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Investigating Properties of Concrete on Partially Replacing Cement by Wheat Straw Ash and Bamboo Wood Ash

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ABSTRACT- This study focuses on the recycling of agricultural and industrial wastes, specifically wheat straw ash (WSA) and bamboo wood ash (BWA), in cement production to promote sustainable and environmentally-friendly concrete. The mechanical properties of WSA and BWA are investigated through tests measuring compressive strength, flexural strength, and split tensile strength of concrete. Different percentages of WSA and BWA (5%, 10%, 15%, and 20% by weight of cement) are used as partially replacement materials in the concrete mix.

The experimental results indicate a reduction in the strength performance of concrete when WSA and BWA are individually used as supplementary cementitious materials at various curing periods (7, 28, 56, and 90 days). The primary objective of this study is to examine the impact of WSA and BWA on the mechanical properties of concrete for the purpose of sustainable development.

The heavy use of energy and raw materials in traditional cement manufacture leads to a significant release of carbon dioxide into the atmosphere, which contributes to environmental pollution and greenhouse gas emissions. The environmental impact of cement production can be minimised by using WSA and BWA as cementitious materials in concrete. This is a successful strategy for reducing the damaging consequences of cement production on the environmentWSA and BWA can be used as cementitious materials in concrete to lessen the negative environmental effects of cement manufacture. This is a practical method for reducing the damaging environmental effects of cement manufacture.

KEYWORDS- Mechanical Properties, Wheat Straw Ash, Bamboo Wood Ash, Concrete, Sustainable Development.

I. INTRODUCTION

A. General

Concrete is a widely utilized construction material composed of cement, fine aggregate, coarse aggregate, and water. Cement plays a vital role in concrete, but its production contributes to greenhouse gas emissions, specifically carbon dioxide (CO2), which contributes to global warming. The production of one ton of cement emits approximately one ton of CO2 and consumes 1.6 tons of natural resources. To address these environmental concerns, researchers have explored the partial replacement of cement with industrial and agricultural waste materials, such as wheat straw ash (WSA) and bamboo wood ash (BWA), which are readily available.

This study aims to investigate the potential use of WSA and BWA as partial replacements for cement in concrete. By incorporating these waste materials into the concrete mixture, it is possible to reduce cement consumption, decrease CO2 emissions, and achieve a more sustainable and environmentally-friendly construction practice. Additionally, utilizing WSA and BWA can contribute to the effective management of agricultural waste, reducing environmental pollution and associated health hazards.

WSA is obtained by controlled burning of wheat straw, which is a byproduct of wheat production. Wheat is a major cereal crop, and a substantial amount of wheat straw is generated globally. Properly burned wheat straw waste yields WSA, which is rich in silica and exhibits pozzolanic properties. Previous studies have explored the use of WSA as a cement replacement, demonstrating its potential to enhance the mechanical properties and durability of concrete.

Similarly, bamboo wood ash, derived from controlled burning of bamboo stems, shows promise as a cementitious material. Bamboo is widely used in construction, and its discarded stems can contribute to environmental pollution if not properly managed. By converting bamboo stems into ash and incorporating it into concrete, the waste can be effectively utilized, reducing environmental impact and offering an alternative to traditional cement.

In this study, the focus is on evaluating the cementitious characteristics of WSA and BWA when used as partial replacements for cement in concrete. The properties investigated include compressive strength, flexural strength, and split tensile strength. By varying the percentage replacements, the optimal proportions of WSA and BWA can be determined to achieve the desired concrete performance.

II. LITERATURE REVIEW

A. Previous Research

- *Bheel et al. [1]* conducted a study to investigate the mechanical properties of concrete using wheat straw ash as a substitute for cement. They explored the effects of incorporating wheat straw ash as a partial replacement for cement in concrete mixtures. The study analyzed parameters such as compressive strength, flexural strength, and workability of the concrete. By studying the performance of concrete with wheat straw ash, they aimed to assess its potential as a sustainable alternative to traditional cement.

- *Chandrasekaran [2]* conducted a characteristics investigation on concrete where dry bamboo ash was used as a partial replacement for cement in M25 grade concrete. The study examined the physical and mechanical properties of concrete, including compressive strength, tensile strength, and durability, with bamboo ash replacing a certain percentage of cement. The aim was to evaluate the feasibility and performance of bamboo ash as a cementitious material in concrete production.
- *Bheel et al. [3]* studied the fresh and mechanical properties of concrete prepared by substituting equal parts of wheat straw ash and millet husk ash for cement and fine aggregate, respectively. The research aimed to understand the effects of these ash materials on the workability, strength, and durability of the resulting concrete. By investigating the performance of this concrete mixture, they sought to assess the potential of using wheat straw ash and millet husk ash as sustainable alternatives in concrete production.
- *Awoyera et al. [4]* examined the effect of wheat straw ash on newly-poured, cured concrete that had jute fiber reinforcement. The study investigated the influence of wheat straw ash on the mechanical properties and durability of jute fiber-reinforced concrete. It aimed to evaluate the potential synergy between wheat straw ash and jute fibers in enhancing the strength and performance of concrete for specific applications.
- *Aksogm et al. [5]* investigated the durability of concrete prepared by partially replacing the fine aggregate with colemanite and barite, and substituting the cement with ashes of maize stalks, wheat straw, and sunflower stalks. The study focused on assessing the long-term performance and durability of this type of concrete. They examined parameters such as compressive strength, water absorption, and resistance to sulfate attack to evaluate the suitability and durability of the concrete mixture.
- *Rodier et al. [6]* conducted a study to investigate the pozzolanic activity of bamboo stem ashes as a partial replacement for cement. They evaluated the reactivity and pozzolanic properties of bamboo stem ash when used as a supplementary cementitious material. The research aimed to understand the potential of bamboo stem ash to contribute to the strength, durability, and performance of concrete by enhancing the pozzolanic reactions.

III. METHODOLOGY AND MATERIAL USED

The experimental study was divided into the following stages:

- Properties of material used in the study.
- Mix Design M25
- Workability test of concrete mixes.
- Casting and curing of specimens.
- Strength tests on specimens.

IV. MATERIALS USED

The following are the materials used:

- OPC Cement 53 grade.
- Wheat straw ash.
- Bamboo wood ash.

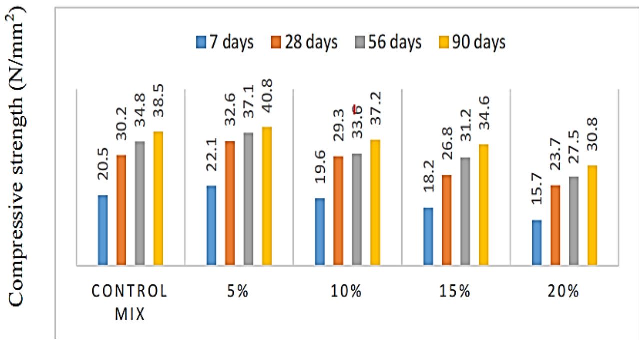
V. RESULT AND DISCUSSION

A. *Compressive Strength Test*

The cured cube samples of concrete and mortar were subjected to compressive strength tests within the lab using the universal testing machine. The compressive strength of the concrete mixtures was evaluated using cuboidal samples with dimensions of 150 mm150 mm150 mm. When defined curing times (7, 28, 56, and 90 days) are reached, the test specimens are removed from the water and placed in a cube in a UTM. The cubes adhere to the specified dimensions without deviating from the volumetric excellent cast. Place the specimen samples inside the UTM so that the force applied to the opposing sides of the concrete cube casts. A total of 3 samples were generated, each with a different mixture and age, and the results shown at each age represent the average of the 3 samples tested. According to IS: 516-1959, the compressive strength of the combination was assessed after 7, 28, 54, and 90 days. A sample was made for the control mix and contrasted with the replacement of cement at various weight percentages of 5, 10, 15, and 20% (shown in table 1 and figure 1 and figure 2).

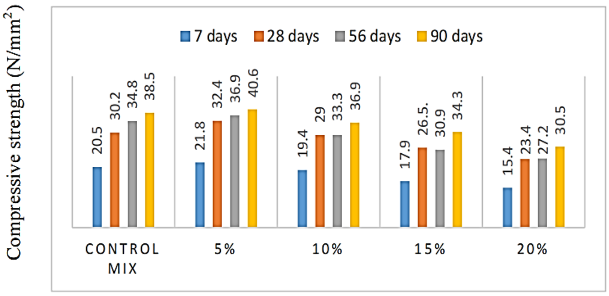
Table 1: Compressive strength test results

%	Compressive strength in N/mm2							
	WSA				BWA			
	7 Days	28 Days	56 Days	90 Days	7 Days	28 Days	56 Days	90 Days
Cont ro l mix	20.5	30.2	34.8	38.5	20.5	30.2	34.8	38.5
5%	22.1	32.6	37.1	40.8	21.8	32.4	36.9	40.6
10%	19.6	29.3	33.6	37.2	19.4	29.0	33.3	36.9
15%	18.2	26.8	31.2	34.6	17.9	26.5	30.9	34.3
20%	15.7	23.7	27.5	30.8	15.4	23.4	27.2	30.5



WSA Replacement (%)

Figure 1: Chart represent compressive strength of concrete containing WSA



BWA Replacement (%)

Figure 2: Chart represent compressive strength of concrete containing BWA

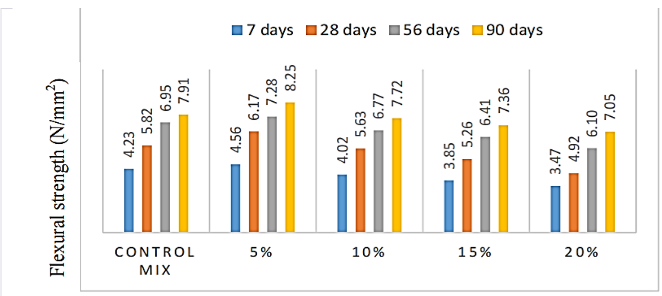
B. *Flexural Strength Test*

Flexural strength tests were performed on beam specimens of 150 mm by 150 mm by 700 mm at 7, 28, 56, and 90 days. The replacement of cement with WSA and BWA at various percentages—5%, 10%, 15%, and 20%—has been tested in samples for the control mix. It makes reference to the IS: 516-1959 test method for concrete beams.

The method of arranging is depicted in figure 3, and the testing sample models were made up of three layers of equal thickness, each of which was tamped with tamping rods using 35 blows. And make sure to clean the beam's exterior after curing it. The test subject was mounted on a hydraulic UTM and was secured to the beam's horizontal axis. They ought to be applied to the surface of the beam gradually. (150mm specimens at 400 kg/min) (shown in table 2)

Table 2: Flexural strength test results

%	Flexural strength in N/mm2							
	WSA				BWA			
	7 Days	28 Days	56 Days	90 Days	7 Days	28 Days	56 Days	90 Days
Cont ro l mix	4.23	5.82	6.95	7.91	4.23	5.82	6.95	7.91
5%	4.56	6.17	7.28	8.25	4.61	6.22	7.33	8.29
10%	4.02	5.63	6.77	7.72	4.10	5.68	6.82	7.77
15%	3.85	5.26	6.41	7.36	3.92	5.31	6.45	7.40
20%	3.47	4.92	6.10	7.05	3.51	4.97	6.14	7.09



WSA Replacement (%)

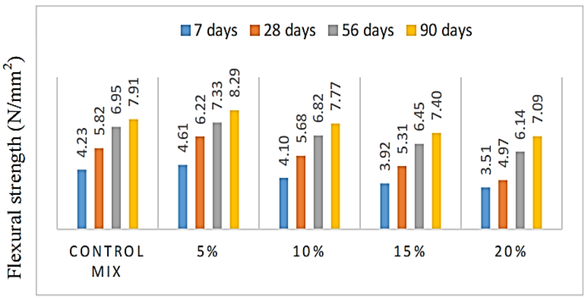
Figure 3: Chart represent flexural strength of concrete containing WSA

Table 3: Tensile strength test results

%	Tensile strength in N/mm2							
	WSA				BWA			
	7 Days	28 Days	56 Days	90 Days	7 Days	28 Days	56 Days	90 Days
Cont ro l mix	2.10	2.45	2.75	2.90	2.10	2.45	2.75	2.90
5%	2.28	2.67	2.90	3.05	2.15	2.54	2.78	2.98
10%	1.95	2.20	2.40	2.55	2.03	2.32	2.52	2.68
15%	1.80	2.05	2.25	2.40	1.89	2.12	2.32	2.48
20%	1.60	1.85	2.05	2.20	1.76	1.99	2.19	2.35

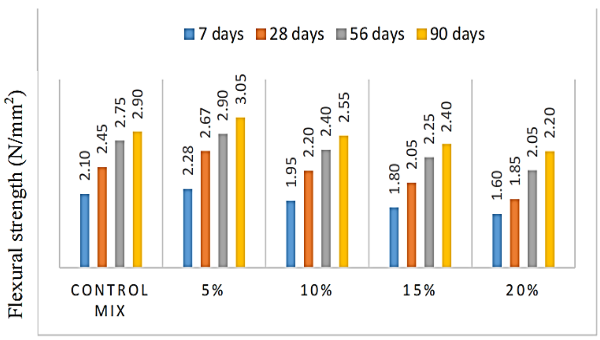
C. *Split Tensile Strength Test*

The split tensile of the concrete mixtures was evaluated using cylindrical samples that had a diameter of 150 metric linear units and a height of 300 metric linear units. The procedure used the association approach after 7, 28, 56, and 90 days to extract the wet water sample. Remove any water from the concrete cylinder specimen's surface. Fix the diameter lines on the concrete cylinder's two ends to ensure that they are in the same axial location. And after placing the site in Figure 4-6 UTM for the necessary range. The largest cylinder portions, which are comparable in depth to the topics, uniformly continue the load tension operating horizontally. Because of Poisson's effects, the strain operating at about 1/6 the depth and lasting 5/6 the depth is studied. Three samples of each blend were examined.



BWA Replacement (%)

Figure 4: Chart represent flexural strength of concrete containing BWA



WSA Replacement (%)

Figure 5: Chart represent flexural strength of concrete containing WSA

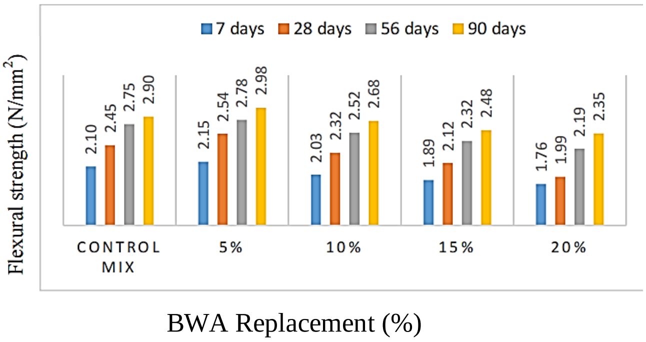


Figure 6: Chart represent flexural strength of Concrete containing BWA

VI. CONCLUSION

The study's objective was to examine and assess the effects of using WSA (wheat straw ash) and BWA (bamboo wood ash) as partial substitutes for cement in concrete. According on the results of the experiment, the following conclusions were made:

A. Compressive Strength

With 5% replacement of WSA, the following compressive strength values were attained: 22.1 N/mm2 (7 days), 32.6 N/mm2 (28 days), 37.1 N/mm2 (56 days), and 40.8 N/mm2 (90 days).
The highest copressive strengths were somewhat lower when BWA was substituted for 5% of them: 21.8 N/mm2 (7 days), 32.4 N/mm2 (28 days), 36.9 N/mm2 (56 days), and 40.6 N/mm2 (90 days).
Lower compressive strength values were attained by the control mix without WSA or BWA: 20.5 N/mm2 (7 days), 30.2 N/mm2 (28 days), 34.8 N/mm2 (56 days), and 38.5 N/mm2 (90 days)..
In terms of compressive strength, 20% replacement of WSA and 20% replacement of BWA were where the lowest values were found.

B. Flexural Strength:

With 5% replacement of WSA, the maximum flexural strength values were obtained: 4.56 N/mm2 (7 days), 6.17 N/mm2 (28 days), 7.28 N/mm2 (56 days), and 8.25 N/mm2 (90 days).
The flexural strengths were somewhat lower with 5% replacement of BWA: 4.61 N/mm2 (7 days), 6.22 N/mm2 (28 days), 7.33 N/mm2 (56 days), and 8.29 N/mm2 (90 days).
The control mix achieved lower flexural strength values.
At 20% replacement of WSA and 20% replacement of BWA, the lowest flexural strength values were noted..

C. Splitting Tensile Strength:

With 5% replacement of WSA, the highest splitting tensile strength measurements were 2.28 N/mm2 (7 days), 2.67 N/mm2 (28 days), 2.90 N/mm2 (56 days), and 3.05 N/mm2 (90 days).
The splitting tensile strengths were somewhat lower with 5% replacement of BWA: 2.15 N/mm2 (7 days), 2.54 N/mm2 (28 days), 2.78 N/mm2 (56 days), and 2.98 N/mm2 (90 days).
The lowest values of splitting tensile strength were found at 20% replacement of WSA and BWA.
Overall Conclusion:
It was determined through the experimental investigations that employing 5% of WSA and 5% of BWA as separate cement replacement materials could produce suitable results in concrete.
In comparison to the control mix, these replacement percentages produced favourable compressive, flexural, and splitting tensile strengths.
It should be noted that lower strength values were obtained at higher replacement percentages (20%) of WSA and BWA, suggesting that there may be a range of replacement percentages that is most effective for achieving desired mechanical qualities in concre

VII. FUTURE SCOPE

- Optimization of Replacement Levels: Examine and refine the use of WSA and BWA as cement substitutes in concrete. Establish the optimal replacement levels for concrete to achieve the desired levels of strength, durability, and other qualities.
- Influence on Fresh Concrete Properties: Analyse how WSA and BWA affect other attributes of new concrete, such as workability and setting time. Examine how various ash components affect the water requirements, consistency, and flow properties of concrete mixtures.
- Strength and Durability Testing: Conduct thorough mechanical strength testing on concrete specimens containing WSA and BWA, including compressive strength, tensile strength, and flexural strength. Assess the durability characteristics as well, such as resistance to sulphate attack, carbonation, and chloride infiltration.
- Long-Term Performance: Examine the durability of WSA- and BWA-based concrete by putting samples through ageing tests and rigorous outdoor exposure. To assure the sustainability and performance of these materials, evaluate their durability, shrinkage, and creep properties over a prolonged length of time.
- Environmental Impact Assessment: Analyse the effects of using WSA and BWA in the manufacture of concrete on the environment. Take into account elements like decreased energy use, carbon emissions, and trash management. Compare the environmental impact of regular concrete to concrete that contains WSA and BWA.
- Standardization and Guidelines: For the purpose of incorporating WSA and BWA into concrete mix design and construction practises, develop guidelines, standards, and specifications. This would ensure uniformity and quality while facilitating the use of these ash materials in the construction section.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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