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Experimental Studies in the Flexural Performances of Novel Polypropylene Monofilament Fibers as Additives in Concrete with Conventional Concrete

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Abstract

The research investigates the flexural performance of novel polypropylene monofilament fiber as additive in concrete with conventional concrete. Some of the cement was replaced with novel polypropylene monofilament to strengthen the concrete's flexural properties. The experiments were divided into two groups. Each group includes 18 different specimens. Pretest power is calculated at 80%. In concrete, cement weight replaced 8% of the polypropylene monofilament. A 100 x 100 x 500 mm prism specimen was subjected to an ASTM standard flexural strength test. The specimens were allowed to cure for 28 days at room temperature before being tested for tensile strength. The independent sample t-test was carried out using SPSS (Statistical Package for the Social Sciences) software version 21. The mean flexural strength of polypropylene monofilament novel fiber-reinforced concrete, with an 8% replacement, was 14.9611 N/mm^2, as compared to conventional concrete's 12.9111 N/mm^2. An independent sample t-test was used to analyze the results. The novel polypropylene monofilament fiber-reinforced concrete had an 8% standard deviation that was 0.360. A significance value of $p = 0.000$ (two-tailed, $p < 0.05$) with a statistically significant difference between the two study groups, was noted. When polypropylene monofilament novel fiber-reinforced concrete is used in place of conventional concrete, the strength of the concrete's flexural component significantly increases.

Keywords

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

Introduction

A composite material called polypropylene monofilament reinforced concrete is created by combining concrete of the specified grade and quantities with this fiber. Concrete's strength is increased more than it would be with conventional concrete by the addition of mixed fiber. Concrete that has been hardened may be more durable than unhardened concrete. Today's construction must be more durable while requiring less funding or commitment. Conventional concrete has lower strength ratings and is brittle. More inexpensive and often readily available components were needed to achieve better strength [1]. These supplementary materials ought to be safe and secure for the environment. Precast concrete buildings, such as those for swimming pools, basements, roadways, and bridges. Less expensive composite construction materials are available. Precast concrete is also stronger than regular concrete and less prone to cracking.

According to over 1050 Google Scholar findings, this type of alternative material to concrete can be used by researchers to lessen its environmental impact. Throughout the past five years, there have been about 149 articles on this subject in Google Scholar and 31 in Science Direct. The papers with the highest citation count are "Strength Assessment of Polypropylene Fibre Reinforced Concrete" [2], "Post-Fire Flexural Tensile Strength of Macro Synthetic Fibre Reinforced Concrete" [3], "Near Concentrate on the Flexural Execution of Cement Supported with Polypropylene and Steel filaments" [4], "Flexural Improvement of Plain Concrete prism Strengthened with High-Performance Fibre Reinforced Concrete" [5]. The research mentioned has done an extensive study on fiber-reinforced concrete with polypropylene fiber. That is one of the advantages discovered when consulting journal papers, despite the fact that only a few writers published the journal's paper with various grades of concrete [6].

The research's findings show that M30 grade concrete reinforced with 8% novel polypropylene monofilament fiber works best. The strength values of the concrete are improved by this combination, and this experiment was designed to determine the effects of those combinations. The use of such materials helps to preserve healthy environmental conditions as well as the conservation of natural resources by successfully utilizing these by-products.

Materials and Method

In Concrete Lab, Department of Civil Engineering at Saveetha School of Engineering served as the site of this study. Sample size was calculated by ClinaCalc. The experiments were divided into two groups. Each group contains 18 different specimens. Pretest power is calculated at 80%. There is a genuinely massive distinction between the two review gatherings, with an importance worth of $p = 0.000$ (two-followed, $p < 0.05$). Conventional concrete had a standard deviation of 0.66145 while it was 0.81684 in novel polypropylene monofilament fiber-reinforced concrete. Group 1 was prepared with 8% replacing novel polypropylene monofilament fiber-reinforced concrete and the other with conventional concrete. Eighteen samples were prepared per group. The materials used to prepare concrete are shown in figure 1.

Concrete prism sized 100 x 100 x 500 mm were prepared to evaluate the concrete's flexural strength. The first group was created using cement that included 8% additional novel polypropylene monofilament fiber than usual. Ramco cement (OPC 53 grade) with the following parameters was used: 3.15 specific gravity, 31.5% consistency, 30 min of initial setting time, and 600 min of final setting time, and 2.8 of soundness. Local M-sand that passed through a 4.75 mm sieve and had a specific gravity of 2.613 and a fineness modulus of 2.746 was used as a fine aggregate. The coarse aggregate, which is crushed stone from a quarry that has been broken into small pieces and has an irregular shape, is utilized in the project, and has a size of 20 mm, with sieve passes through 80 mm, 40 mm, 20 mm, etc. Table 1 shows the properties of cement, whereas table 2 and table 3 include the major properties of fine aggregate and coarse aggregates, respectively.

Both groups should have the mix design for concrete of the M30 grade evaluated using the Indian standard method (IS 10262-2009), and the required materials must then be manually prepared in groups. For group 1, the required materials should be prepared as for conventional M30 concrete in wet conditions, and the compaction procedure should also be made manually by using a tamping rod. Vibration is also used during the casting procedure to eliminate the air spaces from the concrete specimen. A similar procedure should be followed for group 2 as well, with the exception of utilizing 8%

Table 1: Cement - Physical properties.

S. No.	Properties	Result
1	Fineness of cement	90 microns
2	Specific gravity of cement	3.153
3	Consistency of the cement	31.5%
4	Initial setting time	30 min
5	Final setting	600 min

Table 2: Properties of fine aggregate.

S. No.	Properties	Result
1	Size of the sample	4.756
2	Results of sieves analysis	2.567
3	Water absorption test	2.97%
4	Results of specific gravity	2.727

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

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

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

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

Table 3: Properties of coarse aggregate.

S. No.	Name of the test	Result
1	Size of the coarse aggregate	20 mm
2	Sieve analysis test	20 mm
3	Water absorption of coarse aggregate	3.145%
4	Specific gravity of coarse aggregate	2.647

novel polypropylene monofilament fiber and casting concrete specimens in a prism mold.

During sample preparation and during the curing process, specimens are removed from the mold. Figure 2 shows the casting of the prism in mold (a), workability test (b), curing process of the concrete prism (c), and polypropylene monofilament fiber concrete (d). Using a tensile load testing machine, the flexural strengths of both the conventional concrete and the fiber reinforced concrete were assessed after 28 days of curing. It is best to progressively add 140 kg/cm^2 of stress per minute until the specimen collapses before calculating the flexural strength. Figure 3 shows the tensile testing machine used to collect data on flexural strength.

Figure 3: The data on flexural strength were collected using a tensile testing machine.

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 concrete with conventional concrete. The independent-samples t-test approach automates the estimation of the t-test effect size while comparing the means for two groups of instances. The findings of the experiment were examined using the SPSS 22 software, as shown in figure 4.

An independent t-test sample was utilized to ascertain the statistical significance between the study and control groups. There were no dependent factors in the study; the variables that affected flexural strength included concrete grade, water/cement ratio, cement grade, and days of curing. Utilizing this device, it was likewise conceivable to compute the flexural strength's mean, standard deviation, and standard mistake of the mean. There is a measurably tremendous contrast between the two review gatherings, with an importance worth of p = 0.000 (two-followed, p < 0.05). Conventional concrete had a

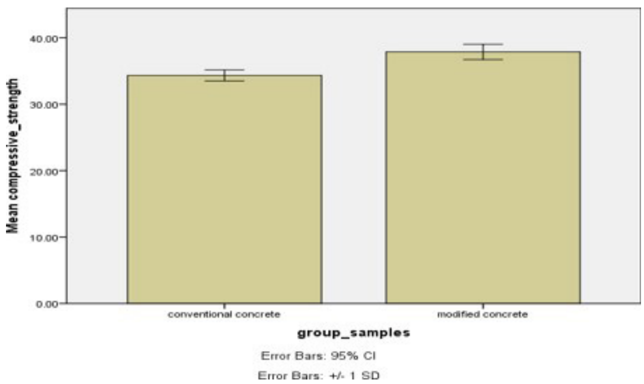

Figure 4: The mean flexural strength of traditional concrete and 8% fiber-built up concrete is examined utilizing a bar diagram. 8% substitution of polypropylene in substantial shows better precision contrasted with customary cement. The Y hub shows mean flexural strength, the X pivot the gathering test, and the mean exactness of recognition is +/-1 standard deviation.

Table 4: Represents group statistics for both sample groups. Mean (12.9111, 14.9611), Standard deviation (0.66145, 0.81684), Standard error mean (0.15591, 0.19253).

	Groups	N	Mean	Std. deviation	Std. error mean
Flexural strength (N/mm^2)	Without fiber	18	12.9111	0.66145	0.15591
	With fiber	18	14.9611	0.81648	0.19253

standard deviation of 0.66145 while it was 0.81684 in novel polypropylene monofilament fiber-reinforced concrete.

Results

The novel polypropylene monofilament fiber-reinforced concrete had a mean flexural strength of 14.9611 N/mm^2, compared to conventional concrete's mean flexural strength of 12.9111 N/mm^2. Flexural strength in conventional concrete had a standard deviation of 0.66145 while it was 0.81684 in novel polypropylene monofilament fiber-reinforced concrete in table 4. The significance of strength according to Levene's test for equality of variances was 0.360 for the 18 samples in table 5 of flexural strength values. Table 6 shows the flexural strength values of 18 samples made without conventional concrete. The flexural strength values of 18 samples made without conventional concrete are shown in table 7.

Table 5 shows the results of the independent samples t-test. For the comparison of mean accuracy values between two groups of conventional concrete and novel polypropylene monofilament fiber-reinforced concrete, the error bars with the mean accuracy detection +/-1 standard deviation was shown in figure 4. An importance worth of p = 0.000 (two-followed, $p < 0.05$) with a measurably tremendous contrast between the two review gatherings, was noticed.

Discussion

In comparison to conventional concrete, the novel polypropylene monofilament fiber-reinforced concrete with added superplasticizer showed a 15.9% increase in flexural strength. Concrete's permeability is decreased, and its strength is increased by the addition of fiber. It was determined that the polypropylene monofilament fiber reinforced with superplasticizer had a larger standard deviation of flexural strength than conventional concrete. It shows that the novel polypropylene monofilament fiber-reinforced concrete with a superplasticizer has a greater variation in flexural strength from its mean value. There was a statistically significant difference between the two research groups, with a significance value of p = 0.000 (two-tailed, $p < 0.05$).

Table 5: Independent samples t-test results: Statistical significance difference observed for flexural strength in an independent sample t-test. Statistically significant difference between the two study groups, with a significance value of p = 0.000 (two-tailed, $p < 0.05$).

		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
Flexural strength	Equal variance assumed	0.86	0.360	-8.275	34	0.000	-2.0500	0.247	-2.5534	-1.546
	Equal variance not assumed			-8.275	32.591	0.000	-2.0500	0.247	-2.5542	-1.546

Table 6: Flexural strength (N/mm^2) of conventional concrete.

Flexural strength for 28 days	Average flexural strength for 28 days
13.4	12.91
13.7	
13.6	
13.5	
13.1	
11.4	
12.8	
12.1	
13.7	
12.5	
12.7	
13.6	
12.5	
12.2	
12.2	
13.4	
12.9	
13.1	

Table 7: Flexural strength (N/mm^2) of novel polypropylene fiber-reinforced concrete (Modified concrete).

Flexural strength for 28 days	Average flexural strength for 28 days
14.9	14.96
16.3	
15.1	
16.1	
14.6	
14	
14.3	
14.7	
15.2	
15.1	
14.2	
16.2	
14	
14.8	
13.7	
16	
14.9	
16.3	

It is a more modern interpretation of M30 grade concrete that was created as a result of research. A 28-day tensile strength test was carried out to create and test it. The concrete was made by adding superplasticizer and polypropylene monofilament fiber to freshly mixed M30 grade concrete. A water-to-cement ratio of 0.5 was used in this study. The results of the two groups flexural tests were compared. The author discusses the use of mineral additives such as polypropylene monofilament fiber and accelerator, superplasticizer, and air-entraining agent in his paper. The tests were completed in 3, 7, and 28 days.

The standard concrete has a flexural strength of 12.81 N/mm^2. The innovative polypropylene monofilament fiber-reinforced concrete has a mean flexural strength of 14.91 N/mm^2. The disadvantages of polypropylene monofilament fiber include its low elastic modulus and subpar bonding abilities with concrete, as well as their vulnerability to fire, sunlight, and oxygen [7, 8]. The structural stability of concrete that has been strengthened with fibrous material is higher. High strength concrete will be required for future construction projects.

Conclusion

The normal flexural strength of the substantial built up with polypropylene monofilament strands is 14.911 N/mm^2. The average flexural strength for conventional concrete was 12.91 N/mm^2. Compared to conventional concrete, novel polypropylene monofilament fiber-reinforced concrete had 15.9% increase. When the flexural strength of conventional concrete is compared to that of polypropylene monofilament with a superplasticizer added, modified concrete outperforms conventional concrete, according to the study.

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None.

Conflict of Interest

None.

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