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Research Article

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Improvement of Concrete Strength by Addition of Novel Polypropylene Fiber in Comparison with Compressive Strength of Conventional Concrete

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Abstract

Aim: The major objective of this study is to increase the strength of ordinary cement concrete by adding novel polypropylene fiber by cement weight.

Method: A study of the impact of extra novel polypropylene fiber in regular Portland cement concrete has been attempted in an effort to enhance these attributes of plain concrete.

Results: Through the use of a compressive strength test at 28 days for concrete of the M25 grade, 4% of fibers in this experimental inquiry have been examined for their impact on the strength characteristics of concrete. The concrete cube mould size was taken as 150 mm x 150 mm x 150 mm cubical steel mold. The findings of the tests indicate that concrete with novel polypropylene fiber performs better than concrete alone. With the addition of novel polypropylene fiber to regular Portland cement concrete, the findings have shown an increase in compressive strength. Concrete added with novel polypropylene fiber at 4% had a mean compressive strength of 30.24 N/mm^2, compared to conventional concrete's 27.46 N/mm^2. The outcomes were examined using an independent sample t-test. Two groups of 36 samples taken for the test. The novel polypropylene fiber standard deviation for concrete was 4% and was 0.91737. The SPSS carried out has a significance of 0.000 ($p < 0.05$). This shows that there are the two groups' statistically significant differences considered in this study.

Conclusion: The results of the experimental study led to the conclusion that adding fibers to the concrete mixture very slightly increases the compressive strength.

Keywords

Novel polypropylene fiber, Cement, Coarse aggregate, Compressive strength, M25 grade, Concrete, Conventional concrete, Water

Introduction

Polycarboxylates (PCE) is a type of nanomaterial utilized in concrete, particularly as a high-range water reducer [1]. It is essentially a polymer composed of methoxy-polyethylene glycol copolymer acting as a secondary or side reaction, reinforced with methacrylic acid copolymer as the main component [2]. The carboxylate group within PCE provides a negative charge along its backbone, while the polyethylene oxide group contributes to a non-uniform distribution of electron cloud, imparting chemical polarity to the secondary or side reaction [3]. The length and number of secondary reactions can be adjusted easily, but excessive electron units in these reactions may reduce their molar mass, affecting the polymer's density and resulting in poor performance in cement suspensions [4].

In concrete applications, PCE serves to control the workability of concrete at low water-to-cement ratios [5-7]. Its inclusion can lead to the production of

self-compacting concrete, which enhances workability and produces a flowable concrete, particularly beneficial in low and high-intensity placement areas [8-10]. Additionally, PCE aids in marine structure applications by improving concrete density through air bubble removal, thereby reducing pores or voids in ultra high-performance concrete (UHPC) and providing a more compact structure. This refinement of the microstructure reduces permeability, mitigating the effects of seawater elements like sulfates and chlorides [11-13].

The utilization of PCE is considered environmentally friendly compared to other additives like silica fume. Studies have shown that incorporating PCE in high strength concrete improves workability and performance compared to silica fume. Moreover, PCE can reduce dependency on other materials in UHPC by up to 70%, including silica fume, superplasticizers, and fibers [14]. The inclusion of PCE in UHPC significantly enhances strength performance, with reports indicating rapid strength gains at early ages, such as doubling the strength from 40 to 80 MPa within one day [15]. By day 28, strengths of 70 - 100 MPa can be easily achieved with lower PCE dosages, demonstrating its efficacy as an alternative admixture for enhancing concrete strength. Its ease of handling and minimal guidelines or techniques required make PCE a popular choice among nano materials for adoption in UHPC [16].

In conventional concrete, nanomaterials were believed to improve strength [17]. Due to the improved dispersion of nanomaterials in concrete, the use of PCE shows improved mechanical properties. In addition to the agglomeration caused by carbon nanotubes, PEC compressive strength, slump value, consistency, etc. have been improved [18]. Silica nanoparticles are generally made from microparticles. It is similar to the performance strength and durability enhancements created by micro or nano silica in UHPC. Nano silica was added to concrete to increase its strength compared to silica fume alone. The use of nano alumina in concrete has been studied only in a limited number of studies. Concrete properties can be greatly affected by nano alumina in concrete, especially UHPC, since it controls cement setting time [17].

Materials and Method

The Saveetha School of Engineering in Chennai's Civil Engineering Department completed the entire project. The following samples were created by molding each mixture in accordance with the goals of the related tests and this study: Five 150 x 150 x 150 mm cubes of each size, each mixed with 4% by volume of cement for traditional concrete and novel polypropylene fibers, were used to evaluate the compression test. Figure 1 depict the polypropylene fiber materials and cement.

The construction of a concrete cube mold is shown in figure 2. The concrete was put in two layers and, in order to accomplish the best consolidation and compaction, vibrated at a frequency of 50 Hz.

The curing of specimens in the fog room takes place having a temperature range between 22 °C - 24 °C. In the fog room, where the temperature ranges from 22 °C to 24 °C, specimens are cured. Concrete cube curing is depicted in figure 3.

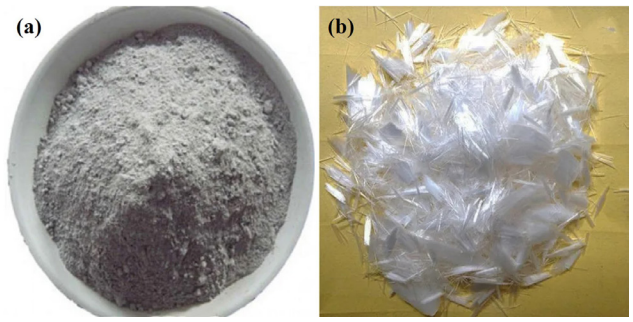


Figure 1: (a) Cement and **(b)** Polypropylene.



Figure 2: Preparing of cube molds.

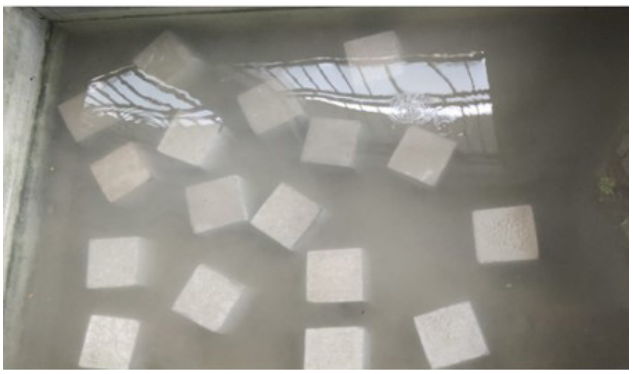


Figure 3: Curing of concrete cubes.

The samples underwent a 28-day temperature cure in a regulated water tank after being extruded. Seven distinct combinations were taken into consideration since the study's goal was to explore the performance characteristic of FRC. The proportion of fiber by volume in each combination, with consistent amounts of water, admixture, fine and coarse aggregate, and cement content. The effectiveness of the fiber reinforcing can be assessed using two parameters, namely the composite's increased strength and toughness when compared to its brittle matrix. The confidence interval is 95%, alpha value is 0.02 and beta is 0.05. The standard deviation and mean to be found through the independent t-test results mentioned in the statistical report.

Two varieties of "novel polypropylene fiber" were utilized to study the effects of different fibers and their volume fractions in concrete matrices. The M25 mix design, which was used as a reference for concrete mixes, was determined to be the best mix design for the purposes of the current study. With

a melting point of 165, novel polypropylene can withstand temperatures of up to around 1005 ˚C for a brief length of time before weakening. Since this substance is inert by nature, any chemical that may injure novel polypropylene fibers would be extremely detrimental to the concrete mix. Figure 4 shows the compressive strength result from using the compression testing equipment. The novel polypropylene fibers have the ability to withstand oxygen or ultraviolet ray deterioration. However, these solutions can be abandoned in concrete after mixing with fibers. Compressive strength measurements were made utilizing.

Statistical analysis

The results of the experiment were examined using SPSS version 26 software. An independent sample t-test was used to ascertain the statistical significance between the study and control groups. The study's independent variables are the following: curing days, cement quality, water to cement ratio, compressive strength, and concrete quality. There are no dependent variables. Using this tool, the compressive strength, mean, constant deviation, and constant error of the mean were all calculated. There is a statistical significance difference observed for compressive strength in an independent sample t-test p = 0.000 as it is less than p = 0.05. The bar chart for comparing conventional and modified concrete is shown in figure 5 with a mean accuracy of detection of ± 1 standard deviation. The group of conventional concrete and modified concrete is displayed on the X-axis. In N/mm², the Y-axis displays the average compressive strength.



Figure 4: The compressive strength result from using the compression testing equipment.

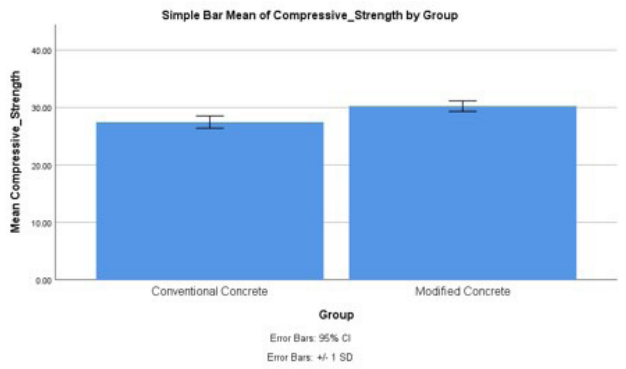


Figure 5: Analysis of the mean compressive strength of modified and conventional concrete using a bar chart. When compared to traditional concrete, the novel concrete with polypropylene added exhibits a stronger result. The average detection accuracy is ± 1 standard deviation. The group of conventional and modified concrete is displayed on the X-axis. N/mm² is the mean compressive strength displayed on the Y-axis.

Results

The results showed that adding novel polypropylene fiber to regular Portland cement concrete improved its compressive strength and flexural strength. The mean compressive strength of 4% addition of novel polypropylene fiber with concrete was 30.24 N/mm² and the compressive strength of conventional concrete was 27.46 N/mm². Independent sample t-test was performed to analyze the results. Group data for a 10% polypropylene fiber concrete sample group. Standard deviation (1.07541, 0.91737), mean (27.4633, 30.2422), and standard error mean (0.25348, 0.21623). Results of the independent samples t-test for concrete with 10% polypropylene fiber: Compressive strength did not show a statistically significant difference in an independent sample t-test (p = 0.000), since it was higher than p = 0.05. Standard deviation for 4% addition of novel polypropylene fiber with concrete was 0.91737. The event's significance was p = 0.000 (p < 0.05). The compressive strength of typical concrete of M25 grade is shown in table 1. Table 2 also displays the compressive strength of concrete with new polypropylene added that is M25 grade.

Table 3 compares the results of the conventional concrete and conventional concrete with Levene's test for equality of variances 4% polypropylene added to it, with a p-value of 0.05 and an error of 95%. Table 4 displays the analysis of the group statistics.

Discussion

Similar to random distribution along the length of the structural member, the fiber reinforcement can be applied in a variety of ways. The rise in shear resistance value, which fur-

Table 1: Compressive strength result of M25 grade conventional concrete.

Mix type	Compressive strength (N/mm²)	
	Load	28 days
Conventional concrete	624	27.73
	627	27.87
	628	27.91
	620	27.56
	631	28.04
	613	27.24
	634	28.18
	606	26.93
	637	28.31
	599	26.62
	640	28.44
	592	26.31
	643	28.58
	585	26.00
	646	28.71
	578	25.69
	649	28.84
	571	25.38

Table 2: Compressive strength result of M25 grade modified concrete.

Mix type	Compressive strength (N/mm²)	
	Load	28 days
Modified concrete	682	30.31
	694	30.84
	686	30.49
	687	30.53
	689	30.62
	680	30.22
	692	30.76
	673	29.91
	695	30.89
	666	29.60
	698	31.02
	659	29.29
	701	31.16
	652	28.98
	704	31.29
	645	28.67
	707	31.42
	638	28.36

ther controls crack, is an advantage of this modification. In addition, if the fiber reinforced concrete is orientated dimensionally, it can be employed as tensile members to balance the steel reinforcement. conventional concrete strengths at standard pressure and temperature.

Strength of steel fiber reinforced concrete compared to regular plain cement concrete. Comparison of the strengths of novel polypropylene fiber reinforced concrete and regular plain cement concrete. Strengths of steel and a novel polypropylene fiber reinforced concrete are compared to one another. Comparative statistical methods that are helpful for all strengths, including those of traditional concrete and with the time allotted and the laboratory set up available, efforts have been made in this study to clarify how to employ so-called fiber reinforced concrete to the best of their abilities. It was determined: Using a superplasticizer, it is possible to obtain a mix with a low cement to water ratio and still achieve the appropriate strength. The maximum result for 28 days of compressive strength at 3% fiber content was achieved in the case of ordinary Portland cement using steel fiber.

The compressive strength of novel polypropylene fiber in nominal concrete is 11% lower than that of steel. The compressive strength gradually rises after 1%, 2%, and 3% of mixing fibers (i.e., steel and novel polypropylene). Increasing the percentage of fibers for both aspect ratios will therefore result in small variations. Compressive strength alters the maximum limit in aspect ratio 60 as aspect ratios change, such as 50 and 60. This demonstrates that more fiber length will result in greater compressive strengths. No changes in strength will occur if there is no mixing of the fibers. Because novel polypropylene has the highest flexural strength, employing its fibers for casting beams is beneficial. For novel polypropylene fibers, the fiber orientations also produce good results. because it is more flexible and capable of resisting loads that are evenly distributed than steel. Steel and novel polypropylene fibers exhibit a significant difference in flexural strength for aspect ratios of 60 and 60. When comparing steel and novel polypropylene, the split tensile strength for aspect ratio 50 varies by 10%. In contrast, there is a 20% fluctuation in aspect ratio for 50 innovative polypropylene fibers. A large difference between steel and novel polypropylene fibers may be seen in the flexural strength for aspect ratio 60. When comparing the split tensile strength for materials with an aspect ratio of 50, steel and novel polypropylene differ by 10%. As opposed to aspect ratio 50, where there is a 20% difference in the same. The property of plasticity FRCs in novel polypropylene fibers makes them more effective in tensile zones.

Table 4: Group statistics for a sample group of 10% novel polypropylene fiber concrete. Mean (27.4633, 30.2422), standard deviation (1.07541, 0.91737), and standard error mean (0.25348, 0.21623).

	Group	N	Mean	Std. deviation	Std. error mean
Compressive strength (N/Mm²)	Conventional concrete	18	27.4633	1.07541	0.25348
	Modified concrete	18	30.2422	0.91737	0.21623

Conclusion

The mean compressive strength of concrete with 4% novel polypropylene fiber addition was 30.24 N/mm², the conventional concrete compressive strength of 27.46 N/mm². This compressive strength test results shows the better performance while adding the fiber in concrete and gives a more durability and stability to the concrete. Compressive strength improved by 10.12% as compared to conventional concrete.

Table 3: Independent samples t-test results for 10% novel polypropylene fiber concrete: There is a statistical significance difference observed for compressive strength in an independent sample t-test p = 0.000 as it is less than p = 0.05.

Load	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
Equal variance assumed	0.779	0.384	-8.341	34	0.000	-2.77889	0.33317	-3.45598	-2.10180
Equal variance not assumed	-	-	-8.341	33.176	0.000	-2.77889	0.33317	-3.45598	-2.10180

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None.

Conflict of Interest

None.

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