Preparation of Concrete Block Incorporated with Wood Ash and Waste Glass Powder.

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1. ABSTRACT

Concrete blocks are fundamental in construction, but there's a pressing need for environmentally friendly and durable options. This study investigates the impact of replacing conventional cement with wood ash ranging from 10% to 25%, while maintaining a consistent 10% substitution of fine aggregates with waste glass powder on cement blocks. Six sample sets, including standard blocks, are tested for compressive strength, water absorption, and heat release after 7, 14, and 21 days of curing. Results indicate that a 15% wood ash replacement yields cement blocks with superior compressive strength and reduced water absorption after 21 days. Incorporating wood ash with waste glass powder further enhances concrete block properties. This research underscores the potential of waste glass powder and wood ash as sustainable alternatives for improving cement-based materials in construction, promising significant advancements in eco-conscious building practices.

Key words - wood ash, partial replacement, waste glass powder, eco-friendly, cement bricks, compressive strength, water absorption.

2. INTRODUCTION

The concrete blocks are widely used around the world including Sri Lanka for the construction of wall and buildings. Due to the low affordability of cement, and its adverse environmental effects the greener technology innovation is urged to use in developing construction material. Lightweight materials have gained attention for their ease of use [1]. There are some crucial physical parameters such as strength, durability and workability considered in the preparation of concrete blocks in accordance with Portland cement properties. Many other studies revealed cement manufacturing as a supplementary material. Wood ash, rice husk and coconut shells are partially replaced by cement [2]. Similarly, waste glass powder, a solution for colored glass waste, improves material properties [3]. This research explores wood ash and waste glass powder to create eco-friendly concrete block material, aiming to reduce environmental impact while maintaining quality construction.

3. METHODOLOGY

3.1 Preparation of Concrete Blocks

Concrete blocks were prepared according to ASTM C109/C109M standards using wooden molds and colored glass powder. Wood ash from household kitchen and waste colored glass were collected as main raw materials. The kitchen ash underwent sieving through an 850-micrometer sieve to ensure consistent particle size, while colored glass was crushed into a fine powder. Then this glass powder and sand sieved through a 1.18 mm sieve.

Table 1 – Concrete preparation design

Sample	Cement (%)	Ash (%)	Sand (%)	Glass powder (%)
1 (Control)	100	0.00	100	0.00
2 (Control)	100	0.00	90	10
3	90	10	90	10
4	85	15	90	10
5	80	20	90	10
6	75	25	90	10

A total of six concrete samples were prepared, with the first two serving as control samples. A 1:6 cement-to-sand ratio is used traditionally for the preparation of concrete blocks. Sample 1 followed the preparation method, while control sample 2 included 10% waste glass powder replacing sand for the subsequent samples. Ash replacement for cement and glass powder replacement for sand were indicated in Table 1 as the percentage. A constant 10% of sand was replaced with waste glass powder, while the percentage of wood ash replacement for cement varied from 10% to 25%. Materials were mixed, then water was added, and thorough mixing for 10 minutes ensured homogeneity. The mixture was poured into molds and allowed to set for an hour in wooden molds then unmolded. After an initial 24-hour room temperature cure process, blocks were submerged in water until testing at 7, 14, and 21 days [4]. Compressive strength, water absorption, and heat release tests were conducted to assess mechanical properties and performance, with results compared to control samples to evaluate the effectiveness of wood ash and waste glass powder in enhancing sustainability and mechanical strength.

3.2 Physical Properties of Cement Blocks

Compression strength

The samples were taken out from the water, and allowed to dry for 24 hours, before the testing. The compressive strength of the concrete block was investigated using a compressive strength testing machine. For each set of blocks, six samples were tested at three different curing ages: 7 days, 14 days, and 21 days. The average compressive strength was then calculated by taking the average of these values [4].

Water absorption

Water absorption testing was conducted on all six sets of cement blocks. The sample blocks were first oven-dried for 24 hours at a temperature of 100-105 °C until their mass became constant, and their dry weights (W1) were measured. Next, the same blocks were immersed in water for 24 hours, and their wet weights (W2) were measured. The percentage of water absorption for each individual sample block was determined using the following equation:

$$\text{Percentage of Water Absorption} = \frac{(W2-W1)}{W1} \times 100$$

Where, W1 represents the oven dry weight of the specimen, and W2 denotes the wet weight of the specimen after immersion in water [4].

Heat Release Test

The heat releasing test was conducted using an infrared (IR) thermometer. A sample block from each set was placed in an oven set at a temperature of 100-105°C for a duration of 24 hours. Within the first hour of removal from the oven, the surface temperature of the sample block was measured at 5-minute intervals using the IR thermometer at Room temperature conditions (25°C). By plotting the surface temperature against time, the rate of heat release was computed [4].

4. RESULTS AND DISCUSSION

4.1 Compression Strength

The compressive strengths of concrete blocks were evaluated at various curing times, as presented in Table 2. The data illustrates a notable increase in compressive strength values for all samples with the progression of curing time (Figure 1). After 21 days of curing, the highest compressive strength is achieved when utilizing 15% wood ash and replacement in the cement and 10 % of sand was replaced by waste glass powder, displayed notably higher compressive strength compared to Sample 1, indicating the positive influence of glass powder incorporation.

Table 2 – Compression Strength of Samples over time

Sample No	Compressive Strength Data (N/mm 2)		
	7 Days	14 Days	21 Days
1	1.24	1.84	1.92
2	1.32	1.88	2.92
3	1.56	2	3.14
4	1.64	2.32	3.52
5	1.28	2.12	2.16
6	1.24	1.84	2.04

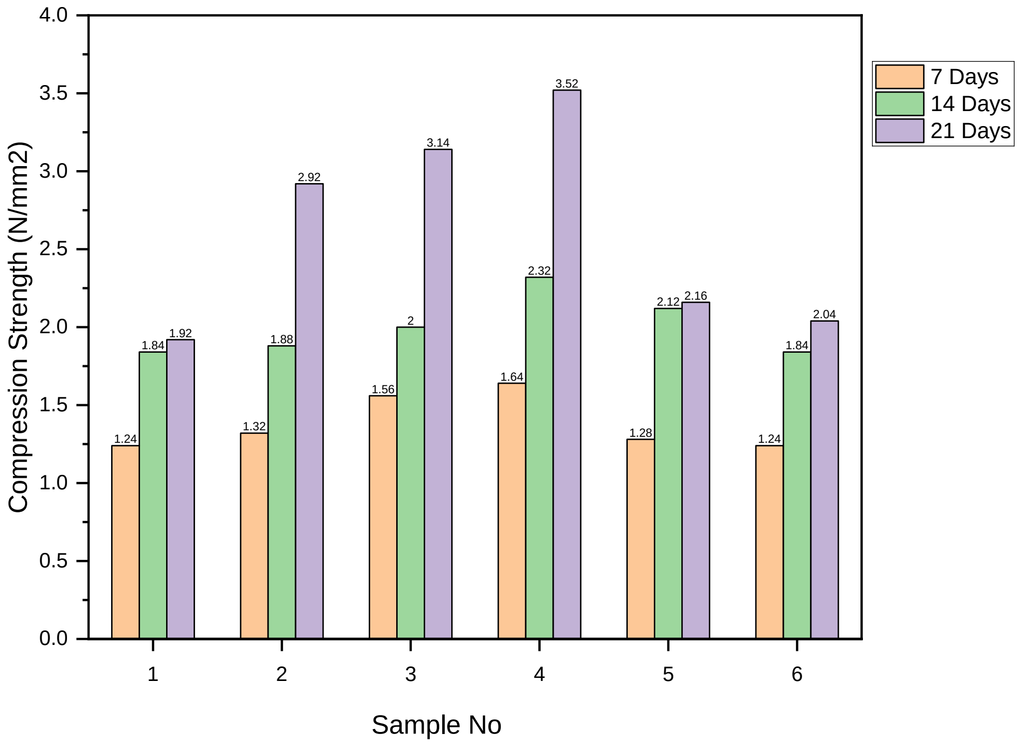

Figure 1 – Compression Strength of Samples over time

Glass incorporated into concrete can exhibit two distinct behaviors, the alkaline-silica reaction (ASR) and the pozzolanic reaction, each affecting concrete differently [5]. ASR can lead to internal stresses, cracks, and structural damage, whereas the pozzolanic reaction, as observed in our study by replacing 10% of the sand with waste glass powder, enhances mechanical properties like compressive strength and durability.
For wood ash replacement, Sample 4, with a 15% ash replacement, demonstrated the most substantial increase in compressive strength compared to the control samples (Sample 1 and 2) This improvement was attributed to the pozzolanic reaction of wood ash, driven by its potassium, magnesium, and calcium content, which raised the pH value of the hydrated cement mixture.

The extensive surface area of wood ash particles facilitated a more extensive pozzolanic reaction, resulting in additional calcium silica hydrate gel formation. This not only improved the binding within the concrete matrix but also contributed to enhanced comprehensive strength, emphasizing wood ash's potential as a sustainable cement replacement material. Moreover, wood ash's presence positively influenced the concrete's pH, further enhancing its pozzolanic activity and, consequently, chemical resistance and durability. It's important to note that the compressive strength results after 21 days varied with different ash replacement percentages, suggesting an optimal replacement level to balance the benefits of the pozzolanic reaction [5].

4.2 Water Absorption Test

The variation in water absorption with percentage of wood ash at 7, 14 and 21 days are shown in Table 3. According to the results, percentage of water absorption of all sample blocks except sample 6 are lower than the control blocks after 21 days of curing period and the lowest absorption level was detected in sample 4 which is correspondent to the 15% wood ash replacement.

Table 3 – Water absorption percentage of Samples over time

%

Sample No	Water Absorption Percentage		
	7 Days	14 Days	21 Days
1	9.36	7.68	8.32
2	7.1	6.07	7.29
3	6.45	6.49	6.17
4	7.42	6.16	6.1
5	6.11	7.35	7.24
6	7.91	9.5	9.18

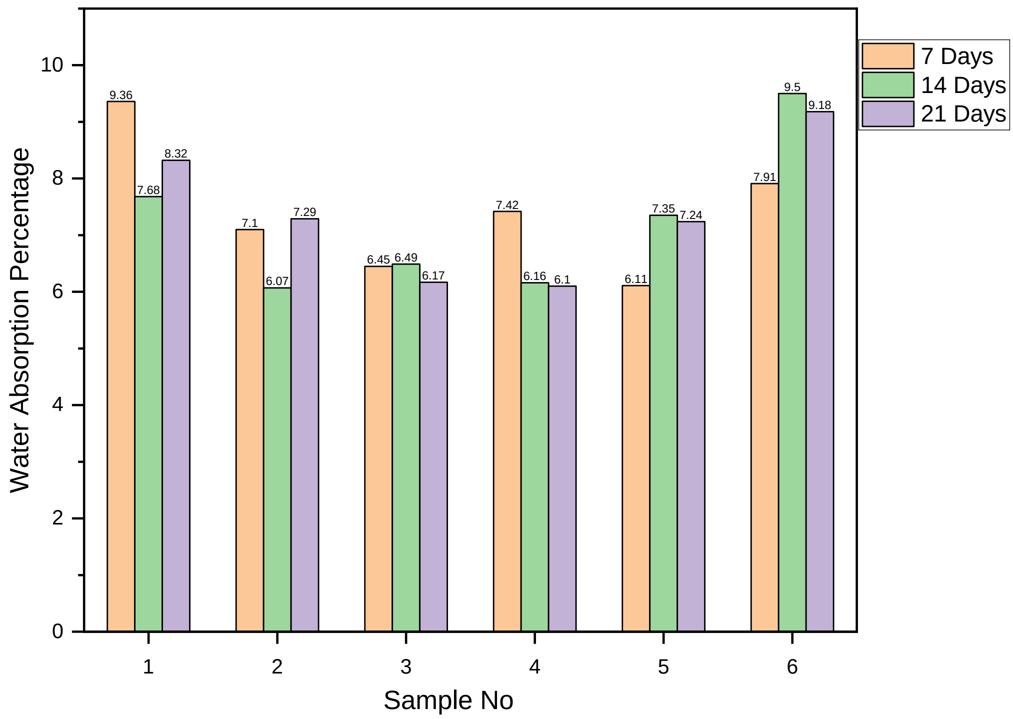

Figure 2 – Water Absorption Percentage of Samples over time

4.3 Heat Releasing Rate Test

The findings regarding the heat release rate with varying percentages of wood ash at 7, 14, and 21 days are presented in Figure 3. Notably, on the 21st day of curing, Sample 3, Sample 4, Sample 5, and Sample 6 exhibited lower heat release rates when compared to the control samples. Among these, sample 4 demonstrates the lowest heat release rate after 21 days, while sample 5 displays the second lowest heat release rate during the same period.

Concrete's water absorption characteristics significantly impact its durability [6]. After 21 days of curing, Sample 4, with 15% ash, exhibited the lowest heat release rate among all the samples. Similarly, Sample 5, with 20% ash, showed the second lowest heat release rate. In comparison to the control samples, all concrete samples containing wood ash demonstrated relatively lower heat release rates, contributing to enhanced thermal comfort.

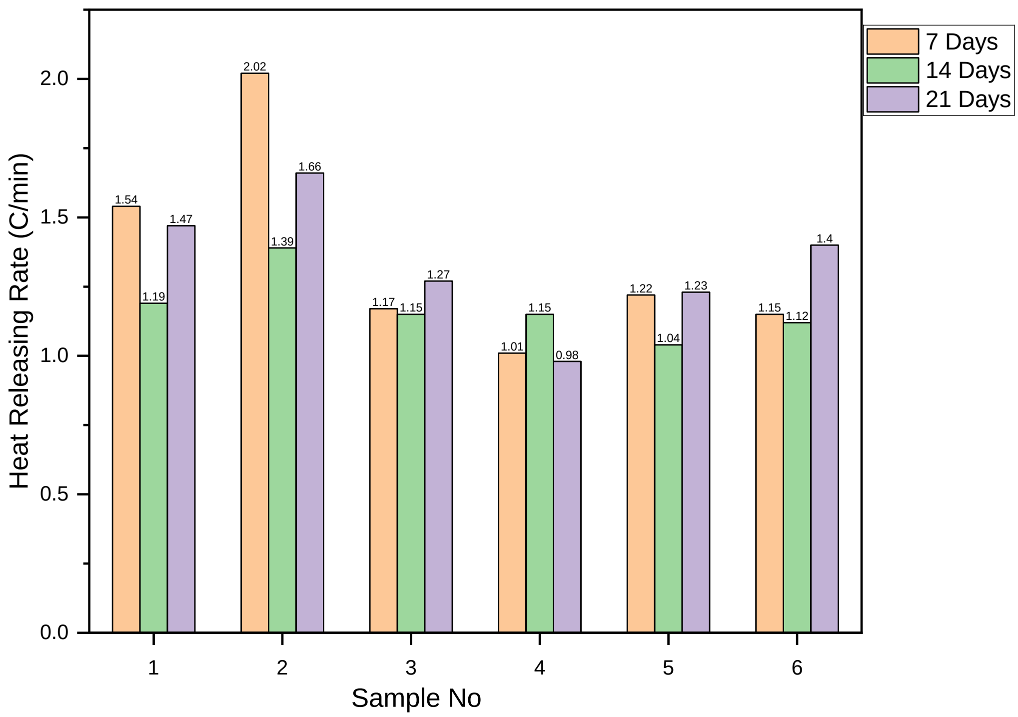

Figure 3 – Heat Releasing Rate of Samples over time.

5. CONCLUSION

The addition of waste glass powder as a 10% replacement for fine aggregate has positively impacted the mechanical properties of cement bricks. The optimal 15% wood ash replacement resulted in cement blocks with higher compressive strength, lower water absorption capacity and lowest heat releasing rate after 21 days of curing. Similarly, wood ash incorporated with glass waste powder has a more positive effect in concrete block manufacturing. Overall, both waste glass powder and wood ash offer promising sustainable alternatives for enhancing the properties of cement-based materials in construction applications.

6. REFFRENCES

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