THE EFFECT OF POLYPROPYLENE FIBERS ON TENSILE STRENGTH OF SELF COMPACTING CONCRETE

[a] Muhammad Tariq*, [b] Moazam Sattar, [c] Muhammad Aleem

a: Civil Engineering, Uet Taxila, tariqdaud2@gmail.com
b: Civil Engineering, Uet Taxila, moazam.malik59@gmail.com
c: Civil Engineering, Uet Taxila, engrm.aleem@gmail.com
* Corresponding author: Email ID: tariqdaud2@gmail.com

Abstract- The mechanical characteristics of fiber reinforced self compacting concrete in the hardened condition are investigated in this study**.** The goal of this experiment is to see what impact polypropylene fibers (PPF) have at different doses, such as 0%, 0.50%, 1%, and 1.50% and to estimate the maximum amount of polypropylene fibers (PPF) that can be added safely. Furthermore, Silica fume was used to displace up to 10% of the cement, which was consistent across all blends. The replacement of fine aggregate was carried out with 10% fly ash for blends (M1, M2, M3 and M4). Then percentage increased up to 20% for mixtures (M5, M6, M7 and M8). The purpose of the experimental study programme was to look at split tensile strength after 14 and 28 days of curing. The mix containing varied amounts of polypropylene fibers was then compared to conventional concrete. Tensile strength was improved by adding polypropylene fibers to the mix. At 1% polypropylene fiber insertion, the tensile strength reaches its maximum.

Keywords- Polypropylene fibers (PPF), split tensile strength, self-compacting concrete (SSC)

1 Introduction

Self-consolidating concrete is another name for self-compacting concrete. By its own weight, this form of concrete can be placed or modified in any location. It may be conveniently installed in busy reinforcing areas. There is no need to use mechanical vibrators to compact the SCC during installation.

In this experiment, seven PPF-containing mixtures and one control blend were used to test SCC tensile strength. All mixtures had a predetermined substitution of cement with silica fume and fine aggregate with fly ash. Fibers were gradually added to all combinations at a rate of 0.5 percent. The percentages of replacement were 0 percent, 0.5 percent, 1 percent, and 1.5 percent. All mixtures used a fixed 0.33 water-cement ratio, and using super plasticizer increased the workability of SCC while maintaining the water content. The goal of this research effort was to determine the mechanical characteristics of concrete, including compression, split tensile and flexural strength. All of the polypropylene fiber mixtures were compared to the control mix. It was discovered that adding fibers to SCC increased tensile strength of concrete [1]. Four different amounts of polypropylene fibers were used in the concrete mixes to determine the tensile strength. The amounts of fibers were 0.10, 0.20, 0.30, and 0.40 percent by the weight of cement. Four different blends were created for this purpose. At 28 days, the tensile strength was assessed. Polypropylene fibers were found to enhance the tensile strength of self-compacting concrete. [2].The properties of SCC in fresh and hardened states were assessed using an experimental method. Polypropylene fibers were added in various amounts of 0 percent, 0.50, 0.75 and 1 percent, together with steel fibers, for this purpose. The greatest tensile strength was reached with the addition of 1% PPF [3]. Polypropylene fibers in the numbers of 1, 2, and 3 kg/m^3 were used in this study. High-performance PPF was used in this study. At temperatures of 250 ^{0}C, 1000 ^{0}C, 2000 ^{0}C, and 3000 ^{0}C, mechanical properties such as tensile, compressive, and flexural strengths were investigated. When 1 kg of fibers were added to concrete, the compression strength enhanced by 14.0 percent, the split tensile strength improved by 17.0 percent, and the flexural strength increased by 8.50 percent [4]. The damage evolution rule, compressive strength, and damage performance of PPF concrete were all tested experimentally. The ordinary concrete was used as a comparison for the results. The results showed that adding PPF to concrete increased its split tensile strength [5]. The 28-day mechanical properties of PP fibers increases at low values, but decreases by 3% - 5% at higher concentrations [6]. The split tensile strength of fibers reinforced concrete was related to the fibers length used. With longer fibers, the split tensile increases [7].Flexural, split tensile, and modulus of rupture were all significantly increased when compared to conventional concrete [8].The purpose of this experimental program was to study the effect of PPF on SCC modified with fly ash. Moreover, to find the optimum content of PPF for SCC modified with fly ash for mechanical property like tensile strength of SCC.

2 Experimental Procedures

The first of all the selection of materials used in the mixes was carried out. The selection of aggregate quarries was influenced by the petrography of the rock resources. The Margalla, Rohi, Sargodha, and Gari Habib Ullah quarries, for example, yield calcium carbonate, dolomite, limestone, and granite minerals. At this point, the project's ingredients included cementitious materials, fly ash, Portland cement, and polypropylene fibers. Then typical mix designs were created in the. The ACI-211 requirements were followed with a one-to-one mix ratio (1:1.4:1.6). PPF was used at the following concentrations: 0%, 0.50%, 1%, and 1.5. The mixes were made with 0.33 w/c ratio to investigate the impact of PPF on concrete properties. The researcher used PPF dosages of 0, 0.5, 1, and 1.5 percent. Figure 1 shows the quantities and identities of cement (C), fine aggregate, coarse aggregate, silica fume (SF), fly ash (FA), admixture, and polypropylene fibres (PPF) in self compacting concrete mixtures. First and foremost, all aggregates were combined in a drum type concrete mixer for about one minute in a dry state. After that, PPF was applied, and the missing was completed for another minute in a dry environment. At the beginning, 2/3 of the water was utilised, and the mixture was mixed for another minute. The last 1/3 of the water and the super plasticizer were added at this point. The fresh properties like slump flow, flow ability and passing ability were determined. The mix proportions used for experimental program are given below. Sample 1:1.4:1.6 mix was used for all the batches. It was because, in Pakistan most commonly used concrete mix as shown in Figure 1.

Mix No.	Mixture ID	W/B	Water	C	SF		FA		Fine Agg.	Coarse Agg.	PPF Fraction		Admixture
-	-		Kg/m³	Kg/m³	%	Kg/m³	%	Kg/m³	Kg/m³	Kg/m³	%	Kg/m³	Kg/m³
1	Control	0.32	142	444	-	-	-	-	690	769	-	-	5.3
2	M1	0.32	128	400	10	44	10	69	621	769	0	0.0	4.8
3	M2	0.32	127	397	10	44	10	69	621	769	0.5	2.2	4.8
4	M3	0.32	126	395	10	44	10	69	621	769	1	4.4	4.7
5	M4	0.32	126	393	10	44	10	69	621	769	1.5	6.7	4.7
6	M5	0.32	128	400	10	44	20	138	552	769	0	0.0	4.8
7	M6	0.32	127	397	10	44	20	138	552	769	0.5	2.2	4.8
8	M7	0.32	126	395	10	44	20	138	552	769	1	4.4	4.7
9	M8	0.32	126	393	10	44	20	138	552	769	1.5	6.7	4.7

Figure 1: Polypropylene fibers

1.1 Materials

The Naturally available sand of Lawrence pur quarry was used as a fine aggregate (FA) & coarse aggregate (CA) of crushed Margalla Hills was used. The addition of silica fume & polypropylene fiber (PPF) reduces the workability of concrete, to get desirable slump value superplasticizer was used. In this research, an Ultra high range water reducing admixture viscocrete 3110 was used.

1.2 Polypropylene fibre

The monomer C3H6 is used to make polypropylene fibres. These fibres are chemically resistant. Figure 2 shows the white polypropylene fibres with a diameter of 12 mm that were employed in the research for the experimental programme.

Figure 2: Polypropylene fibers

2 Research Methodology

Splitting tests on cemented concrete may be used to assess tensile strength. Moreover, direct tension test and the flexural test can be used to find the tensile strength of concrete. Crack size and depth in constructed settings are directly related to the tensile strength of concrete. Because of this, concrete is very brittle and hence extremely weak under strain. Furthermore, the concrete is extremely weak under tension due to its brittle character. As a result, direct tension is unlikely to be tolerated. Cracks emerge when tensile forces exceed the concrete's tensile strength. The maximum load bearing capacity of concrete components was determined by determining its strength. It's also possible to assess the tensile strength of concrete by breaking it in half. According to ASTM C496 standards. As a last step, we'll go through the various aspects of the split cylinder's test for concrete samples. The tensile strength of SCC in the hardened condition was tested at 14 and 28 days after curing to see how PPF affected its performance.

The tensile strength of SCC was determined by applying stress to cylindrical samples having 150 mm diameter and 300 mm height. According to ASTM C39, compression testing machine was used to determine the split tensile strength. For this purpose, the specimen was placed on a flat surface with the vertical and centered lines drawn on the ends. Laid another plywood strip over the specimen and lowered it until it touched the plywood strip. Determined the breaking load. By using that load, tensile strength was determined. The calculated tensile strength is shown in Figure 3. The average of three samples were used as a final result.

Figure 3: Polypropylene fibers

3 Results

The split tensile strength was determined according to ASTM C496. The tensile strength of SCC with different proportions of PPF and proposed contents of silica fume and fly ash are shown in the Figure 4.

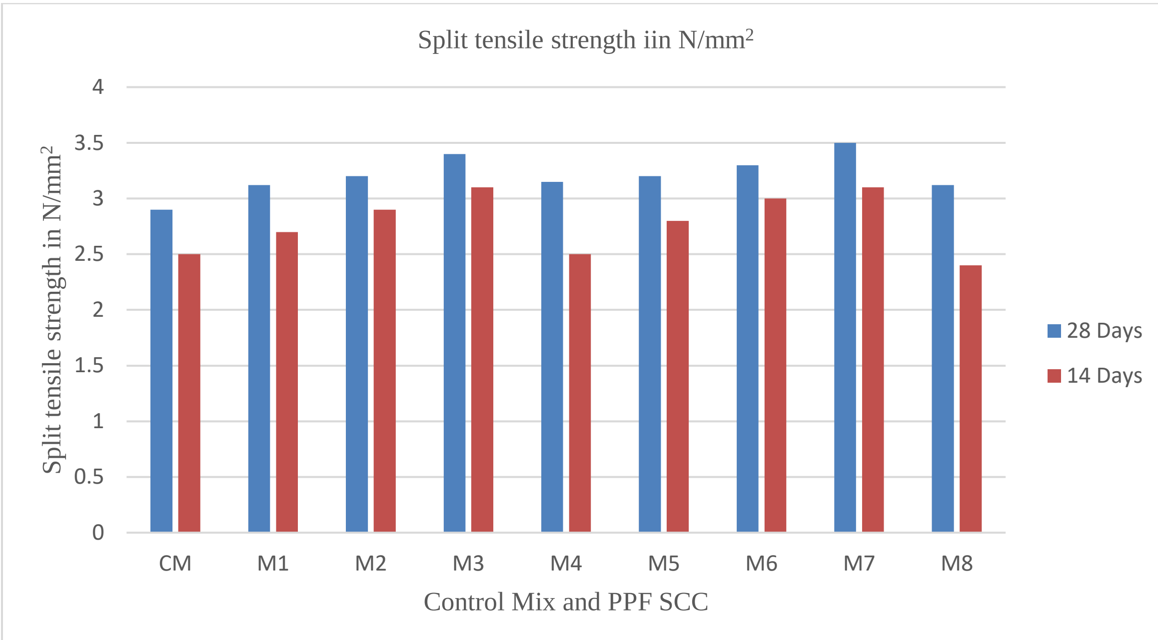

Figure 4: Polypropylene fibers

Figure 3 shows the tensile strength of SCC with various PPF percent and proposed silica fume and fly ash contents. The improvement in mixes containing 10% fly ash for M1 to M4 and 20% for M5 to M8, 10% silica fume for mixes and proposed contents of PPF are shown in the graph. The effect of PPF in increasing split tensile strength was more than that of compression test & get the improvement in the results up to 1% PPF. The mix containing 0%, 0.5%, 1% and 1.5% PPF increased the strength by 8%, 10%, 17% and 7% respectively at 28 days for M1 to M4 for mixes M5 to M8 the strength improved by 10%, 14%, 21% and 8% respectively at 28 days of curing. Since PPF and cement paste were interlocked during testing, this failure pattern differed from that of plain concrete mixtures, the failure pattern was unique as shown in Figure 5.

Figure 5: Polypropylene fibers

4 Conclusion

The main purpose of the study was to evaluate the beneficial effect of polypropylene fibers in contents like 0%, 0.5%, 1% and 1.5% on self compacting. SCC behavior was also studied under the influence of fly ash and silica fume. From the research, the following findings can be drawn:

1. In case of tensile strength, the addition of PPF increased the tensile strength of SCC. The addition of PPF reduced the brittleness nature of concrete. As a result tensile strength increased.
2. The maximum strength was obtained at 1% addition of PPF. The failure pattern was different than the plain concrete mixes, after testing the two parts were not separated from each other due to the interlocking of PPF in the cement paste.
3. As a result of the entire experimental study, it is possible to use polypropylene fibers in the creation of SCC up to a maximum of 1%. Further addition of PPF causes the reduction of tensile strength of SCC.

References

[1] Rani, B.S. and N. Priyanka, "Self compacting concrete using polypropylene fibre, " *International Journal of Research Studies in Science, Engineering and Technology*, vol. 4, pp. 16-19,2020.

[2] Kurian, S.V and A. Sarah, "Inflence of polyproplene fibbre in self compactng concrete," *International Research Journal of Engineering and Technology*, vol. 5, pp. 1102-1104,2021.

[3] Abaeian, R., et al., "Effects of high temperatures on mechanical behavior of high strength concrete reinforced with high performance synthetic macro polypropylene (HPP) fibres," *Construction and Building Materials*, vol. 165, pp. 631–638,2018

[4] Liu, X, et al., "Properties of self-compacting lightweight concrete reinforced with steel and polypropylene fibers," *Construction and Building Materials*, vol. 226, pp. 388–398,2022.

[5] Qin, Y.,et al., "Experimental study of compressive behaviour of polypropylene-fibre-reinforced and polypropylene-fibre-fabric-reinforced concrete," *Construction and Building Materials*, vol. 194, pp. 216–225,2022.

[6] Priti A. Patel, Dr. Atul K. Desai and Dr. Jatin A. Desai, "Evaluation of Engineering Properties for PP Fiber Reinforced Concrete," *International Journal of Advanced Engineering Technology*, Vol.3,pp. 42-45,2022.

[7] Miss Komal Bedi, "Experimental Study For Flexure Strength on PP Fiber Reinforced Concrete," *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*, vol.3, pp. 16-22,2022.

[8] Mounir M. Kamal, Mohamed A. Safan, Zeinab A. Etman,, Bsma M. Kasem,"Mechanical Properties of Self Compacted Fiber Mixes," *Housing and Building National Research Center Journal (HBRC)*, Vol.10,pp. 25–34,2022