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Experimental Investigation on the Flexural Behavior of Optimized Green Concrete

Laksmipurapu Sai Ram Phani Kesari and Samuel Simron Rajkumar*

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

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

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Abstract

The project aims to investigate the effect of incorporating various sustainable materials such as recycled aggregates or industrial by-products into concrete mixtures to enhance its flexural behavior. The various items present in modified concrete are cement, fine aggregate, 20 mm coarse aggregate, water, and novel wood waste ash which is found more precious in modified concrete. The partial replacement of 30% wood ash in concrete mix gives a very good impact in flexural strength. These results were compared with conventional concrete to find out the efficiency of the mix and quality of the mix. Using the SPSS (Statistical Package for the Social Sciences) 26 software, the samples are analyzed, and independent t-test variables are also examined. represents the two sample groups' group statistics. The compressive strength of novel E-waste concrete is 37.86 N/mm^2. The significance value of 0.000 ($p < 0.05$) and standard deviations are 0.26 and 0.49 respectively. The significance error is zero, while the standard deviation is +/- 1 standard deviation. The 2-tailed G-power mean difference is $p = 0.001$, which is less than 0.05. Together with more studies on increasing the amount of wood waste ash in concrete by 1.04%, the effectiveness of adding 30% more wood waste ash will also be assessed.

Keywords

Novel wood waste ash, M20 grade, Cement, Coarse aggregate, Conventional concrete, Modified concrete, Flexural strength

Introduction

Supplementary cementitious materials (SCMs) are substitute goods that strengthen cement's performance as a component of concrete rather than detracting from it. Basic cement characteristics are present in SCMs. Since they lessen the quantity of clinkers, which lowers the cost of energy, source clinkers, and gas discharge, they are used in combination with clinker [1]. The several substances that are mixed with water, another liquid, or both to produce a cementing paste that may be or formed into an entire piece of plastic but will eventually take on a solid shape are also considered to be cementitious materials [2]. Cement with these ingredients is referred to as blended cement. The Greeks, who employed hydraulic lime and volcanic ash to build cementitious mortar, were the first culture to incorporate extra cementitious ingredients. The mighty Roman emperors constructed several historic structures, including such technological marvels as the Coliseum and the Roman aqueducts, both of which are still in use today.

Throughout the past five years, around 19800 researchers have been working in this field, according to Google Scholar. The two groups of supplementary cementitious materials— hydraulic and pozzolanic—are separated based on the type of reaction [3]. While pozzolanic SCMs are silicate and aluminate-rich materials with few cementitious properties, they can be combined with water and calcium hydroxide in powdered form to create cementitious materials, whereas hydraulic SCMs can be combined with water to create compounds with cementitious properties. Other cementitious components include cupola furnace slag powder, blast furnace slag powder, wood waste ash, fly ash, rice husk ash, metakaolin, coconut husk ash, and palm oil fuel ash, corn, and sugar cane bagasse ash. They can be added to cement to supplement it by inter-grinding with cement clinker, combining with cement after grinding, or adding it to the concrete mix. SCMs alter the performance of cement in concrete to suit various applications because of the change in chemistry [4]. By utilizing SCMs, the building industry is able to maintain cement performance while reducing the quantity of clinker required in cement. Less greenhouse gas is emitted into the environment as a consequence [5]. Recent studies have concentrated on employing pozzolanic materials made from agricultural waste, notably bamboo leaf ash (BLA). Ashes and waste products from agriculture can be used to concrete to improve its properties and benefit the environment. As of 2018, Fajarwati, Kuntari, and Kuntari are one of the agricultural byproducts is bamboo leaves. One of nature's most valuable resources, its tree grows faster and may be used in lieu of fiber. Little study has been done on BLA's usage as an SCM in concrete. Several nanomaterials can also be used to forage into nanoscale based applications.

Figure 1: Cement.

Figure 2: Coarse aggregates.

Figure 3: Wood waste ash.

Materials and Method

The molding of cubes, curing and testing of cubes are completed in the Civil Engineering division at Saveetha School of Engineering, Chennai. In accordance with the study's goals and related testing, the following specimens were made utilizing each combination: 500 x 100 x 100 mm. Each size of beam received a 30% volume cement mixture. Separate groups were created for standard concrete and customized concrete. Group 1 had 18 beams built, while group 2 had the same number. Assume that group 1 is made of regular concrete, whereas group 2 is made of modified concrete. Cement and coarse aggregate are shown, respectively, in figure 1 and figure 2. Figure 3 also displays the inventive wood waste ash [6]. Innovative wood waste, for instance. Figure 4 presents a flexural strength testing machine. Figure 5 presents the flexural beam was placed in the curing ponds at the period of 28 days.

It implies that strength won't rise linearly over time in response to the applied load as the connection between concrete strength and time is nonlinear. Fine aggregate, cement, and coarse aggregate are the macro-ingredients of concrete, which progressively reach their 100% strength at the hardened stage [7]. In just 24 h, the starting strength of concrete increases by 16%, and after 7 days of casting and curing, it has reached 65% of its desired strength. After the first 14 days of installation, concrete demonstrates 90% of the planned strength; however, after that, the strength growth slows, and it takes an additional 28 days to reach 99%. In this experiment, 18 beams were examined using flexural assessment.

Statistical analysis

The results of the experiment were examined using SPSS

Figure 4: Flexural strength testing machine.

Figure 5: The flexural beam was placed in the curing ponds at the period of 28 days.

version 26 software. An independent sample t-test was used to assess the statistical significance between the study and control groups. There are no dependent variables in this study; the variables that determine flexural strength, concrete quality, water to cement ratio, cement quality, and curing days are all independent. This program was used to calculate the constant error of the mean, constant deviation, and mean of the flexural strength. Mean, standard deviation, and standard error are (10.7500, 12.7500), (1.14082, 2.08108), and (0.26889, 0.49051), respectively. Table definition was carried out using SPSS version 26. Figure 6 shows a bar chart comparing the flexural strength of conventional concrete and new wood waste ash concrete after 30% extra wood waste ash was added.

Results

Although the results in M20 grade conventional concrete have an average flexural strength of 10.75 N/mm^2, M20 grade modified concrete has an average flexural strength of 12.75

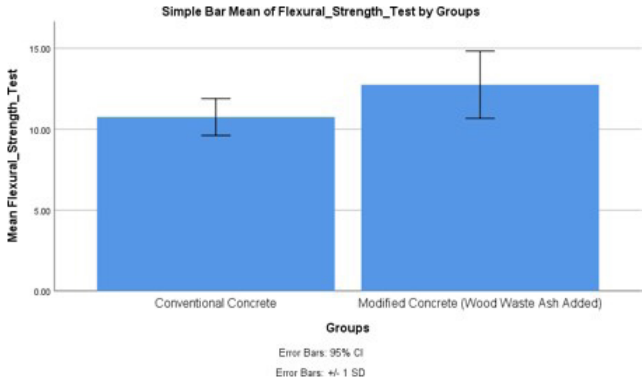

Figure 6: Bar chart analysis of mean flexural strength of wood waste ash modified concrete and conventional concrete. Addition of wood waste ash shows better accuracy compared to conventional concrete. X-axis: Conventional concrete and wood waste ash modified concrete. Y-axis: Mean flexural strength and a 95% CI and standard error bars +/- 1 standard deviation.

N/mm^2. At each curing age, the optimal replacement level of 30% above the control mix was used to measure the strength improvement. To assess the trial's outcomes, a flexural strength test was used. Flexural strength was regarded as an independent variable in this study. Report on group statistics using SPSS version 26 to determine the mean value, standard deviation, and standard error as well as a table.

The independent t-test samples for comparing the flexural strength of traditional concrete with the relationship between concrete strength and time is nonlinear, which implies that as time goes on, strength won't grow linearly in response to the applied load. The concrete is used 18.60% more than it would be in a typical building. Table 1 shows the 28-day flexural strength of concrete of typical M20 grade. The 28-day flexural strength of M20 grade for modified concrete is shown in table 2. Table 3 shows that there was no statistically significant variance in the flexural strength of the concrete.

Table 1: Represents the flexural strength of M20 grade conventional concrete.

S. No.	Weight	Strength (kN)	Flexural strength (N/mm^2)
1	12.357	19	9.50
2	12.159	21	10.50
3	12.784	19	9.50
4	12.394	24	12.00
5	12.465	22	11.00
6	12.681	19	9.50
7	12.579	24	12.00
8	12.468	25	12.50
9	12.182	19	9.50
10	12.671	23	11.50
11	12.522	21	10.50
12	12.462	20	10.00
13	12.258	19	9.50
14	12.531	24	12.00
15	12.425	23	11.50
16	12.254	19	9.50
17	12.652	25	12.50
18	12.341	21	10.50

Table 3: Represents group statistics for both sample groups. Mean (10.7500, 12.7500), standard deviation (1.14082, 2.08108), and standard error mean (0.26889, 0.49051).

	Groups	N	Mean	Std. deviation	Std. error mean
Flexural strength (N/mm^2)	Conventional concrete	18	10.750	1.140	0.268
	10% Geopolymer concrete	18	12.750	2.081	0.490

Table 4: Independent samples t-test results: No statistical significance difference observed for flexural strength in an independent sample t test p = 0.001 as it is less than 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	1.762	0.193	-3.575	34	0.001	-2.0	0.559	-3.136	-0.863
	Equal variance not assumed	-	-	-3.575	26.371	0.001	-2.0	0.559	-3.149	-0.850

Table 2: Represents the flexural strength of M20 grade 30% of wood waste ash concrete.

S. No.	Weight	Strength (kN)	Flexural strength (N/mm^2)
1	12.845	22	11.00
2	12.978	24	12.00
3	12.799	22	11.00
4	13.010	27	13.50
5	12.927	25	12.50
6	13.201	22	11.00
7	12.911	27	13.50
8	13.110	25	12.50
9	12.990	22	11.00
10	12.926	26	13.00
11	13.103	24	12.00
12	13.213	23	11.50
13	12.956	23	11.50
14	13.149	28	14.00
15	13.193	26	13.00
16	12.886	22	11.00
17	13.201	37	18.5
18	13.050	34	17.0

Discussion

The physical and chemical characteristics of wood ash are important in defining its practical usage and can differ substantially depending on a number of variables. The type of tree, the environment in which it grows, the way and conditions of burning, including temperature, the use of other fuels in addition to wood fuel, and the technique used to collect wood ash all affect these characteristics [8]. Due to the massive volumes of trash and industrial waste, solid waste management is a major worry for everyone on earth. Recycling and using industrial waste and byproducts are the only choice since there isn't enough room for landfills and because they are becoming more expensive [9].

As a mineral additive in concrete, wood ash may be used according to ASTM C 618, "Standard for coal fly ash and raw or calcined natural pozzolan for use as a mineral additive in concrete", despite the fact that there is presently no specific code of practice for its usage [3]. Sigvardsen and Ottosen [10], when some of the cement is replaced with wood ash, the slump of the concrete suffers. The capacity of the concrete to absorb water increases as the amount of wood ash in it increases. Although concrete mixes' strength attributes age more favorably than wood ash content due to pozzolanic effects, this impact is quite small. Precast objects and structural grade concrete may both be produced utilizing.

Conclusion

Concrete mixes strength attributes age more favorably than wood ash content, but this difference is only marginal. The addition is 18.60% higher than in conventional concrete. This demonstrates that as compared to regular concrete, the addition of novel wood waste ash improves the concrete's flexural strength.

Acknowledgements

None.

Conflict of Interest

None.

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