Utilizing Of Wood Sawdust Ash in Eco-Friendly Interlocking Bricks: A Sustainable Approach

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Abstract. This study evaluates the possible effects of sawdust from scrap wood on the mechanical and microstructure characteristics of interlocking bricks when used as an additive in construction materials. Bricks with increased porosity levels were manufactured by adding more recycled wood sawdust ash (WSA) additive at larger sizes. The findings demonstrated that while sound insulation and water absorption increased with the addition of WSA, compressive strength decreased. WSA is added to aid increase unit weight and compressive strength. A higher WSA results in improved sound absorption. WSA are therefore intriguing raw materials for the creation of construction materials that use less energy.

1. Introduction

For the past 10 years, the growing population and consequent chronic shortage of building materials have made it increasingly difficult for civil engineers to convert industrial wastes into usable building and construction materials. The building material sector is in high demand as a result of this. Environmental issues have been highlighted by the uncontrolled accumulation of waste, especially in developing countries. Recycling such garbage into building materials appears to be a practical way to address the issues of cost-effective construction design as well as pollution.

Several previous research investigations have yielded informative results about the use of industrial wastes in the manufacturing of various forms of concrete. Several previous research [1,2] used wood sawdust ash (WSA) in place of cement in concrete compositions. Even although the results of these investigations are encouraging, WSA is present in the concrete mixtures. The forest provides an abundance of these wastes, which were used in our study. Geographical location and industrial processes are two factors that significantly affect the physical and chemical properties of WSA. Hardwoods tend to produce more ash than softwoods, while trees with bark and leaves tend to produce more WSA than trees with internal wood. Typically, 5–10% of the wood that is sawed is ash.In [3]

WSA is seen as a heterogeneous combination of particles with varying sizes and typically angular shapes. Bark and wood that has burned or partially burned make up these particles. The average amount of wood ash that passes the 200 sieve is 50%, while the percentage of ash that is retained on the 325 sieve is 31%, which are used to assess fineness.[4] Agrowaste is useful in the manufacturing of concrete in a few ways. It can be utilized as raw or processed aggregate or as binders to replace some of the portland cement in concrete. For instance, WSA has gained some attention as a lightweight concrete material in recent years. Despite positive findings from studies on the structural properties of WSA concrete [5, 6], the treatments created to neutralize the compounds in the WSA that prevent cement from hydrating and setting properly make the concrete much more costly and impractical in developing nations where WSA is easily accessible. Using WSA instead of sawdust in its natural state could lead to less costly concrete.

Interlocking bricks are defined as bricks with holes that account for more than 25% of the cross-sectional area of the brick and more than 25% of the total volume of the border [7]. Numerous research have examined different aspects of the mechanical behavior of interlocking bricks. For instance, interlocking block masonry wall panels under compression and horizontal loading were examined [8]. It was discovered that there was a clear correlation between the strength of the wall panel and the compressive strength of each individual unit. The results also showed that the wall panels tended to be lifted off the base by lateral stresses before the wall collapsed. It was found that the strength of the interlocking brick wall decreased with increasing eccentricity from the midline of the wall panel [9]. It was discovered that the interlocking brick wall panels' out-of-plane shear capacity was 25% greater than their in-plane shear capacity [10].

The results of the literature review revealed that there hasn't been much research on WSA's performance in interlocking bricks published in the open literature. Consequently, the primary focus of this work is on the application of WSA in the creation of interlocking bricks with mix variations of 0%, 2.5%, 5%, 7.5%, and 10%. The interlocking bricks were 25 x 12.5 x 10 cm in size, and each of the two holes had a diameter of 5 cm. There are five different ways to employ WSA: 0%, 2.5%, 5%, 7.5%, and 10%.

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2. Experimental Program

2.1 Materials

The WSA utilized in this investigation was produced during the sawmill’s mechanical processing of raw wood. The WSA that was sampled was retrieved from its disposal site, close to a nearby lumber mill, in its original state. Portland cement, water, and sand were the cement ingredients employed in this investigation.

2.2 Mixing and fabrication of interlocking bricks

Prepare the necessary tools and materials. Weigh WSA, cement, sand and water according to the measurements. Mix the materials (without the addition of WSA), for the next mixture with the addition of WSA 2.5%, 5%, 7.5% and 10%. Stir all ingredients until smooth. Add water by trial until the mixture is not too wet, and not too dry. The amount of water is approximately ± 25% of the total weight of cement. Lubricate the mould using oil so that when the test specimen is removed from the mould it does not crack. After that, the dough that has been mixed evenly is put into the interlock brick mould until the full part of the mould, then compacted. Close the mould cover and lock then press for ± 5 seconds until the test object is completely solid. Perform curing by watering the test specimen in the first three days, and let the test specimen dry for up to 28 days before the test specimen is ready for testing.

<table>
<thead>
<tr>
<th>Test Item</th>
<th>WSA Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0  2.5  5  7.5  10</td>
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</table>

| Interlocking bricks | Compressive strength | 5  5  5  5  5 |
|--------------------|----------------------|----|----|----|----|
| Water absorption   | 5  5  5  5  5 |
| Sound insulation and fire resistance | 15  15  15  15  15 |

Table 1. WSA usage variation for test objects

| Number of test pieces | 25 25 25 25 25 |
| Total                | 125 |

Table 2. Mixture proportions of Interlock Brick

<table>
<thead>
<tr>
<th>Mix Designation</th>
<th>Sample Amount</th>
<th>Cement (gr)</th>
<th>Sand (gr)</th>
<th>WSA (gr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% (BBI-N)</td>
<td>25</td>
<td>79209.1125</td>
<td>88005.13</td>
<td>0</td>
</tr>
<tr>
<td>2.5% (BBI – S2.5)</td>
<td>25</td>
<td>79209.1125</td>
<td>85805</td>
<td>2200.1286</td>
</tr>
<tr>
<td>5% (BBI – S5)</td>
<td>25</td>
<td>79209.1125</td>
<td>83604.87</td>
<td>4400.2572</td>
</tr>
<tr>
<td>7.5% (BBI – S7.5)</td>
<td>25</td>
<td>79209.1125</td>
<td>81404.74</td>
<td>6600.3858</td>
</tr>
</tbody>
</table>

2.3 Test Methods

The brick samples' water absorption, unit weight, compressive strength, sound insulation, and fire resistance were all evaluated through a battery of tests.

The brick samples are evaluated for water absorption after 28 days of curing. After being removed from the curing tank, they are placed on it to allow the surface water to drain. a lattice of metal wire. After wiping away any visible surface water using a moist cloth, the samples are promptly weighed. They are dried to a constant mass for 28 hours at 105 °C after reaching the saturated weight content. Afterward, they are removed from the oven and weighed at room temperature. Samples' dry and wet weights' water absorption is computed. After the brick samples are allowed to cool to room temperature, their unit weights are calculated by dividing their mass by volume.

At the Rekayasa Bahan Laboratory of the Department of Civil Engineering, Faculty of Engineering, University of Sumatera, Utara, the dry compressive strength of brick samples was ascertained by means of a compression test.

Compressive strength is computed by dividing the maximum load by the area of the load region applied to the brick sample. Sound absorption is tested using a sound level meter. Meanwhile, the fire resistance was tested during four hours of temperature variations of 250, 500, and 750 °C.
The microstructure of interlocking bricks with the highest compressive strength value was observed using a scanning electron microscope (SEM) in the Integrated Research Laboratory Universitas Sumatera Utara.

3. Result and discussion

3.1 Water absorption and unit weight

The mass and volume of the samples are taken into consideration when computing the two terms for water absorption. Fig. 2 illustrates the proportionality between the water absorption and the percentage WSA values. An improvement of 10% in the WSA content causes the initial water absorption value to increase from 2.65 to 5.58%. The water absorption by mass is within a somewhat acceptable range when this WSA concentration is contrasted with regularly used lightweight building materials like AAC, which has an estimated water absorption value of 60%. [11]

Fig. 2. Graphical representation of the water absorption and Unit weight

The test results confirm that the unit weight values are inversely proportional to the amount of sand replacement with WSA content (see Fig. 2). The unit weight of the control mix can be decreased by 20% by substituting 10% of the WSA. This result was anticipated because of WSA’s capacity to absorb water. Assuming that a conventional concrete brick weighs 2.1 g/cm³, the mixture with 10% WSW produces concrete that is 65% lighter. This positive finding of the WSA combination’s potential for use in applications involving lightweight building materials is the decrease in unit weight.

3.2 Compressive strength

The compressive strength values that were obtained from the testing are displayed in Fig. 3.

Fig. 3. Graphical representation of the Compressive strength

The average compressive strength values have an inverse relationship with the proportion of WSA replacement. WSA experiences a sharp decline in strength as replacement level increases. The control mix strength is reduced by 94% with 10% WSA replacement, yielding an average result that is 0.81 MPa lower than BS67-03 [12]. Moreover, even at this compressive strength value, the WSA-cement composite is easily cut with a standard handheld saw.

3.3 Sound insulation and fire resistance

Fig. 4 display the sound values that were determined throughout the test.

Fig. 4. Graphical representation of the Sound absorption

Fig. 4 illustrates how the insulating sound value rises as the percentage of WSA in the interlock brick increases. 34.6 dB is the highest figure recorded. Fig. 5 demonstrates the interlocking bricks' compressive strength ratings after they are calcination at 250, 500, and 750°C.
The greatest value, 18.67 MPa, is obtained after the interlock bricks are calcined at 250 °C. This value is even higher than the interlock bricks without heat treatment. This is due to the possibility that during the heating process, the raw material particles will melt and fuse together to form a denser and more robust structure. Bricks that interlock can be strengthened by this process, called sintering. Heating can also enhance the crystallization of raw materials, resulting in a more reliable and uniform crystal structure. Furthermore, heating can remove water and other volatile substances from the raw materials, resulting in denser and more durable interlocking bricks. [13, 14]

3.4 Microstructure analysis

The interaction and compatibility of WSA with binder was investigated by scanning electron microscopy analysis.

Good structural integrity is demonstrated by the OPC binder as dispersed hydration products on the surface of the WSA. The WSA's pores also contained a little quantity of needle-like material, which somewhat improved the material's water resistance. The cause of the compressive strength value achieved not reaching the maximum value is the inhomogeneous structure, as shown in Figure 6. An analysis using scanning electron microscopy was performed to explore how sawdust powder interacts and aligns with the binder. Numerous sawdust particles contain whisker-like fibers, which are commonly observed on the surface of pore walls or within defects in the sawdust. This observation is in line with the discoveries made by Barbieri et al. [15] and Qin et al. [16]. Additionally, the examination revealed hydration products within the paste, suggesting the presence of needle-shaped crystals.

4. Conclusions

Brick samples with WSA are examined for their mechanical and physical characteristics. The test findings indicate that the combination of WSA and results has the potential to be used in the development of a new, lighter, more affordable brick material. According to the test results, the WSA combination yields results that might be used in the creation of a brand-new, lightweight, and less expensive brick material. The experiment results show that even beyond the failure loads, a brittle fracture that occurs quickly is not caused by the 0–10% WSA replacements in the matrix, which leads to a high energy absorption capacity and lower labor costs. This combination produces a composite that is around 65% lighter than regular concrete bricks. A 10% replacement level of WSA, 0.81 MPa compressive strength, and suitability for use are characteristics of concrete that satisfies BS67-03 criteria for a building material to be utilized in structural applications. Nevertheless, a more comprehensive analysis of brick samples utilizing the WSA combination should include additional durability testing.
References

6. T.W. Parker. Sawdust-cement and other sawdust building product and industry. 67, 593-595 (1947)