Effect of Wood-Ash as Partial Replacement to Cement on Performance of Concrete

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Abstract: Concrete is a mixer of various materials. These materials include water, cement, and aggregates respectively. The making of cement produces enormous quantity of greenhouse emissions. There is a need to develop substitute materials for cement. It reduces both greenhouse emissions and the cost of concrete. In this work, an endeavor has been made to utilize wood-ash as a substitute material to cement. The effect of wood-ash as an alternative to cement on the performance of concrete has been studied. Wood is a sustainable source for energy and eco-amiable material. The cement has been replaced with wood ash by 5%, 10%, 15%, and 20%, and studied for the performance of concrete. Results confirm that the wood-ash addition as a partial alternative to cement improves the overall performance of concrete.

Key-words: Wood-Ash, Strength, Water absorption

1. INTRODUCTION

Concrete is the most usually utilized construction material because its easy availability of materials, strength and durability. Cement is the main binding material in concrete. The one ton manufacturing of cement produces 0.9 ton of CO₂ to the atmosphere. About 5-7% of global Greenhouse gas emissions are from cement plants[1][2][3]. Researchers are searching for alternatives to conventional materials in concrete [4][5][6]. Ground granulated blast-furnace slag (GGBS), fly-ash, and rice husk-ash, etc., are used as cement replacements. The utilization of fly-ash as cement replacing material in concrete up to 25% improves the performance of concrete [6][7]. The addition of rice-husk ash as an alternative to cement also improves the performance of concrete [8][9]. Similarly, steel, iron industry wastes and GGBS are also used as substitute to cement [10][11]. However, use of these alternate materials not completely eliminates the use of cement in concrete. There is a need to search for alternate materials to cement for considerable reduction in environmental pollution [12]. Recently, wood ash gained popularity as substitute material to cement in concrete [13][14]. Wood is a sustainable energy source and an eco-friendly material. Hence, the utilization of waste wood for energy generation is growing and more wood ash waste is thus created [15]. The utilization of wood ash in concrete not only serves to minimise disposal and environmental issues, but also to make it economical. Very limited work on the impact of wood ash partially substitutes to cement on the concrete's properties was reported. This work aims to use wood ash as alternative material to cement in concrete. The role of wood ash on strength and water absorption of concrete is highlighted in the present study.
2. MATERIALS

43 grade Ordinary Portland cement having specific gravity of 3.01 is utilized as a binder in this study. River sand with specific gravity 2.6 and crushed granite of 20 mm maximum size with specific gravity 2.6 are utilized as fine and coarse aggregate respectively. Wood ash attained by ignition of wood waste from wood furnishing plant is ground to powder to pass from 90 micron sieve. Fig.1 shows the pictorial view of wood ash.

![Fig.1 Image of wood ash used in this study](image)

3. CONCRETE MIX DETAILS

Concrete mix proportions are prepared as per IS: 10262-2019 [16] for 0.4 water-cement ratio. The cement has been partially replaced with the wood ash by 10%, 15%, and 20% by weight. The mix proportion details are illustrated in Table.1.

| Mix Details | Cement | Wood ash | Water | Fine Aggregate | Coarse Aggregate |
|-------------|--------|----------|-------|----------------|------------------|
| CM          | 410    | Nil      | 164   | 545            | 1063             |
| WM10        | 369    | 41       | 164   | 545            | 1063             |
| WM15        | 348.5  | 61.5     | 164   | 545            | 1063             |
| WM20        | 328    | 82       | 164   | 545            | 1063             |

4. RESULTS AND DISCUSSION

4.1 Compressive strength

Strength test is performed to all concrete mixes on triplicate. Fig.2 illustrates the results of compressive strength for different mixes.
From the figure it is noticed that the utilization of wood ash in concrete enhances the strength. There is a maximum of 8.24% improvement in compressive strength was noticed by the utilization of 15% wood ash as substitute to cement. The utilization of wood ash up to 15% enhances the compressive strength. The addition of 20% of wood ash as substitute material to cement in concrete slightly diminishes the strength.

4.2 Flexural strength

Concrete beams specimen of size 100 x 100 x 500 mm are prepared for testing flexural strength of concrete. The test has been performed to all concrete mixes on triplicate at an age of 28 days. Fig. 3 illustrates the flexural strength results of different mixes. From the figure it is noticed that the utilization of wood ash considerably enhances the flexural strength. Pattern of results is similar to compressive strength. There is a maximum of 7% improvement in flexural strength was noticed with addition of 15% of wood ash as a substitute to cement.
4.3 Water absorption

The test has been performed to all concrete mixes on triplicate. The 28 days cured specimens were oven dried at 110°C in oven for 24 hours. The specimens were removed from the oven after 24 hours and cooled in room temperature. The weight of the oven dried cubes was noted (W₁) and these cubes were saturated in water for 24 hours. The cubes were separated from curing after 24 hours and the surface water was wiped and the weights of saturated specimens were taken (W₂). The water absorption capacity of concrete is calculated using equation (1).

\[
\text{Water absorption (\%) } = \frac{W₂ - W₁}{W₁} \times 100 \quad \text{(1)}
\]

Fig.4 shows the water absorption test results of different mixes. From the figure it is noticed that the utilization of wood ash as alternative to cement posses higher water absorption in concrete. As the wood ash proportion increases the water absorption also increases. Similar, pattern of results are observed in [17] as the dosage of wood ash in concrete increases the water absorption also increases.

Fig.4 Water absorption results of different concrete mixes

5. CONCLUSIONS

The effect of wood ash as alternative to cement was studied in this work. The wood ash has been added in concrete by 10%, 15%, and 20% by weight of cement. The addition of wood ash in concrete improves the strength of concrete. There is an 8.24% maximum improvement in strength of concrete was identified by the utilization of 15% of wood ash as replacement to cement. The water absorption test results show that the utilization of wood ash slightly diminishes the durability of concrete. The addition of wood ash in concrete up to 15% as partial substitute material cement is suggested for developing sustainable concrete.

6. REFERENCE

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