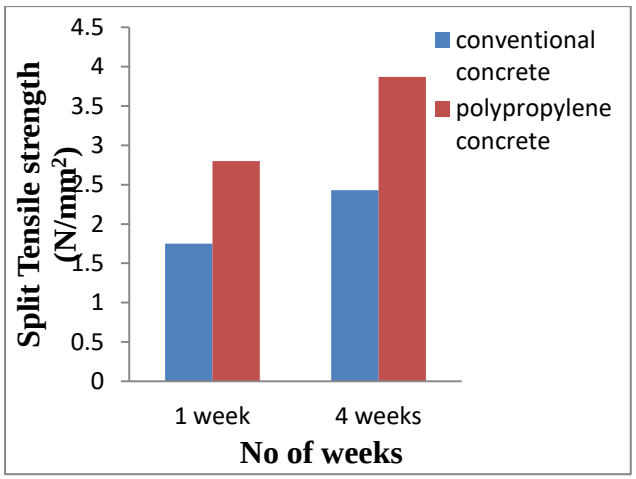

Fig.2 Graph showing Split tensíle strength of concrete and PPFs containing concrete after 1 and 4 weeks of Watering

The flexurál strength tests were operated in the laboratory after 1 and 4 weeks of watering respectively and the consequences obtained reveal that the addition of PPFs increased the flexural strength of concrete as compared to the conventional concrete. Fig. 3 shows a comparison between the flexural strength of conventional concrete and PPFreinforcedconcrete.

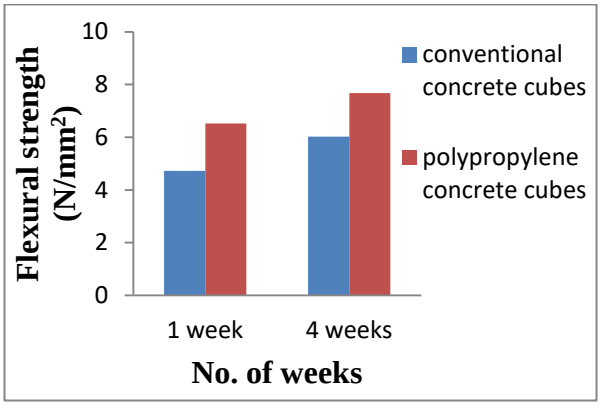

Fig.3 Graph showing flexural strength of conventional and PPF reinforced concrete after 1 and 4 weeks.

2. The fire tests are performed at a temperature of 400^0 C and 800^0 C for one hour in Annealing (gas) furnace. Concrete samples with and without polypropylene fibers are tested and after cooling strength tests (compressive strength, split tensile strength and flexural strength) tests are conducted for 1 week and 4 weeks. Fig. 4, Fig.5 and Fig.6 shows the comparison of compressive strength, split tensile strength and flexural strength at different temperatures. The results have shown that the addition of polypropylene fibers to concrete increases the strength as well as fire resistance of the concrete structures.

Table. 2 shows the value of compressive, split tensile and flexural test at different temperatures after 4 weeks.

Sr. No	Tests	Conventional concrete			Polypropylene concrete		
		0^0c	400^0c	800^0c	0^0c	400^0c	800^0c
1	Compressive test	32.15	29.09	14.98	35.07	32.13	17.03
2	Split tensile test	2.43	1.96	1.23	3.87	2.73	2.02
3	Flexural test	6.03	5.39	3.2	7.9	6.94	4.51

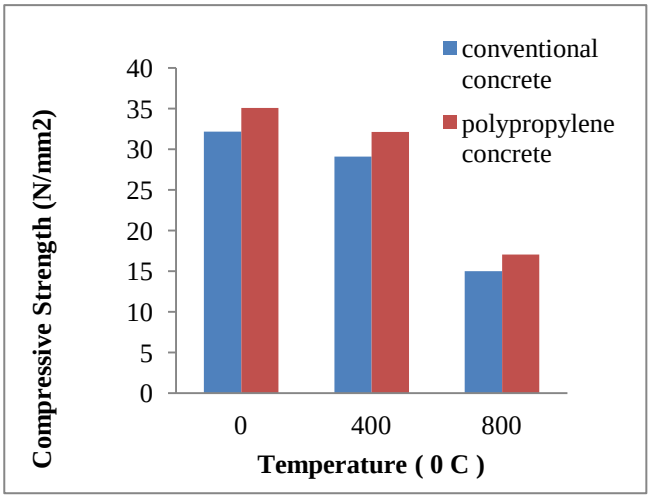

Fig.4 Graph showing compressive strength of conventional and PPF reinforced concrete (0.5%) at different temperatures after 4 weeks.

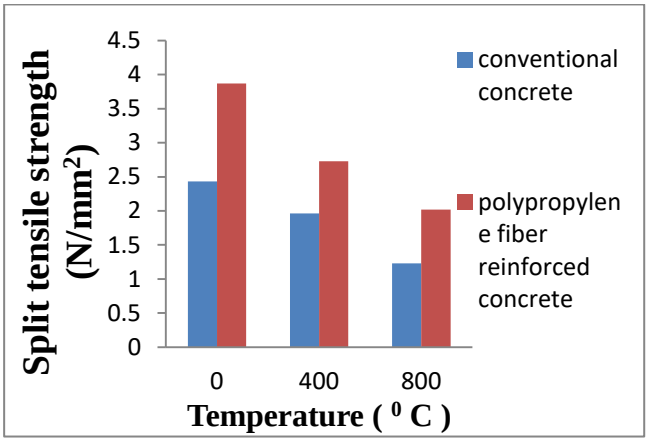

Fig.5 Graph showing split tensile strength of concrete with PPFs (0.5%) at different temperatures after 4 weeks.

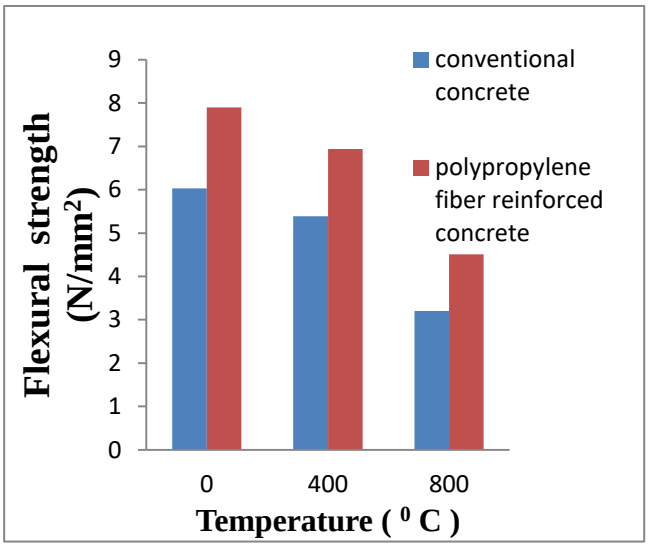

Fig. 6 Graph showing flexural strength of concrete with PPFs (0.5%) at different temperatures after 4 weeks.

V. CONCLUSION

After conducting the different tests on the conventional as well as polypropylene reinforced concrete samples, it is found the strength like compression, flexural and split tensile strength was more in PPF reinforced concrete. The results have shown that the addition of admixtures increases their properties to a large extent and thus their percentage can be enhanced to increase the concrete properties. The results revealed that the polypropylene reinforced concrete display an rise in compression, split tensile and flexural strength by 8.97%, 60% and 38.05% after 1 week, 9.08%, 59.25% and 27.36% after 4 weeks. Also it was seen that due to the increase in the temperature the quality of the concrete got decreased. However, the addition of polypropylene fibers (PPFs)to concrete increases the strength of concrete at higher temperatures.At 400^0C the ratio rise in compression strength, split tensile strength, flexural strength of polypropylene reinforced concrete for 1 week is 12.72%, 64.86% and 19.32% respectively and for 4 weeks is 10.45%, 39.28%, and 28.75% respectively.

After curing of 4 weeks, there was rise in compression strength, split tensíle and flexural stréngth at 800^{o}C as 13.68%, 64.22% and 40.93%.Due to increase in the temperature of the concrete, it resulted in spalling effect and the addition of PPF to the concrete increased its ductility, thus prevents the structure from collapsing. The inclusion of PPFs at lower temperatures resulted in increasing the concrete strength and vice versa. The studies on the fire resisting structures can be conducted at different percentages of PPFs, higher temperatures greater than 800^{o}C can be carríed out. The use of fíbers other than PPFs that have a better fire resistance like glass fibers can be utilized as a substitute of fíne particles in reinforced concréte.

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AUTHORS PROFILE

Er. Sukhvir Singh Grewal received B.tech degree in civil engineering from Desh Bhagat Engineering college Mandi Gobindgarh, Punjab, india. He is M.tech Scholar in Construction Technology and Management from Desh Bhagat University, mandi Gobindgarh, Punjab, India. Currently he is working as Lecturer at Ludhiana Polytechnic College, Katani Kalan, Punjab , India.

Er. Suryakant Jaryal, received B.tech degree in civil engineering from SBBSIET, Punjab, India in 2014 and he received M.tech degree in Construction Technology and Management from NITTTR,Chandigarh, India in 2018. Currently he is working as Assistant professor in Dept. of Civil Engg. At Desh Bhagat University, Punjab. He has qualified GATE IN 2018 and 2019.His area of interest include concrete technology, transportation engg. Etc.