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Influence of Novel Cellulose Fiber Based Concrete Compared with Conventional Concrete with Respect to Compressive Strength

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Abstract

The main objective of this study is to conduct an experimental analysis of the mechanical characteristics of concrete reinforced with new cellulose fibers. The natural fiber, which had an average length of 30 mm, was blended in at a mass ratio of 2% and 3% with M25 grade concrete. River sand is used as a fine aggregate, and 20 mm blue metal is used as a coarse aggregate. With an increasing proportion of novel cellulose fiber, the compressive strength of the created concrete samples with cellulosic fiber reinforcement gradually increased. The results might be examined using the independent t-test reports created by the SPSS (Statistical Package for the Social Sciences) program version 26. Using the independent-samples-t-test method, the statistical report of the conventional and modified concrete was compared. G-power value $p < 0.05$ significant p-value i.e., $p = 0.000$ There isn't much of a difference. The mean value (27.4633, 30.2422), standard deviation (1.07541, 0.91737), and mean standard error (0.25348, 0.21623) were obtained using group statistics using SPSS version 26. As an innovative building material, the commercial usage of natural fiber-reinforced concrete for interior or exterior pavements and flooring slabs is possible. Additionally, this study comes to the conclusion that novel cellulose fiber reinforced concrete has superior compressive strength than regular concrete. This might improve durability and lessen shrinkage fractures.

Keywords

Novel cellulose fiber, Concrete, Compressive strength, M25 grade concrete, Fine aggregate, Coarse aggregate

Introduction

Due to environmental issues brought on by global warming, there has been a fast rise in research and invention in the field of novel natural fiber composites. These materials' benefits over rivals like synthetic fiber composites, which include low environmental impact, low cost, and support for their potential in a wide range of applications, justify interest in them. Much work has been done to enhance the mechanical performance of this group of materials in an effort to expand their capabilities and applications [1]. In addition to outlining accomplishments made using natural fiber composites, this paper seeks to give a general overview of the variables influencing their mechanical performance and durability performance. Some of the paste volumes of the concrete mix saturate the surface of the concrete fiber when it is combined with fluid concrete [2]. 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 [3]. The novel cellulose fibers include jute, ramie, flax, hemp, and cotton. The most common synthetic cellulose fiber is rayon, which is generated by regenerating dis-

solved cellulose. Novel cellulose fiber has special qualities that make it stand out from other cellulose fibers, including natural hydrophilicity, excellent gripping power, a sizable surface area dedicated to the fiber, high toughness, and strength, Under the influence of external force and water immersion, a significant amount of evenly distributed fine fibers are created, which can successfully stop cracks from developing in concrete caused by plastic shrinkage, dry shrinkage, and temperature changes [4].

About 17,100 results from Google Scholar for the past five-year research in this area by various researchers and scientists. Where the sand, rock, and fiber effectively contribute to the composite concrete. The production of concrete fiber uses a variety of ingredients. Concrete performance characteristics and benefits particular to a work type are produced by the various materials used [5]. A fiber's effectiveness in concrete is typically determined by two factors: form and material type. Due to their high fiber surface area, compact fiber spacing, and strong bonding with the hydrated cementitious matrix, novel cellulose fibers are excellent at controlling cracks [6]. To strengthen surface durability against plastic shrinkage cracking and impact resistance, novel cellulose fibers are employed [7].

Additionally, cellulose is resistant to the alkaline conditions present in cementitious paste, ensuring that the material's durability won't deteriorate with time [8]. Additionally, because of a more refined matrix as the cementitious matrix continues to solidify over time, it will further embed the cellulose. 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 [9]. It has natural hydrophilicity, high strength, and high modulus properties, as well as strong surface gripping power because plant cells naturally divide rather than artificially.

Materials and Method

The conventional concrete material is cement 53-grade ordinary Portland cement, river sand as fine aggregate, and 20 mm coarse aggregate. A total of 18 samples were prepared such as 150 x 150 mm concrete cubes. The prepared cubes are oiled well and poured concrete in the cube. After casting, 24 h are needed to dry and placed in the curing pond for 28 days. Figure 1 shows the cement. The heat hydration process will be done at that stage. The same procedure is for modified concrete specimens i.e., natural fiber added to concrete. The novel cellulose fiber added in concrete is 2% and 3% in that mass of cement and m sand is used as a fine aggregate. Figure 2 shows the novel natural cellulose fiber. After 28 days of concrete cube storage, a test for compressive strength was conducted. Currently, a wide variety of reinforcement, such as natural fibers and nanocellulose, are used for this purpose. Composite materials with natural fillers have not only met the environmental appeal, but also contribute to developing low-density materials with improved properties.

This test was done by using the compression testing machine. The M25 grade concrete was used for the mixing of the materials. The IS: 10262:2009 concluded that the mix proportion results for M25 grade concrete. Figure 3 shows the preparation of cube molds. 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. Figure 4 shows the curing of concrete cubes following sample preparation, the specimens are withdrawn from the mold after 24 h and submerged in 100% water for 28 days, a procedure known as curing.



Figure 1: Cement.



Figure 2: Novel natural cellulose fiber.

Figure 5 shows the compressive strength result from using the compression testing equipment. It is the process of determining the regulating rate and degree of moisture loss from concrete during cement hydration. After 28 days of curing, both conventional concrete and ES25 concrete were tested using universal testing equipment. The load should be applied progressively at a rate of 140 kg/cm^2 per minute until the specimen collapses, at which point the compressive strength should be determined.

Statistical analysis

The results of the experiment were examined using SPSS



Figure 3: Preparing of cube molds.

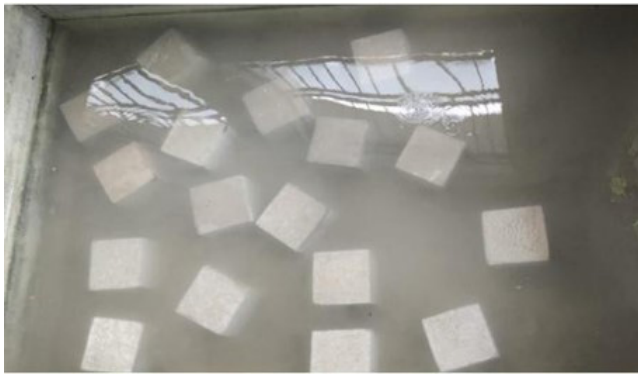


Figure 4: Curing of concrete cubes.



Figure 5: The compressive strength result from using the compression testing equipment.

version 26 software. An independent sample t-test was performed to ascertain the statistical significance between the study and control groups.; the independent variables are concrete quality, curing days, water-to-cement ratio, and compressive strength. Compressive strength as well as the mean, constant deviation, and constant error of the mean were calculated using this tool. The bar chart analysis of the mean compressive strength of conventional concrete and modified concrete was shown in detail in figure 6. Comparing the novel natural fiber-added concrete to standard concrete, the strength increases. Mean detection accuracy is +/- 1 standard deviation.

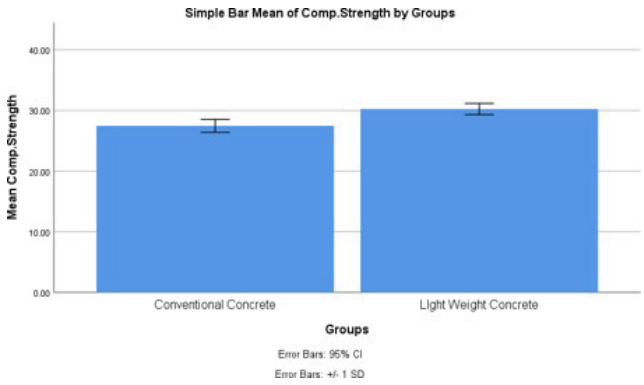


Figure 6: Bar chart analysis of mean compressive strength of conventional concrete and modified concrete. The novel natural fiber-added concrete shows an increase in strength compared to conventional concrete. Mean accuracy of detection = +/- 1 standard deviation. The X-axis shows the group of conventional concrete and modified concrete. Y-axis shows the mean compressive strength in N/mm^2.

Results

The average M25 grade concrete compressive strength for standard concrete is 27.46 N/mm^2. Additionally, the M25 grade concrete's average compressive strength for the novel cellulose fiber concrete is 30.24 N/mm^2. Table 1 shows the compressive strength result of M25 grade concrete for the conventional concrete. Table 2 shows the compressive strength result of M25 grade concrete for the modified concrete. This performance gives the 10.12% increment value while comparing the compressive strength result of conventional concrete. The significance p-value is less than 0.05 i.e., p = 0.000. There is a significant difference. Table 3 shows the independent-sam-

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

Compressive strength (N/mm^2)		Average compressive strength (N/mm^2)
Load	28 days	28 days
624	27.73	27.46
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 3: Independent-samples-t-test from the SPSS software statistical analysis and the comparative statistical report of the conventional and modified concrete. The significance p- value less than 0.05 i.e., p = 0.000. There is a significant difference.

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

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

Compressive strength (N/mm²)		Average compressive strength (N/mm²)
Load	28 days	28 days
682	30.31	30.24
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	

ples-t-test from the SPSS software statistical analysis and the comparative statistical report of the conventional and modified concrete. Group Statistics derived from the SPSS version 26 and the mean value (27.4633, 30.2422), standard deviation (1.07541, 0.91737), and the standard error mean (0.25348, 0.21623). Table 4 shows the group statistics report analysis.

Discussion

Up to a certain limit for fiber loading, it was seen that the mechanical performance of concrete reinforced with novel cellulose fibers improved. Tensile, bending, compressive, and impact performance diminishes as the natural fiber loading percentage is raised further [10]. Such behavior at a fiber loading greater than 2% is attributable to voids and cracks brought on by uneven fiber orientation, which marks the beginning of concrete's mechanical breakdown [11]. Numerous opportunities exist for the novel cellulose fiber-reinforced concrete to replace pure concrete in slabs and pillars. As a result, it is possible to manufacture sustainable building material with improved mechanical and durability properties [12]. Utilizing waste fibers from industry and agriculture can further reduce the cost of the material [13].

Table 4: Group statistics derived from the SPSS version 26 and the mean value (27.4633, 30.2422), standard deviation (1.07541, 0.91737), and standard error mean (0.25348, 0.21623).

	Groups	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

Normal filaments with high energies and environmental protection issues are currently attracting increasing attention as a result of the simultaneous growth in condition and energy. Experts and researchers have found a different type of concrete, though. Jute, sisal, coir, rice husk, flax, bamboo, banana, oil palm, sugarcane bagasse, and other materials are some examples of these [14]. Because of their low thickness, simplicity, and biodegradability, the outcomes of sisal, coconut, and bamboo have also been observed to be more successfully done in test conditions [14]. Although natural fibers are less expensive than conventional reinforced concrete, little is known about how well they will hold up over time. They also require greater expertise to produce, set, and blend [15].

Conclusion

This research is based upon the compressive strength test comparison for the M25 grade concrete. Through the result, the modified concrete compressive strength gives a high performance depending upon that. This performance gives the 10.12% increment value while comparing the compressive strength result of conventional concrete. And also, this research concludes that novel cellulose fiber reinforced concrete has better compressive strength than conventional concrete. This could reduce shrinkage cracks and give better durability.

Acknowledgements

None.

Conflict of Interest

None.

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