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Experimental Investigation on the Enhancement of Compressive Strength of 5% Novel Polypropylene Monofilament Fiber as Additive in Concrete with Conventional Concrete

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Abstract

The aim of this study is to investigate the enhancement of the compressive strength of concrete using 5% novel polypropylene monofilament fiber as additive in concrete with conventional concrete. Cement was partially replaced with polypropylene monofilament to increase the concrete's compressive strength. The experiments were divided into two groups. Each group consists of 18 specimens. Pretest power is calculated at 80%. 5% of polypropylene monofilament was replaced in concrete by the weight of cement. A compressive strength test was carried out per ASTM standards using a cube specimen on dimensions 150 x 150 x 150 mm. After 28 days at room temperature, the compression strength of the specimens was measured using a compression testing machine of 2000 kN capacity. SPSS (Statistical Package for the Social Sciences) Software was used to carry out independent sample t-tests. Novel polypropylene monofilament fiber-reinforced concrete exhibited a compressive strength of 37.6489 N/mm^2 compared to conventional concrete. The standard deviation for novel polypropylene monofilament fiber-reinforced concrete for 5% replacement with concrete was 2.30843. A statistically significant difference between the two study groups, with a significance value of $p = 0.000$ (two-tailed, $p < 0.05$) was observed. The compressive strength of concrete significantly increased with the replacement of 5% novel polypropylene monofilament fiber- reinforced concrete in cement.

Keywords

Novel polypropylene monofilament fiber-reinforced concrete, M30 grade, Coarse aggregate, Compressive strength, Conventional concrete, Fine aggregate

Introduction

Monofilament fibers are fibers with greater tensile strength and modulus of elasticity. These concrete fiber additions are evenly distributed throughout the concrete matrix, effectively controlling plastic shrinkage cracking. This research aims to develop a higher strength, eco-friendly and sustainable monofilament replaced concrete. Novel polypropylene monofilament fiber-reinforced concrete is a composite material made up of the concrete mix of the designed grade and proportions of concrete with partial replacement of polypropylene monofilament fiber. Mixed fiber is added to the concrete to boost its strength, which is higher than that of conventional concrete. In today's world, construction requires higher strength with less investment or cost. Conventional concrete is brittle and has lower strength values. To achieve higher strength admixtures and superplasticizers are to be added to concrete with varying proportions. These extra components which are used should be eco-friendly and safe for the environment [1]. Increasing the strength of the concrete will reduce the development of cracks in concrete, low-cost solutions of composite material in construction. This concrete

can be used in precast structures like pools, basements, roads, and bridges.

About 1100 results from Google Scholar, lead to this type of alternate material in addition to concrete and reduce the environmental impact by researchers. There have been approximately 160 examinations on this area in Google Researcher for the past seven years, and 17 from Science Direct. The most referred papers are " Study on shear behaviour of high-performance polypropylene fiber-reinforced lightweight aggregate concrete beams " [2], "Multi-scale disintegration and microstructure of polypropylene fiber concrete by salt freezing" [3], "Mechanical properties of reused total cement containing morsel elastic and polypropylene fiber" [4], and "Experimental study on adding polypropylene fiber to compressive strength and flexural strength of concrete" [5]. This exploration has broadly concentrated because of fiber-built up concrete with polypropylene fiber [6, 7].

In the research, the M30 grade concrete with 5% polypropylene monofilament fiber reinforcement concrete was cast. The addition of polypropylene monofilament improves the compressive strength. The experimental results conducted on the specimen show a development in compressive strength when compared to conventional concrete. Effective utilization of these by-products assists in the conservation of natural resources and also aids in preserving favorable environmental conditions.

Materials and Method

This examination was completed in the Substantial lab, Branch of Civil Engineering at SSE. The test size was determined by ClinaCalc. The trial information has been separated into two gatherings. Each gathering comprises of 18 unique examples. Pretest power is determined at 80%. There is a genuinely huge contrast between the two review gatherings, with an importance worth of $p = 0.000$ (two-followed, $p < 0.05$). Standard deviations for compressive qualities of traditional and novel polypropylene monofilament fiber-supported concrete were 1.65492 and 2.30843 individually. Group 1 consists of specimens with 5% replacement of novel polypropylene monofilament fiber-reinforced concrete and group 2 with conventional concrete is represented in table 1 and table 2. Figure 1 shows the materials used to prepare concrete.

To test the strength of the concrete, 15 x 15 x 15 cm concrete cubes were cast. Group 1 cement was defined as cement with a replacement of polypropylene monofilament fiber of 5%. Ramco concrete (OPC 53 grade) was used; its boundaries included explicit gravity of 3.15, consistency of 31.5%, beginning setting season of 30 min, extreme setting season of 600 min, and adequacy of 2.8. M-sand going through a 4.75 mm sifter and had a fineness modulus of 2.74 and explicit gravity of 2.63 was utilized as a fine total. Coarse total of quarry squashed stone 20 mm size and going through 80 mm, 40 mm, 20 mm, strainer was utilized [8]. The boundaries of concrete are displayed in table 3. The boundaries of fine and coarse total are displayed in table 4 and table 5, respectively.

For both groups, the mix design of the M30 grade of concrete has been evaluated according to the Indian standard

Table 1: Compressive strength of concrete (Conventional).

S. No.	Wt. (Kg)	Load (kN)	Compressive strength (N/mm²)
1	8.132	590	30.67
2	8.543	672	34.31
3	8.231	659	33.73
4	8.987	680	34.67
5	9.011	674	34.40
6	8.654	685	34.89
7	8.256	725	32.22
8	8.987	689	35.07
9	9.231	617	31.87
10	8.765	693	35.24
11	9.043	662	33.87
12	8.798	653	33.47
13	8.675	696	35.38
14	8.793	699	35.38
15	9.045	720	36.44
16	8.894	650	33.33
17	9.406	597	35.42
18	9.654	746	37.60

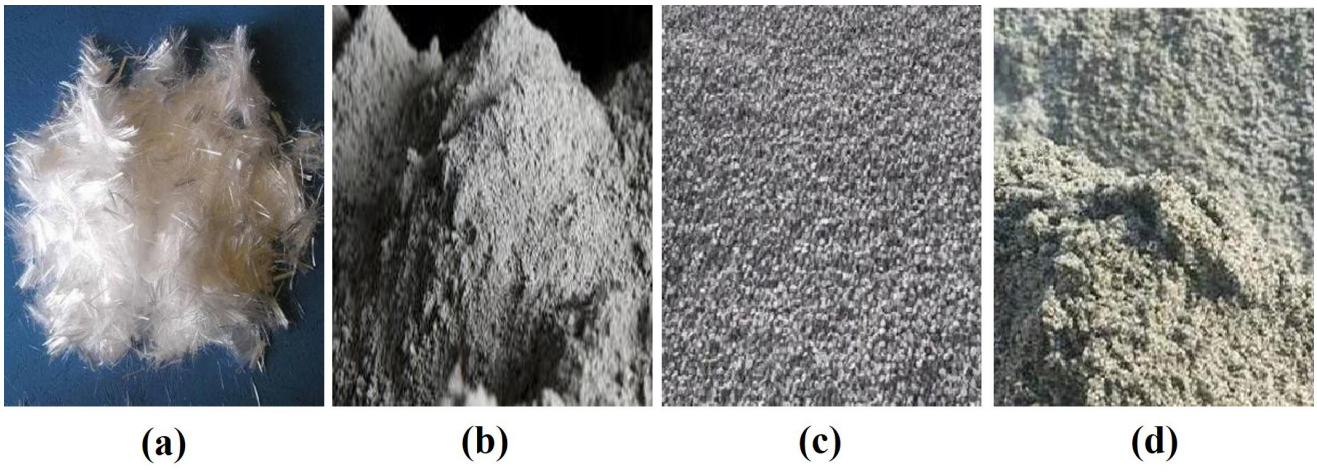


Figure 1: Materials used in concrete preparation. **(a)** Polypropylene monofilament fiber, **(b)** Cement (OPC53 Grade), **(c)** Coarse aggregate, and **(d)** Fine aggregate.

Table 2: Compressive strength of 5% novel polypropylene monofilament fiber reinforced concrete.

S. No.	Wt. (Kg)	Load (kN)	Compressive strength (N/mm²)
1	8.132	840	37.33
2	8.543	892	39.64
3	8.231	820	36.44
4	8.987	847	37.64
5	9.011	800	35.56
6	8.654	802	35.64
7	8.256	780	34.67
8	8.987	757	33.64
9	9.231	760	33.78
10	8.765	852	37.87
11	9.043	840	37.33
12	8.798	907	40.31
13	8.675	920	40.89
14	8.793	862	38.31
15	9.045	900	40.00
16	8.894	917	40.76
17	9.406	880	39.11
18	9.654	872	38.76

Table 3: Cement properties.

S. No.	Properties	Result
1	Fineness of cement	90 microns
2	Specific gravity of cement	3.142
3	Consistency	30.5%
4	Initial setting time of cement	30 min
5	Final setting time of cement	590 min

Table 4: Properties of fine aggregate.

S. No.	Properties	Result
1	Size	4.75
2	Sieve analysis of fine aggregate	2.59
3	Water absorption of fine aggregate	3%
4	Specific gravity of fine aggregate	2.65

Table 5: Properties of coarse aggregate.

S. No.	Properties	Result
1	Size	20 mm
2	Sieve analysis of coarse aggregate	20 mm
3	Water absorption of coarse aggregate	3.14%
4	Specific gravity of coarse aggregate	2.68

method (IS 10262-2009) and then batching of required materials has been prepared manually. For group 1, the mixing of required materials as for normal M30 grade concrete has been done in wet conditions and the compaction process also be made manually by using a tamping rod. To eliminate the air gaps that are present in the concrete specimen, a vibrator is also used during the casting process. Similarly, for group 2 the same procedure has been carried out with addition of 5% polypropylene monofilament fiber and the concrete specimens are cast in the cubic mold.

After the preparation of samples is done, the specimens are removed from the mold after 28 days of curing process. Figure 2 shows the casting of the cube in mold (a), the workability test (b), the curing process of the concrete cube (c), and polypropylene monofilament fiber concrete (d). After 28 days of curing, a compression testing machine was used to test the compressive strength of specimen and the performance of conventional concrete and fiber-reinforced concrete was evaluated. By gradually applying pressure at a rate of 140 kg/cm² per minute until the specimen collapses, the compressive strength is ascertained. Figure 3 shows the universal testing machine that was used to get data on compressive strength. Figure 4 shows the broken specimen after testing.



(a) (b) (c) (d)

Figure 2: (a) Casting of the cube in mold, **(b)** Workability test, **(c)** Curing process of concrete cube, and **(d)** Polypropylene monofilament fiber concrete.



Figure 3: Universal testing machine to obtain the compressive strength results.



Figure 4: Broken specimen after testing.

Statistical analysis

Version 2.3 (2022) of IBM-SPSS software was used to conduct the statistical analysis to compare group 1 and group 2 of comparison of compressive strength of novel polypropylene monofilament fiber-reinforced concrete with conventional concrete. The free examples t-test approach robotizes the assessment of the t-test impact size while looking at the means for two gatherings of occasions. Figure 5 shows the correlation of analysis' outcomes analyzed utilizing the SPSS 22 programming. An autonomous t-test was completed to learn the factual importance between the review and control gatherings. The factors that impacted pressure strength, substantial grade, water/concrete proportion, concrete grade, and long stretches of restoring were all autonomous in the review; there were no reliant factors. The standard deviation for novel polypropylene monofilament fiber-built up concrete for 5% supplanting with concrete was 2.30843. There is a measurably tremendous distinction between the two review gatherings, with an importance worth of p = 0.000 (two-followed, p < 0.05).

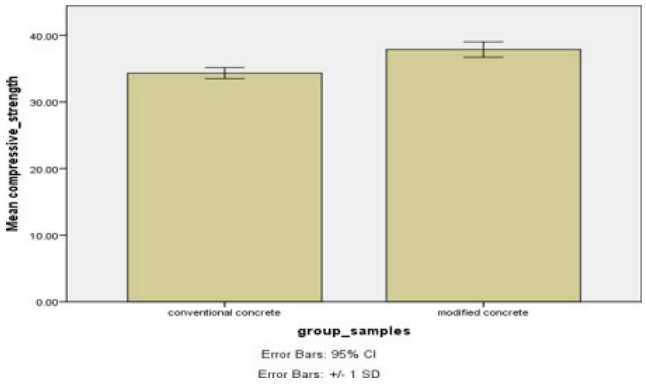


Figure 5: A bar chart comparing the mean compressive strength of conventional concrete and concrete with 6% fiber reinforcement is shown. When 6% more polypropylene is included in concrete than conventional concrete, the high accuracy is increased. The X-axis shows the group sample, the Y-axis shows the mean compressive strength, and the mean highest standard of quality is +/- 1 standard deviation.

Results

Table 6 shows the mean strength of M30 grade conventional concrete, which was 34.3311 N/mm^2. Novel polypropylene monofilament fiber-reinforced concrete had a compressive strength of 37.6489 N/mm^2. Standard deviations for compressive strengths of conventional and novel polypropylene monofilament fiber-reinforced concrete were 1.65492 and 2.30843, respectively. Table 7 incorporates the compressive strength for 18 examples as well as the meaning of compressive strength as surveyed by Levene's test for balance of differences, which was 0.118.

Table 4 shows the compressive strength upsides of 18 examples of regular cement. Table 5 shows the compressive strength upsides of 18 examples made of 5% polypropylene fiber supported concrete. Table 7 shows the results of the autonomous examples t-test. Figure 5 looks at the mean precision values for two gatherings of standard endlessly concrete supported with polypropylene monofilament fiber utilizing a 95% blunder bar There is a genuinely massive distinction between the two review gatherings, with an importance worth of p = 0.000 (two-followed, p < 0.05) and with a +/ - 1 standard deviation mean exactness recognition mistake.

Discussion

The difference between conventional concrete and novel polypropylene monofilament fiber- reinforced concrete with added superplasticizer was determined to be 8.8% higher in terms of compressive strength. Concrete's permeability is reduced, and its compressive strength is boosted by the inclusion of fiber. It was found that the compressive strength of ordinary concrete had a larger standard deviation than novel polypropylene monofilament fiber-reinforced concrete that contained a superplasticizer. It demonstrates that concrete reinforced with polypropylene monofilament fibers and a superplasticizer exhibits a greater departure in compressive strength from its mean value. Compressive strength comparison shows a statistically significant difference between the two study groups, with a significance value of p = 0.000 (two-tailed, p < 0.05).

Table 6: Represents group statistics for both sample groups. Mean (34.3311, 37.6489), standard deviation (1.65492, 2.30843), Standard error mean (0.39007, 0.54410).

	Groups	N	Mean	Std. deviation	Std. error mean
Compression strength	Without fiber	18	34.3311	1.65492	0.39007
	With fiber	18	37.6489	2.30843	0.54410

Table 7: Independent samples t-test results: Statistically significant difference between the two study groups, with a significance value of p = 0.000 (two-tailed, and "p" < 0.05).

		Levene's test for equality of variances		T-test for equality of means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% CI of the difference	
									Lower	Upper
Compressive strength	Equal variance assumed	2.572	0.118	-4.956	34.00	0.00	-3.31778	0.66948	-4.7832	-1.95724
	Equal variance not assumed			--4.956	34.00	0.00	-3.31778	0.66948	-4.68350	-1.95205

M30 grade concrete was cast with by-product and eco-friendly monofilament fiber as an outcome of the research and was tested for 28-day compressive strength test. The concrete was made by mixing the superplasticizer and polypropylene monofilament fiber into fresh M30 grade concrete. 0.5 water-to-cement ratio was used. The results of the two groups compressive tests were compared. The tests were carried out for 28 days. The impact of various fiber-fortifications on the mechanical properties of typical strength and high strength concrete was explored in this review [9]. In this review, the impact of fiber fortifications on the mechanical properties of typical strength and high-strength concrete was examined. The plan thickness of jointed plain substantial asphalt was then assessed under a similar traffic-stacking conditions utilizing the mechanical properties of cement [10].

Compressive strength of conventional concrete was 34.3311 N/mm^2. Compressive strength of 5% polypropylene monofilament fiber was 37.6489 N/mm^2. Compared to conventional concrete, novel polypropylene monofilament fiber-reinforced concrete had an 8.8% increase [11]. The disadvantage of polypropylene monofilament fiber is that they are sensitive to fire, sunlight, and oxygen, they have a low modulus of elasticity, and they bond poorly with concrete. In future, high strength concrete is required for construction work. Fiber-reinforced concrete is concrete containing fibrous material which increases its structural integrity.

Conclusion

Novel polypropylene monofilament fiber-reinforced concrete has an average strength of 37.6489 N/mm^2. Conventional concrete had a mean compressive strength of 34.3311 N/mm^2. Compared to conventional concrete, novel polypropylene monofilament fiber-reinforced concrete had an 8.8% increase. Comparison of the compressive strength of polypropylene monofilament with superplasticizer added in concrete with conventional concrete with respect to compressive strength and modified concrete gives better results over conventional concrete.

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None.

Conflict of Interest

None.

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