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Influence of Wood Additions in Concrete to Improve Compressive Strength and Compared with M20 Grade of Concrete

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Abstract

The project was to determine the compressive strength of different concrete samples containing wood particles and compared conventional (M20) grade concrete. The ingredients used in modified concrete are cement, fine aggregate, 20 mm coarse aggregate, water, and novel wood waste ash. Two sets of groups were defined with eighteen specimens prepared for each group. The G-power value was taken as 80%, alpha 0.05 and confidence interval (CI) as 95%. The impact of novel wood waste ash in concrete can be determined by the concrete's compressive strength, which will be compared to conventional concrete with a 30% wood waste ash replacement in cement. Based on the one-way ANOVA (Analysis of variance) using SPSS (Statistical Package for the Social Sciences) software, the compressive strength of conventional concrete is 22.97 N/mm^2. The compressive strength of novel E-waste concrete is 29.41 N/mm^2. There is a significant difference between the two groups and the significance value of 0.000 ($p < 0.05$) and also mean, standard deviations standard errors are (22.9711, 29.4089), (0.26610, 0.43490), and (0.06272, 0.10251) respectively. The effectiveness of the 30% wood waste ash addition to the concrete will be evaluated, and further investigation will be done on the 28.04% increase in wood waste ash percentage.

Keywords

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

Introduction

Modified cementitious materials are substitute goods that strengthen cement's performance as a component of concrete rather than detracting from it. Comprise the fundamental characteristics of cement [1]. They are employed in conjunction with clinker because they reduce the amount of clinker, which lowers the amount of energy, material source, and discharge gas. Other cementitious ingredients are combined with water to create a paste that can be molded into a complete piece of plastic but will eventually take on a solid shape [2]. Blended cements are those that contain these components. The first civilization to use additional cementitious elements was the Greeks, who used hydraulic lime and volcanic ash to make cementitious mortar [3]. The Romans built such technical marvels as the Coliseum and the Roman aqueducts, both of which are still standing, thanks to the knowledge that the Greeks had handed on to them. Natural, easily accessible materials, like volcanic ash or diatomaceous earth, made up the earliest supplementary cementitious materials (SCMs) [4]. Blast furnace slag, wood waste ash, and fly ash are just a few of the industrial by-products that have recently been created in large quantities as a result of severe air pollution management and legislation. Tons of waste materials are landfilled as garbage that can be used by the concrete manufacturing sector in the creation of concrete. Also, it lessened the environmental harm caused by the extraction and processing of virgin resources. The main purposes of supplementary cementitious materials are to increase workability, durability, and strength [5]. With the help of these components, the manufacturer of concrete can create and alter the concrete mixture to suit the intended use. High Portland cement percentage concrete mixtures are more prone to cracking and increased heat generation. Using additional cementitious materials can help reduce these effects to some extent. Also, using them reduces the amount of Portland cement needed to make the same volume of concrete. Moreover, there is a reduction in the amount of energy and emissions used in the production of Portland cement [6].

According to Google Scholar, around 19,700 researchers have been working in this area over the last five years. The cementitious materials are divided into categories of reaction type: hydraulic and pozzolanic materials [7]. While SCMs are rich in silicates and aluminates that have paste in nature, when it is added with water, it forms compounds that have cementitious properties [8]. Cupola furnace slag powder, blast furnace slag powder, fly ash, rice husk ash, metakaolin, coconut husk ash, palm oil fuel ash, wood waste ash, sugarcane bagasse ash, corn cob ash, and bamboo leaf ash (BLA) are some additional cementitious materials [9]. They can be added to cement to supplement it by grinding with cement clinker, combining with cement grinding, or adding it to the concrete mix [10]. Because of the chemical shift, SCMs enable the building sector to preserve cement performance while lowering the amount of clinker needed in cement. As a result, less greenhouse gas is released into the atmosphere [11].

The various researchers have focused on using agricultural waste as pozzolanic material, specifically BLA. Waste from agricultural fields is added to concrete to increase its properties while also being better for the environment [12]. As of 2018, Kuntari and Fajarwati Bamboo leaves are among the agricultural wastes. Its tree is among the planet's most important natural resources; it grows more quickly and can be used in place of fiber. There has been little research on BLA's use as an SCM in concrete. Cocina, Morales, Santos Savastano, and Frias were the first to conduct a chemical investigation of BLA.

Materials and Method

The entire project was carried out in Saveetha School of Engineering, Department of Civil Engineering. While using each mixture, the following specimens were molded in accordance with the aims of the investigation and related tests: Each size cube measures 150 x 150 mm and is mixed with 30 percent cement by volume [13]. Both conventional concrete and modified concrete are divided into two sets of groups, and for group 1 and group 2, the identical number of 18 cubes was made. Assumedly, the group 1 specimen is for conventional concrete, and the group 2 specimen is for modified concrete. Figure 1 and figure 2 show cement and coarse aggregate, respectively.

Figure 3 also depicts the innovative wood waste ash. The addition of novel wood waste ash reduces the workability of OPC/novel wood waste ash concrete by increasing water input. This is due to novel wood waste ash's higher carbon concentration [14]. The ideal water-cement ratio was determined

Figure 1: Cement.

Figure 2: Coarse aggregates.

Figure 3: Wood waste ash.

to be 0.45 using the slump cone test. The removal of impurities was accomplished by complete drying of the coarse and fine aggregate. The IS 10262:2009 code book was utilized to prepare the mix amounts. Furthermore, it has been established that M20 grade concrete was employed in the project's design. Typically, beam, column, and slab structural components made of this M20 grade concrete are employed in residential buildings. The nominal mix includes the M20 grade [15].

In order to get the best consolidation and compaction, two layers of concrete were added after the molds had been prepared and vibrated at a frequency of 50 Hz. 22 °C to 24 °C is the temperature range used to cure specimens in a room setting. Using the compression testing apparatus in figure 4, the compressive strength test was performed. The samples were extruded and thermally cured in a controlled water tank for 28 days.

Therefore the primary objective of the study was to examine the new wood waste ash performance characteristic. Each combination contained 30% new wood waste ash by volume, while the amounts of cement, fine and coarse aggregate, water, and additives were constant. In the first step, cement and fine aggregate were combined. Thereafter, the cement and fine aggregate mixture was supplemented with the coarse aggregate. As the last step of the concrete preparation process, water was added after all other materials. Two factors, namely the composite's improved strength and toughness as compared to its brittle matrix, can be used to evaluate the novel wood waste ash's efficacy [16].

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. Fine aggregate, cement, and coarse aggregate make up the macro-ingredients in concrete, which develops its 100% strength over time at the hardened stage. Within 24 h, concrete increases its initial strength by 16%, while after 7 days of casting and curing, it has reached 65% of its intended strength. Concrete demonstrates 90% of the desired strength up to 14 days after placement, after which the strength increase slows and takes 28 days to reach 99%. In this investigation, 18 cubes were produced and put through a compression strength test before being given a 28-day curing time. The Concrete cube was positioned in the curing ponds for a period of 28 days, as shown in figure 5.

Figure 4: Compressive strength test for concrete cube.

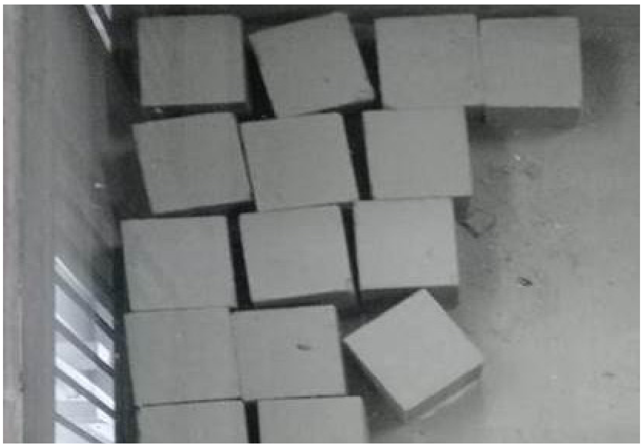

Figure 5: The concrete cube was placed in the curing ponds at the period of 28 days.

Statistical analysis

Using SPSS version 26, the entire findings are examined. For statistical significance between the study and control groups, an independent sample t-test was conducted. All the substances used in concrete are summarized as independent factors; there are no dependent variables. This tool was used to compute compressive strength and to calculate the mean, constant deviation, and constant mean error [17]. Figure 6 displays a bar chart for comparing the compressive strength of novel wood waste ash concrete, which has 30% more wood waste ash added, to traditional concrete.

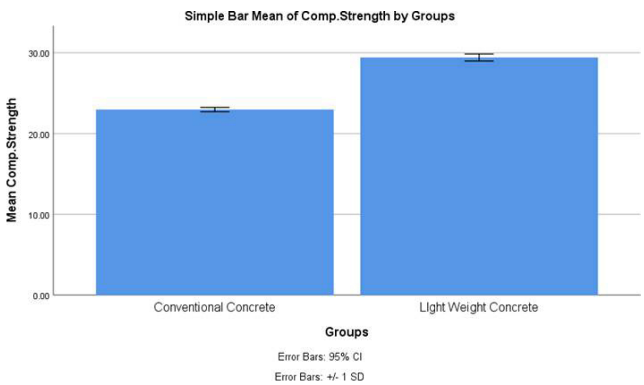

Figure 6: Shows a comparison between conventional concrete and novel wood waste ash concrete with a 30% addition to compressive strength. The compressive strength of traditional concrete with novel wood waste ash concrete with 30% of wood waste ash, as reported statistically by SPSS, is shown as a bar chart with mean accuracy. For both mixes, the mean accuracy is the same. Additionally, the standard deviation is roughly equal for both mixes. Traditional concrete versus novel novel wood waste ash concrete on the X-axis. Y-Axis: Mean detection is +/- 1 standard deviation.

Results

According to the results in M20 grade conventional concrete, the average compressive strength is 22.97 N/mm^2, but for M20 grade modified concrete, it is 29.41 N/mm^2. At every curing age, this increase in value was measured at the maximum level of 30% added above the control mix. The experiment findings were calculated in compression testing machine as an independent variable in this study. The increased percentage over traditional concrete is 28.04%. The 28-day compressive strength of typical concrete of M20 grade is shown in table 1.

The 28-day compressive strength result of M20 grade for modified concrete is shown in table 2. Results of the independent samples t-test: An independent sample t-test for compressive strength did not reveal any statistically significant differences. The calculated p-values are $p = 0.075$, or $p > 0.05$. The independent t-test samples used to compare the compressive strengths of traditional concrete and novel wood waste ash concrete are shown in table 3. The group statistics report for determining the mean value, standard deviation, and standard error is shown in table 4. Table 5 displays the mix design and mix proportion for the wood waste ash concrete, which is 1:1.5:3, and table 6 displays the design requirement for the mix proportion.

Discussion

The basic characteristics of wood ash have a vital role in defining their useful applications and vary widely depending on a variety of circumstances. These characteristics are impacted by the type of tree, the environment in which it grows the method and conditions of combustion, including temperature [18] the use of other fuels in addition to wood fuel, and the collection method for wood ash. Due to the vast volumes of waste and industrial byproducts, solid waste management is a major challenge worldwide [19]. Recycling and utilization of industrial waste products is the main solution due to a lack of land-filling area and its rising cost [20]. From the Levene's test for equality of variances shows the F is 3.381, significance is 0.07 and from the statistics shows the t-test for equality of means t value is -53.571 and df value is 28.164.

This study provides the vast idea of safety in site construction, in which the amount of wood waste generated in construction is the most vulnerable factors [21]. In various countries, 16% of wood waste is stagnated in non-residential buildings and 42% in residential buildings [22].

Most of the cases wood has been used as a construction material for fulfilling the basic needs. For long term consideration for construction elements like column, beam and panel members, it is deliberately used in building. In countries like Finland and Hong Kong, are best examples for wooden methods of construction, where 40% of the materials are constructed by wood [20].

All the authors considerably indicate that the waste gen-

Table 1: Compressive strength of conventional concrete of M20 grade.

Mix type	Load (kN)	Compressive strength (N/mm²)
Conventional concrete	28 Days	28 Days
	527	23.42
	524	23.29
	525	23.33
	522	23.20
	523	23.24
	520	23.11
	520	23.11
	518	23.02
	518	23.02
	516	22.93
	516	22.93
	513	22.80
	514	22.84
	511	22.71
	512	22.76
	509	22.62
	509	22.62
	507	22.53

Table 2: Compressive strength result of M20 grade for modified concrete (added novel wood waste ash).

Mix type	Load (kN)	Compressive strength (N/mm²)
Modified concrete	28 Days	28 Days
	678	30.13
	665	29.56
	676	30.03
	662	29.44
	673	29.93
	660	29.32
	671	29.83
	657	29.21
	669	29.72
	655	29.09
	667	29.62
	642	28.53
	664	29.52
	649	28.86
	662	29.42
	647	28.75
	660	29.32
	644	28.63

Table 3: SPSS statistics one-sample t-test report, according to the independent sample t-test, there is a significant difference between the groups. p = 0.000 which is less than 0.05 table defined from SPSS version 26.

		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
Load	Equal variance assumed	3.381	0.075	-53.571	34	0.000	-6.437	0.120	-6.682	-6.193
	Equal variance not assumed			-53.571	28.164	0.000	-6.437	0.120	-6.683	-6.191

Table 4: The statistical data for the two sample groups. Mean (22.9711, 29.4089), standard deviation (0.26610, 0.43490), standard error mean (0.06272, 0.10251). Table defined from SPSS version 26.

	Groups	N	Mean	Std. deviation	Std. error mean
Compressive strength	Conventional concrete	18	22.971	0.266	0.062
	Novel wood waste ash concrete with 30% SF	18	29.408	0.434	0.102

Table 5: The mix design and proportions for the wood waste ash concrete and M20 grade concrete.

Description	Cement (kg/m³)	FA (kg/m³)	CA (kg/m³)	Wood waste ash (Kg)	W/C ratio
Conventional concrete mix	352	528	1056	0	0.45
Wood waste ash concrete mix	246.4	528	1056	105.6 (30%)	0.45

Table 6: Design stipulation.

Grade of concrete	Material for one cube in Kg	Material for 18 cubes (1 group) in Kg
Cement (Kg)	0.931	16.76
Wood waste ash (Kg)	0.40 (30%)	7.2
Sand (%)	2	36
Water to binder ratio	0.45%	0.45%
Aggregates (Kg)	4	72

erated in construction industries are the major factors, but it may be vanished. Mainly the form work for constructing the structural member or even precast structure is the main factors for wood waste.

Conclusion

With an addition of wood ash content, the desirable strength of concrete mixtures increase gradually; however, as they age, they become stronger due to pozzolanic actions. This indicates that adding novel wood waste ash to concrete 28.04% increases its compressive strength when compared to conventional concrete.

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None.

Conflict of Interest

None.

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