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Effect Of Novel Polypropylene Fiber and Natural Fiber Based Concrete Compared to Conventional Concrete with Respect to Flexural Strength

Eslavatha Thanmy* **and Muniyandi Tholkapiyan**

Department of Civil Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamil Nadu, India

***Correspondence to:**
Eslavatha Thanmy
Department of Civil Engineering,
Saveetha School of Engineering,
Saveetha Institute of Medical and Technical Sciences, Saveetha University,
Chennai, Tamil Nadu, India.
E-mail: sakthiveltg.sse@saveetha.com

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Abstract

This study's primary goal is to increase the strength of plain cement concrete. An effort has been made to research the impact of extra polypropylene fiber in regular Portland cement concrete in an effort to enhance these features of plain concrete. In this experimental investigation, flexural strength tests and flexural strength tests at 28 days for concrete of the M25 grade were conducted to determine the effects of fibers in various percentages (between 3 and 4%). The flexural beam size was taken as 500 mm x 100 mm x 100 mm. According to test results, concrete with polypropylene fiber demonstrates superior performance than concrete without fiber. Comparison of both polymers reinforced concrete beam and conventional concrete beam mean value is (13.0372, 14.4730, and 16.0122), standard deviation is (0.20096, 0.29784), and the standard error is (0.04737, 0.07020). The SPSS (Statistical Package for the Social Sciences) carried out has a significance of 0.000 ($p < 0.05$). This shows that there is a statistically significant difference between the two groups considered in this study. Fiber insertion much more improves the flexural strength of concrete.

Keywords

Novel polypropylene fiber, Natural fiber, Cement, Flexural strength, M25 grade, Concrete

Introduction

Typically, concrete is not made to withstand direct tension. Multi-axial states of stress may also produce principal tensile stresses [1]. In the absence of any fibers, concrete will crack due to volume fluctuations, drying shrinkage, and plastic shrinkage [2]. Concrete often cracks when tensile strength exceeds its limiting value. To overcome this low tensile strength, there are two options: pre-stressing or using reinforcement [3]. With or without rebar, modern reinforced concrete can include a variety of reinforcing components consisting of steel, polymers, or alternative composite materials [4].

About 17,100 results from Google Scholar for the past five-year research in this area by various researchers and scientists. One of the most successful commercial applications has been novel polypropylene fiber. The "Secondary Reinforcement" of the new generation for the construction industry is called Recron 3s [5]. Additionally, cellulose is resistant to the alkaline conditions present in cementitious paste, ensuring that the material's durability won't deteriorate with time. Additionally, because of a more refined matrix as the cementitious matrix continues to solidify over time, it will further embed the cellulose [6]. The action of a fiber that has not mechanically or chemically adhered to the concrete's hardened matrix is referred to as fiber pull-out. If the fiber is engaged through the paste during the application of service loads, the lack of bond at the fiber's interface with the toughened will render the fiber worthless [7]. The fiber will be extracted from the hardened matrix and provide very little resistance to the tensile loads that it was designed to withstand [8]. The nanomaterials such nano scale fibers have prolonged and constructive effects over the composites.

This novel natural cellulose fiber for concrete is produced from a specific plant species in the alpine region using a special chemical and mechanical processing method. Polypropylene fibers, also known as novel polypropylene fiber, are utilized in a wide range of products, such as clothing, automobile parts, and packaging [9]. It is the perfect reinforcement material because it is incredibly strong and resistant to various chemical solvents, bases, and acids [3]. Novel polypropylene fiber is frequently used to make plastic hinges, such as those on flip-top bottles, since it is fatigue-resistant. Due to its great heat resistance, it is also frequently employed in the production of kettles and food containers [10]. Due to its excellent colorfastness, lightness, and strength, the material is also used to create carpets, rugs, mats, and rope. Other nonwoven products made of novel polypropylene fiber include filters, diapers, sanitary towels, medical mesh, and face masks.

Materials and Method

The entire project work has been carried out in the department of Civil Engineering at Saveetha School of Engineering, Chennai (Tamil Nadu, India). Cement: According to IS 8112-1989, ordinary Portland cement of grade 53 was utilized. Utilizing the specific gravity bottle, it was determined that cement has a specific gravity of 3.26. Fine aggregate: 4.75 mm and smaller natural river sand that complies with zone 3 of IS 383-1970 was used. The tests listed below were performed to confirm that zone 3 of IS 383-1970 was used while using natural river sand with a size of 4.75 mm or less as the fine aggregate. Figure 1 shows the cement and figure 2 shows the novel polypropylene fiber. The following tests were being run. 20 mm and 10 mm natural crushed stones were used as coarse aggregate.

Figure 1: Cement.

(a) **(b)**

Figure 2: (a) Novel polypropylene fiber and **(b)** Novel natural cellulose fiber.

Testing was done on the specific gravity, water content, free surface moisture, and water absorption. Water For mixing and curing purposes in this experiment, regular portable water was used. Beam mold preparation is shown in figure 3. The confidence interval (CI) 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.

In Haryana's Faridabad, Recron 3s fiber was purchased from Kunal Conchem Pvt. Ltd. The Recron 3s fiber had an aspect ratio of roughly 320, a diameter of 34 microns, and a length of 12 millimeters. In this study, weight batching and machine mixing are used to produce concrete for concrete's M25 grade of flexural strength. Hand mixing and casting of beams were also used. Nine beams, each measuring 500 x 100 x 100 mm were cast for each proportion. After adding coarse particles, 25% of the entire amount of water was added. Figure 4 shows the casting of flexural strength. The fibers and sand were then combined with the remaining 25% of the water.

Before adding cement and the last half of the water, the aggregates were thoroughly mixed. Using a slump test, the workability of each mixture was assessed. A total of 33 beams, including one each for the control mix and fiber-reinforced concrete, were cast. After being prepared, the mixture was

Figure 3: Preparing of flexural molds.

Figure 4: Casting of flexural beams.

squeezed onto a vibration table. After casting for 24 h, remodeling was completed. A curing tank was used to cure the specimens. The method of cure by immersion in water was used. Beams underwent a 28-day treatment. The flexural beam's testing setup is shown in figure 5.

Statistical analysis

SPSS version 26 software was used to examine the experiment's findings. To determine the statistical significance between the study and control groups, an independent sample t-test was conducted. M25 grade of flexural strength, concrete quality, water to cement ratio, cement quality, and curing days are all independent factors in the study; there are no dependent variables. This tool was used to compute compressive strength and to calculate the mean, constant deviation, and constant error of the mean. There is a significant difference and the p = 0.000 i.e., less than 0.05. Figure 6 shows the bar chart analysis of mean flexural strength of conventional concrete and modified concrete. The novel polypropylene fiber added concrete shows an increase in strength compared to conventional concrete. Mean accuracy of detection=+/- 1 standard deviation.

Results

Figure 5: Flexural strength testing arrangements.

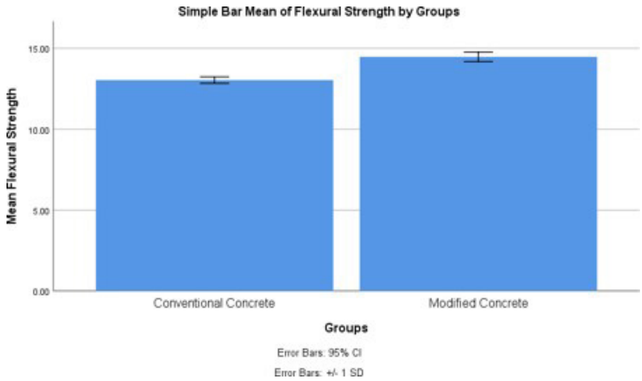

Figure 6: Bar chart analysis of mean flexural strength of conventional concrete and modified concrete. The novel polypropylene fiber added concrete shows an increase in strength compared to conventional concrete. Mean accuracy of detection = +/- 1 standard deviation. X-axis shows the group of conventional concrete and modified concrete. Y-axis shows the mean flexural strength in N/mm².

The mean flexural strength of M25 grade was found out for both the groups. The flexural strength of group-1 conventional concrete sample is 13.035 N/mm² and the flexural strength of group-2 novel polypropylene fiber and natural fiber concrete specimen sample is 14.473 N/mm². The flexural strength of M25 grade was found to be increased in group-2 when compared with group-1 samples. The increment in the M25 grade of flexural strength of the group-2 was 1.44 N/mm². Table 1 shows the flexural strength test result of conventional concrete @ 28 days of specimen. Table 2 shows the flexural strength test result of modified concrete @ 28 days of specimen. Table 3 shows the group statistics. Table 4 shows the mean, standard deviation, and significance difference of the group-1 and group-2 are shown. There is a significant difference between the groups (Independent sample t-test).

Discussion

The concrete mix saturates the surface of the concrete

Table 1: Flexural strength result of M25 grade concrete for conventional concrete.

S. No.	Conventional concrete flexural strength (N/mm²)
1	13.04
2	12.87
3	12.93
4	13.01
5	13.00
6	13.02
7	12.97
8	13.12
9	13.57
10	12.95
11	13.09
12	12.88
13	13.31
14	12.9
15	12.77
16	13.24
17	13.23
18	12.77

Table 4: Mean, standard deviation, and significance difference of the group-1 and group-2 has shown here. There is significance difference between the groups (Independent sample t-test). The p-value is 0.000 and it is less than 0.05. Hence it is statistically significant.

Flexural strength	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	2.909	0.097	-16.954	34	0.000	-1.43578	0.08469	-1.60788	-1.26367
Equal variance not assumed	-	-	-16.954	29.822	0.000	-1.43578	0.08469	-1.60878	-1.26278

Table 2: Flexural strength result of M25 grade concrete for novel polypropylene fiber and natural fiber added concrete.

S. No.	Flexural strength (N/mm²)
1	13.990
2	14.670
3	14.510
4	14.867
5	14.313
6	13.996
7	14.417
8	14.576
9	14.663
10	14.676
11	14.415
12	14.919
13	14.731
14	14.510
15	14.336
16	13.876
17	14.319
18	14.730

Table 3: Group statistics.

	Groups	N	Mean	Std. deviation	Std. error mean
Flexural strength	Conventional concrete beam	18	13.0372	0.20096	0.4737
	Polymer reinforced concrete beam	18	14.4730	0.29784	0.7020

fiber when it is combined with fluid concrete [1]. The fiber is mechanically fixed into the paste-hardened concrete as it cures and hardens. Similar to how cementitious paste hardens around sand and rock grains, this phenomenon occurs [10]. Where the sand, rock, and fiber effectively contribute to the composite concrete [11]. A comparison of regular concrete mix and concrete mix combined with artificial fibers showed that fibers were superior at enhancing tensile strength [12]. After 28 days, the average tensile strength of Recron 3s continued to rise, rising by 0.3% to 16.45%. Recron 3s fiber increases the continuity, integrity, and long-term tensile strength of concrete, which is beneficial for the resilience and security of concrete constructions [13]. Recron 3s fibers, when added to fresh concrete in a small volume percentage, reduce surface permeability, stop microcracks from forming and spreading, and stop cement from bleeding. Due to its low permeability, it is more durable and corrosion-resistant [11].

The study found that deflective strength tests performed best with a 0.5 water cement ratio and a 2 percent addition of coconut fiber [14]. The incorporation of coconut fiber can enable a structural component to withstand twice its load without failing as observed in the test reported. It reveals that adding coconut fiber to concrete boosts not just its strength but also its ability to withstand severe loads [15]. It also retains the concrete in place even after failure, which is a characteristic that can be investigated for future usage, particularly in seismic zones and other hazardous conditions.

Conclusion

Comparison of the flexural strength of novel polypropylene fiber and natural fibers added concrete with conventional concrete with respect to flexural strength and modified concrete gives the better results over conventional concrete. The novel polypropylene fiber and natural fiber added concrete has 11.03% increased over than the conventional concrete. It shows better performance in flexural strength.

Acknowledgements

None.

Conflict of Interest

None.

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