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Employment of ash derived from agricultural waste for sustainable cement replacement in flowing concrete

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Abstract: The increasing amounts of agricultural residues, including rice husks and sugarcane bagasse in Indonesia, present an escalating threat to environmental quality and public health if not managed properly. As reported by the Central Bureau of Statistics in 2024, rice husk waste has reached approximately 10.5 million tons, while sugarcane bagasse accounts for about 7.41 million tons. According to previous studies, ashes from sugarcane bagasse and rice husks in concrete can enhance certain mechanical properties while promoting eco-friendly construction practices. These ashes exhibit pozzolanic behavior, which makes them suitable for partially replacing cement, thus reducing the carbon footprint of concrete production. This study investigates alternative materials substituting a portion of cement with ashes derived from sugarcane bagasse and rice husks to determine how they contribute to the properties of flowing concrete, utilizing Sika-Viscocrete as a superplasticizer. The flowing concrete was evaluated based on its slump flow and absorption. In this investigation, the slump flow test was carried out following ASTM International [1] while the absorption test was executed according to SNI 03-6433-2000. The results showed that all slump flows met the standard requirements, with the minimum absorption value being 3.34% at a variation of 12.5% rice husk ash.

Keywords: *Absorption, Flowing concrete, Rice husk ash, Slump flow, Sugarcane bagasse ash.*

1. Introduction

Indonesia is widely recognized as an agrarian country, with the majority of its population engaged in farming activities. Rice milling generates by-products in the form of rice husks, which account for approximately 20%–33% of the harvested paddy [2]. According to data from the Central Bureau of Statistics, Indonesia's rice production in 2024 reached 52.66 million tons, resulting in an estimated 10.5 million tons of rice husks [3]. In the same year, the Badan Pusat Statistik (BPS) [4] reported that national sugar production amounted to 2.47 million tons [3]. On average, sugarcane processing in sugar mills produces 25%–33% bagasse from the weight of the cane, while sugar recovery accounts for about 10% [5]. Based on this ratio, the total amount of bagasse generated in 2024 is estimated at 7.41 million tons. The accumulation of such agricultural residues can create environmental concerns, since their natural decomposition takes place rather slowly. Without proper management, the excessive build-up of this biomass waste could pose significant challenges.

Based on earlier research, rice husk ash (RHA) is well known for its remarkable pozzolanic activity, high specific surface area, and considerable amorphous silica content, all of which contribute to improving the hydration mechanism and refining the microstructural composition of cement paste [6, 7]. When rice husk ash (RHA) is added to concrete, the silica it contains reacts with calcium hydroxide released from cement hydration. This reaction forms a gel known as calcium silicate hydrate (C–S–H),

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which slowly fills the pores in the cement matrix. As these pores become denser, the concrete absorbs less water and becomes more resistant to moisture penetration. Such microstructural densification leads to a notable reduction in water absorption and permeability, which strengthens concrete's resistance to moisture intrusion and mitigates durability issues such as steel reinforcement corrosion or sulfate-induced damage [8]. Sugarcane bagasse ash (SBA) also plays an important role since it comprises a large proportion of amorphous silica and reacts actively with cement components. When included in the mix, SBA helps make the concrete denser, strengthens the structure, and reduces how easily water can pass through it [9].

Cement, which serves as the main binding material in concrete, is largely responsible for CO_2 emissions [10, 11]. It is recognized that its production generates large amounts of carbon dioxide emissions, which are estimated to account for about 5–8% of global CO_2 output [12]. As demand for cement continues to rise, the environmental load also increases, driving climate change and degrading the natural ecosystem [10, 11]. To reduce this impact, researchers have been testing various alternative materials that can partially replace cement. These substitutes can help lower emissions while still maintaining or even improving the performance of concrete.

Flowing concrete spreads easily and does not require much vibration when being placed. It is known for its high flowability, stability against segregation, and ability to move through narrow spaces or dense reinforcement without a vibrator [13, 14]. The mix usually includes cement, fine and coarse aggregates, water, and superplasticizers. The superplasticizer, such as Sika-Viscocrete used in this study, improves workability, enhances flow, and allows a lower water-to-cement ratio (w/c) without weakening the concrete [15].

To reduce environmental waste from rice husks and sugarcane bagasse, minimize cement use, and limit reliance on mechanical vibration during casting, this study employed flowing concrete incorporating Sika-Viscocrete as the superplasticizer. Rice husk ash (RHA) was added to the mix at 0%, 5%, 7.5%, 10%, and 12.5% as a partial replacement for cement. Similarly, sugarcane bagasse ash (SBA) was used at 0%, 2.5%, 5%, 7.5%, and 10%. The study focused on two primary parameters: slump flow and water absorption. The slump flow test was performed according to standard procedures [1] while the water absorption test was executed according to Badan Standardisasi Nasional [16].

2. Materials and Methods

2.1. Material

The study employed materials including fine and coarse aggregates, water, and Portland Composite Cement (produced by Gresik Cement), along with rice husk ash (RHA), sugarcane bagasse ash (SBA), and Sika-Viscocrete as a superplasticizer.

Before mixing, all materials were evaluated to ensure compliance with quality standards. Flowing concrete is considered high-quality when its constituents meet these specifications. The materials examined in this study are detailed below:

- RHA and SBA: Their chemical components were analyzed applying X-Ray Fluorescence;
- The fine aggregate underwent various tests, such as measuring its water absorption and specific gravity, following [17]. The gradation of particles was analyzed through a sieve test according to ASTM International [18]. Bulk density and void content were tested in accordance with ASTM International [19]. The moisture content was assessed following [20], and cleanliness was evaluated through washing, in accordance with ASTM International [21].
- The coarse aggregate was evaluated through tests of absorption and specific gravity following ASTM C127-01, sieve analysis in accordance with ASTM International [18], measurement of voids and bulk density based on ASTM International [19], moisture content testing as per [20], and cleanliness testing by washing according to ASTM International [21]. In addition, the abrasion resistance of coarse aggregate was examined using [22].

2.2. Methods
Mixture composition of flowing concrete specimens:

Mixture composition of flowing concrete was in line with Badan Standardisasi Nasional [23], Guidelines for the Design of Normal Concrete Mixes, and [24] regulations. Cylindrical specimens measuring 15 × 30 cm and 10 × 20 cm were prepared for the mixture using the following mix proportions:

2.3. Rice Husk Ash
- · Portland composite cement: 455.5 kg/m^3 (0% RHA); 448.474 kg/m^3 (5% RHA); 444.737 kg/m^3 (7.5% RHA); 440.86 kg/m^3 (10% RHA); and 436.834 kg/m^3 (12.5% RHA).
- Fine aggregate: 890.441 kg. m^{-3}
- Coarse Aggregate: 194.44 kg. m^{-3} (5-10 mm); 598.076 kg. m^{-3}(10-20 mm)
- Water: 186.5 kg. m^{-3}
- Superplasticizer: 6.8 kg. m^{-3}
- Rice husk ash: 0 (0%); 23.6 kg.m^{-3} (5%); 36.06 kg.m^{-3} (7.5%); 48.9 kg.m^{-3} (10%) and 62.4 kg.m^{-3} (12.5%)

2.4. Sugarcane Bagasse Ash
- Portland composite cement: 455.5 kg.m^{-3} (0% SBA); 452.078 kg.m^{-3} (2.5% SBA); 448.474 kg. .m^{-3} (5% SBA); 444.737 kg.m^{-3} (7.5% SBA) and 440.86 kg.m^{-3} (10 % SBA)
- fine aggregate: 918.43 kg.m^{-3}
- Coarse Aggregate: 199.092 kg.m^{-3} (5-10 mm); 616.619 kg.m^{-3} (10-20 mm);
- Water: 178.3 kg.m^{-3}
- Superplasticizer: 6.8 kg.m^{-3}
- Sugarcane bagasse ash: 0 (0%); 11.6 kg.m^{-3} (2,5%); 23.6 kg.m^{-3} (5%); 36.1 kg.m^{-3} (7.5%) and 48.9 kg.m^{-3} (10%)

2.5. The Process of Making Ash from Rice Husk Explained in These Steps
1. Burn rice husk in a burning barrel, then rice husk ash is sieved no 200

Figure 1.
A. burning the rice husk. B. Then rice husk ash was sieved no 200 sieve to get a finer material.

2. Burn sugarcane bagasse in a burning barrel; then, sieve the sugarcane bagasse ash through a No. 200 sieve.

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Figure 2.
A. Burning the sugarcane bagasse. B. Then sugarcane bagasse ash was sieved no 200 sieve to get a finer material.

2.6. Making a Specimen of Flowing Concrete for the Slump Flow Test

1. Combine all the components, including sand, cement, water, superplasticizer, and rice husk ash (RHA) as a partial substitute at proportions of 0%, 5%, 7.5%, 10%, and 12.5%.
2. Mix the materials thoroughly until a uniform consistency is achieved.
3. Prepare the slump flow cone along with the base plate.
4. Coat the inner surface of the cone with oil to prevent fresh concrete from sticking to its walls.
5. Once evenly coated with oil, position the cone with its narrow opening facing downward on the base plate.
6. Place fresh concrete into the cone, and once it is full, gently raise the cone in a vertical and smooth motion.
7. Allow the fresh concrete to spread freely until it forms a circular shape and comes to rest.
8. Determine the spread width in both orthogonal directions: the vertical and horizontal axes.
9. Repeat steps 1–8 using flowing concrete mixtures containing sugarcane bagasse ash as a partial substitute at proportions of 0%, 2.5%, 5%, 7.5%, and 10%.

2.7. Making a Specimen of Flowing Concrete for Adsorption Test

1. Combine sand, cement, water, superplasticizer, and rice husk ash as an additional material, with replacement levels of 0%, 5%, 7.5%, 10%, and 12.5%.
2. Mix all the components until the blend is homogeneous.
3. Place the fresh concrete into the prepared cylinder mold, then tamp the mixture 25 times.
4. Allow the specimen to rest for 24 hours before removing it from the mold.
5. Cure the concrete specimens in water according to the planned curing ages.
6. Remove the specimens from the curing tank one day before the absorption test is performed (on the 27th day).
7. Weigh each specimen to examine the initial mass of the flowing concrete.
8. The specimens were oven-dried for a duration of 24 hours to ensure complete drying.
9. After a 24-hour drying process, the specimens were withdrawn from the oven and weighed again to obtain the dry mass.
10. Calculate the absorption value of the flowing concrete based on the recorded measurements.
11. Repeat steps 1–10 for flowing concrete mixtures incorporating sugarcane bagasse ash at proportions of 0%, 2.5%, 5%, 7.5%, and 10%.

2.8. Testing of Specimens

2.8.1. Slump Flow

The slump flow test is carried out by filling a cone-shaped mold with fresh concrete in a single layer without vibration or compaction. Once the mold is lifted, the concrete is allowed to spread until it comes to rest. Finally, two perpendicular diameters of the spread concrete are measured, and the slump flow value is taken as the average of these two measurements [1]:

$$D = \frac{D_1 + D_2}{2} \quad (1)$$

Where: D_1 = Diameter One (cm)
D_2 = Diameter Two (cm)
D = Average Diameter (cm)

2.9. Water Absorption

The water absorption test is employed to quantify the amount of water present in a concrete specimen. In essence, the test determines how much water the sample can absorb. The concrete's water content is then calculated using the formula provided in Badan Standardisasi Nasional [16]:

$$\text{Absorption} = \frac{M_s - M_d}{M_d} \, x \, 100\% \quad (2)$$

Where: M_s= Saturated sample mass (gr)
M_d= Dry sample mass (gr)

3. Results and Discussion

3.1. Slump Flow

Specimens are used to calculate the slump flow of flowing concrete. Figure 3 shows how the average slump flow of flowing concrete is affected by the substitution of agricultural waste ash.

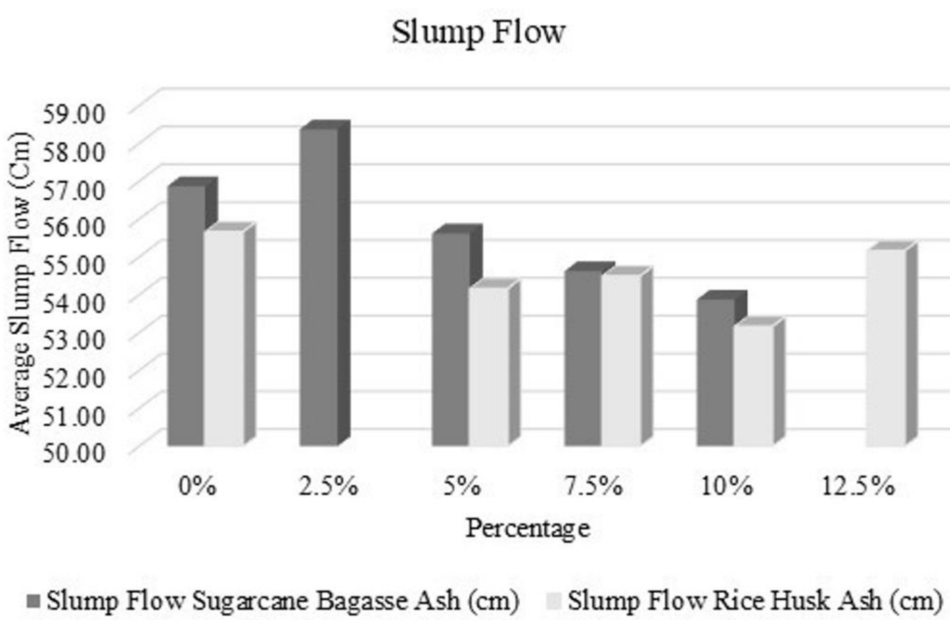

Figure 3.
Comparison of agricultural waste ashes on slump flow in flowing concrete.

The workability or consistency of concrete is determined by its slump flow. The average slump flow for the control mix exceeds 50 cm, indicating that the slump flow meets the requirements [25].

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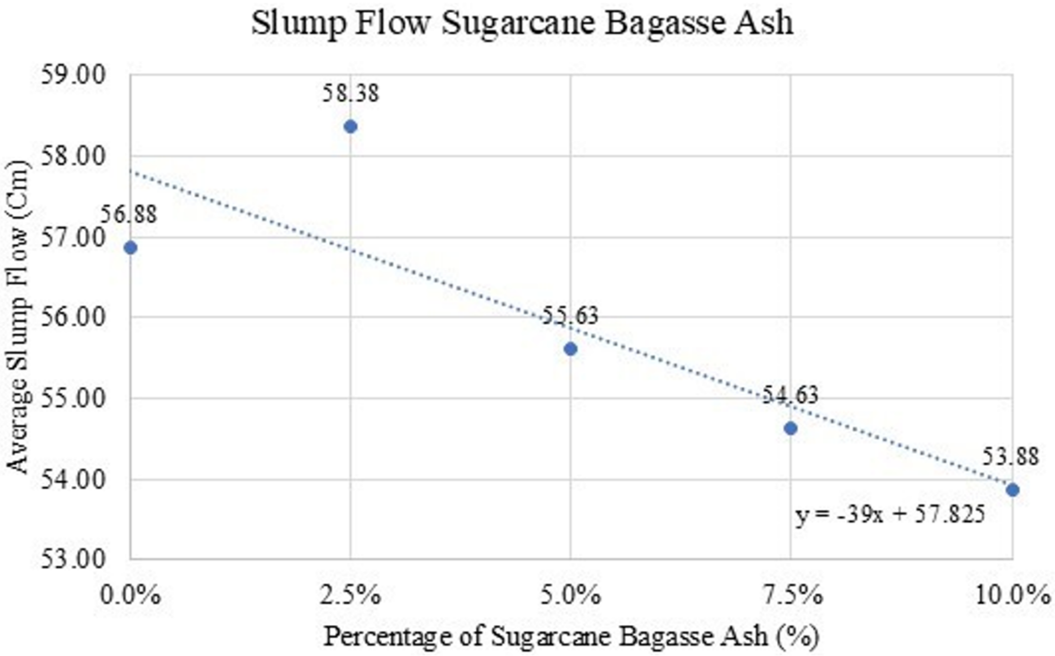

Figure 4.
Influence of sugarcane bagasse ash on slump flow in flowing concrete.

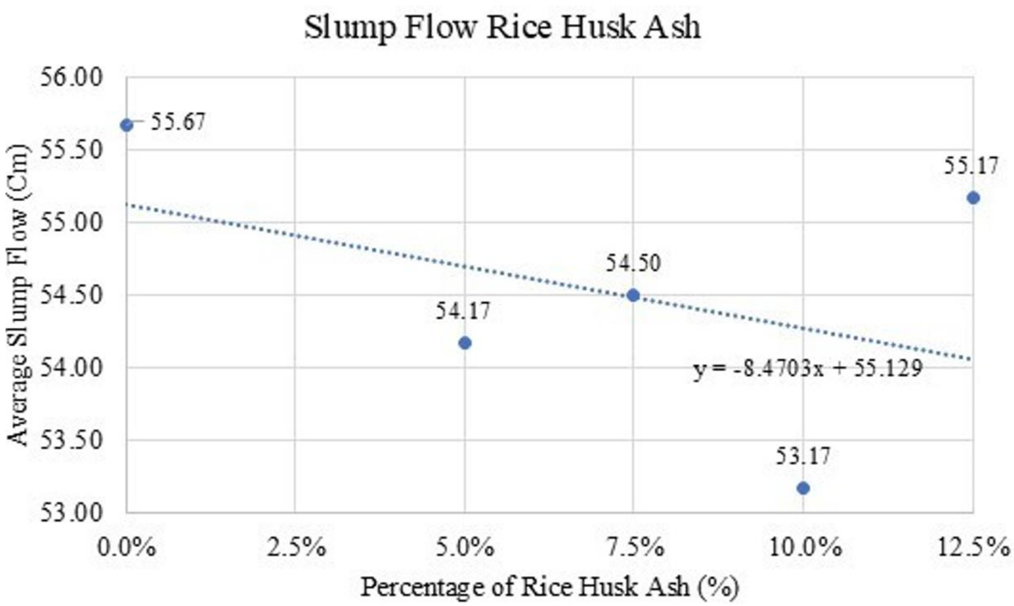

Figure 5.
Influence of rice husk ash on slump flow in flowing concrete.

Figure 4 and 5 demonstrate how the slump flow of flowing concrete tends to decrease with the substitution of rice husk ash and sugarcane bagasse ash. These findings, consistent with Maglad et al. [26], indicate that the slump flow diameter declines as the level of cement replacement with sugarcane bagasse ash increases. This reduction is primarily associated with the influence of the surface area of the substitute material. Specifically, when cement is partially replaced with sugarcane bagasse ash, the overall binder surface area increases, which elevates the water demand. Consequently, the amount of free water within the paste decreases, resulting in a reduction in slump flow. According to Su and Xu [27], incorporating rice husk ash into concrete leads to a reduction in slump, with the value decreasing progressively as the replacement level increases. This occurs because rice husk ash, when used as a substitute binder for cement, possesses an extensive specific surface area. Its inclusion enlarges the overall surface area associated with the binder, resulting in greater water adsorption. Consequently, the amount of free water in the mix is diminished, which in turn lowers the workability and flowability of the concrete. Liu et al. [28] noted that the decline in slump flow may be associated with the irregular morphology of rice husk ash particles, which heightens the frictional resistance among particles and thereby hinders the ease of movement within the mixture.

3.2. Absorption

Flowing concrete specimens are tested for water absorption. Figure 6 illustrates how agricultural waste ash affects the absorption value of the flowing concrete.

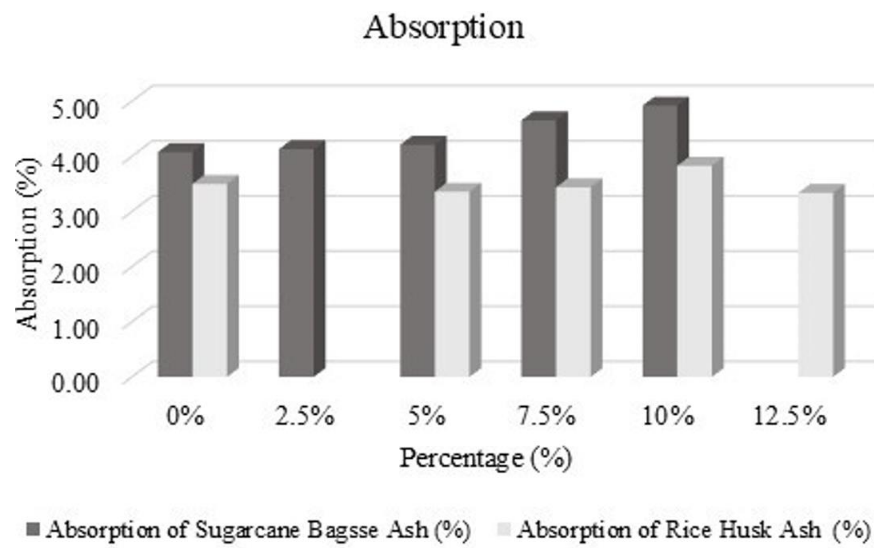

Figure 6.
Comparison of agricultural waste ashes on absorption in flowing concrete.

Figure 6 indicates that concrete incorporating sugarcane bagasse ash (SBA) generally demonstrates greater water absorption than mixes containing rice husk ash (RHA). This variation is closely linked to their chemical composition: while RHA is rich in silica at around 91.3%, SBA contains only about 59.3%. The abundance of amorphous silica in RHA improves its pozzolanic reaction with calcium hydroxide, producing additional calcium silicate hydrate (C–S–H). This secondary C–S–H contributes to pore refinement and lowers capillary porosity within the concrete matrix. Conversely, the comparatively lower silica content combined with the higher loss on ignition (LOI) of SBA reduces its reactivity and filling capacity, which often leaves a more open microstructure, resulting in higher water uptake. Previous investigations also highlight that highly siliceous pozzolans, such as RHA and silica fume, effectively decrease permeability and absorption, whereas SBA, due to its reduced reactive silica, frequently leads to higher absorption values [29, 30].

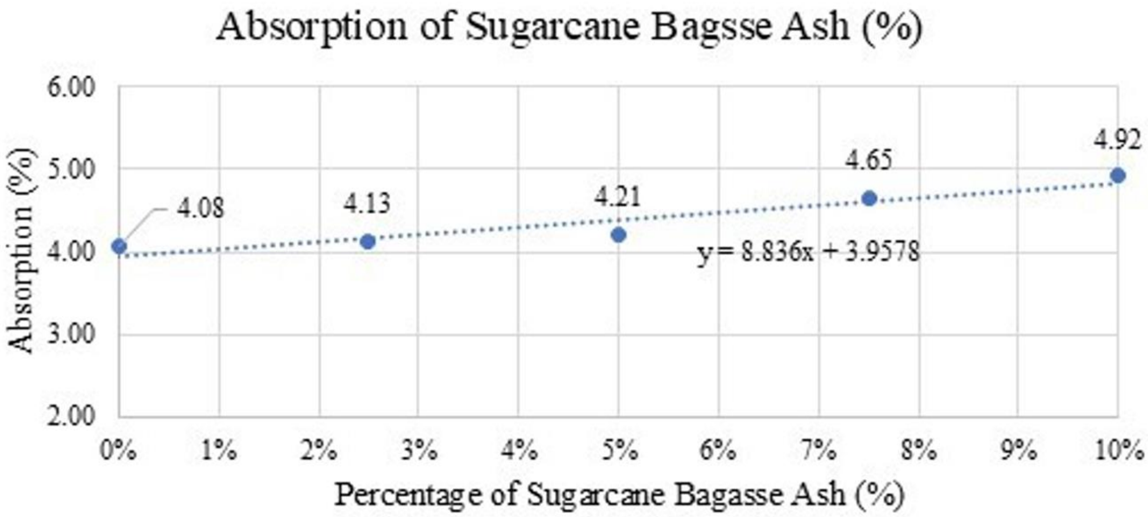

Figure 7.
Influence of sugarcane bagasse ash on absorption in flowing concrete.

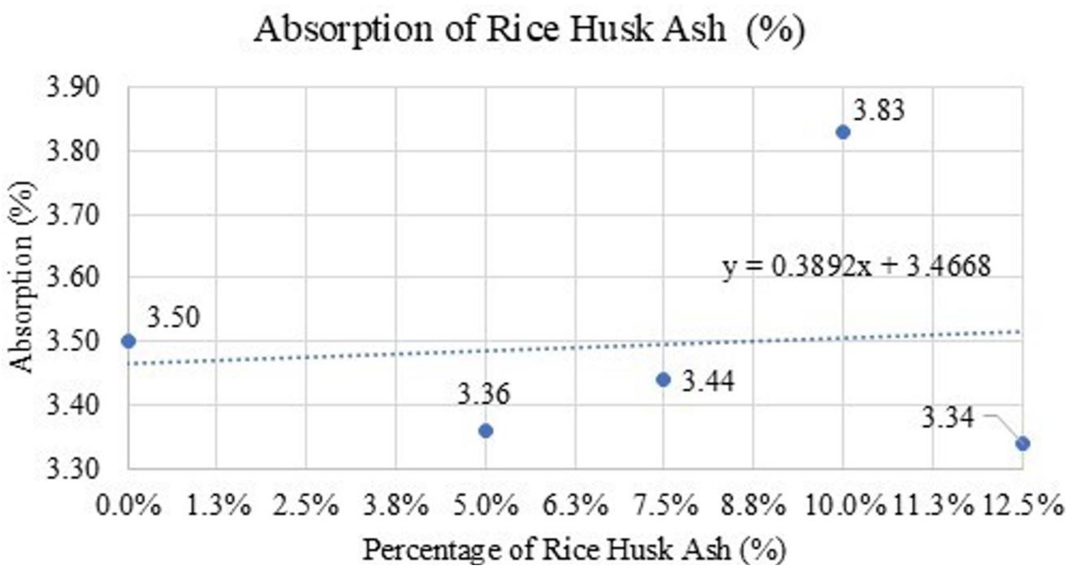

Figure 8.
Influence of sugarcane bagasse ash on absorption in flowing concrete.

Figure 7 and 8 indicate how adding sugarcane bagasse ash and rice husk ash to the flowing concrete mixture tends to increase. Adding rice husk ash to the mixture led to an increase in water absorption, with the rate of increase becoming more gradual as the content was raised, a similar outcome reported by Su and Xu [27]. This behavior is largely explained by the hygroscopic nature of rice husk ash [7], which promotes higher water uptake. Thomas et al. [31] also observed that increasing the amount of SBA in the mix results in greater water absorption, a consequence of its inherent hygroscopic nature.

4. Conclusion

All samples showed slump flow values that satisfied the required standards, proving that the mixtures had good workability. The minimum mixture in terms of water absorption was observed in the mix containing 12.5% sugarcane bagasse ash, with a value of 3.34%. Adding SBA and RHA tends to increase water absorption because both materials naturally attract moisture. This effect is stronger when their proportion is low, but higher replacement levels seem to slow down the rate of increase. Overall, the findings show that choosing the right type and proportion of pozzolanic materials is essential for improving durability and moisture control in concrete.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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References

[1] ASTM International, *ASTM C1611-05: Standard test method for slump flow of self-consolidating concrete*. West Conshohocken, PA: ASTM International, 2005.

[2] I. M. Ríos-Badrán, I. Luzardo-Ocampo, J. F. García-Trejo, J. Santos-Cruz, and C. Gutiérrez-Antonio, "Production and characterization of fuel pellets from rice husk and wheat straw," *Renewable Energy*, vol. 145, pp. 500-507, 2020. https://doi.org/10.1016/j.renene.2019.06.048

[3] Badan Pusat Statistik (BPS), "The rice harvest area in 2024 is estimated at 10.05 million hectares with rice production of around 52.66 million tons of dry milled grain (GKG)," 2024. https://www.bps.go.id/id/pressrelease/2024/10/15/2376/luas-panen-padi-tahun-2024-diperkirakan-sebesar-10-05-juta-hektare-dengan-produksi-padi-sekitar-52-66-juta-ton-gabah-kering-giling--gkg--.html. [Accessed 20 August 2025]

[4] Badan Pusat Statistik (BPS), "Statistics of Indonesian annual plantation crops 2024 (Sugarcane and Tobacco)," 2024. https://www.bps.go.id/id/publication/2025/08/29/35f854853b5e9a06ae5bad9d/statistik-tanaman-perkebunan-semusim-indonesia-2024--tebu-dan-tembakau-.html. [Accessed 20 August 2025]

[5] O. Sahu, "Assessment of sugarcane industry: Suitability for production, consumption, and utilization," *Annals of Agrarian Science*, vol. 16, no. 4, pp. 389-395, 2018. https://doi.org/10.1016/j.aasci.2018.08.001

[6] M. Chaitanya, T. Nagaraju, L. Gadhiraju, V. Madepalli, and S. N. R. Jampana, "Strength and micro-structural performance of geopolymer concrete using highly burned rice husk ash," *Materials Today: Proceedings*, 2023. https://doi.org/10.1016/j.matpr.2023.04.617

[7] A. N. Givi, S. A. Rashid, F. N. A. Aziz, and M. A. M. Salleh, "Contribution of rice husk ash to the properties of mortar and concrete: a review," *Journal of American Science*, vol. 6, no. 3, pp. 157-165, 2010.

[8] F. Y. Al-Saffar, L. S. Wong, and S. C. Paul, "An elucidative review of the nanomaterial effect on the durability and calcium-silicate-hydrate (CSH) gel development of concrete," *Gels*, vol. 9, no. 8, p. 613, 2023. https://doi.org/10.3390/gels9080613

[9] J. T. Kolawole, A. J. Babafemi, E. Fanijo, S. C. Paul, and R. Combrinck, "State-of-the-art review on the use of sugarcane bagasse ash in cementitious materials," *Cement and Concrete Composites*, vol. 118, p. 103975, 2021. https://doi.org/10.1016/j.cemconcomp.2021.103975

[10] S. A. Miller, G. Habert, R. J. Myers, and J. T. Harvey, "Achieving net zero greenhouse gas emissions in the cement industry via value chain mitigation strategies," *One Earth*, vol. 4, no. 10, pp. 1398-1411, 2021. https://doi.org/10.1016/j.oneear.2021.09.011

[11] S. Griffiths *et al.*, "Decarbonizing the cement and concrete industry: A systematic review of socio-technical systems, technological innovations, and policy options," *Renewable and Sustainable Energy Reviews*, vol. 180, p. 113291, 2023. https://doi.org/10.1016/j.rser.2023.113291

[12] M. Z. Khaiyum, S. Sarker, and G. Kabir, "Evaluation of carbon emission factors in the cement industry: An emerging economy context," *Sustainability*, vol. 15, no. 21, p. 15407, 2023. https://doi.org/10.3390/su152115407

[13] F. Arsasuta and N. Rochmah, "The effect of glass powder as a partial substitution of cement on the compressive strength of flowing concrete," *Jurnal Teknik Sipil dan Teknologi Konstruksi*, vol. 10, no. 1, pp. 12-23, 2024. https://doi.org/10.35308/jts-utu.v10i1.9475

[14] S. Wahab, A. M. Abbasi, A. Ahmed, and I. U. Khan, "Influence of acetic acid treated recycled concrete aggregates on the rheological and mechanical properties of self-compacting concrete: Experiments and machine learning," *Construction and Building Materials*, vol. 491, p. 142770, 2025. https://doi.org/10.1016/j.conbuildmat.2025.142770

[15] M. J. de Hita and M. Criado, "Influence of superplasticizers on the workability and mechanical development of binary and ternary blended cement and alkali-activated cement," *Construction and Building Materials*, vol. 366, p. 130272, 2023. https://doi.org/10.1016/j.conbuildmat.2022.130272

[16] Badan Standardisasi Nasional, *SNI 03-6433-2000: Test method for density, absorption and voids in hardened concrete*. Jakarta: Badan Standardisasi Nasional, 2000.

[17] ASTM International, *ASTM C128-01: Standard test method for relative density (specific gravity) and absorption of fine aggregate*. West Conshohocken, PA: ASTM International, 2001.

[18] ASTM International, *ASTM C136-01: Standard test method for sieve analysis of fine and coarse aggregates*. West Conshohocken, PA: ASTM International, 2001.

[19] ASTM International, *ASTM C29/C29M-97: Standard test method for bulk density (unit weight) and voids in aggregate*. West Conshohocken, PA: ASTM International, 1997.

[20] ASTM International, *ASTM C566-97: Standard test method for total evaporable moisture content of aggregate by drying*. West Conshohocken, PA: ASTM International, 1997.

[21] ASTM International, *ASTM C117-95: Standard test method for materials finer than 75-µm (No. 200) sieve in mineral aggregates by washing*. West Conshohocken, PA: ASTM International, 1995.

[22] ASTM International, *ASTM C131/C131M-14: Standard test method for resistance to degradation of small-size coarse aggregate by abrasion and impact in the Los Angeles machine*. West Conshohocken, PA: ASTM International, 2014.

[23] Badan Standardisasi Nasional, *SNI 03-2834-2000: Procedures for making a normal concrete mix plan*. Jakarta: Badan Standardisasi Nasional, 2000.

[24] EFNARC, *Specification and guidelines for self-compacting concrete*. Surrey, UK: EFNARC, 2002.

[25] ASTM International, *ASTM C1017/C1017M – standard specification for chemical admixtures for use in producing flowing concrete*. West Conshohocken, PA: ASTM International, 1998.

[26] A. M. Maglad, M. Amin, A. M. Zeyad, B. A. Tayeh, and I. S. Agwa, "Engineering properties of ultra-high strength concrete containing sugarcane bagasse and corn stalk ashes," *Journal of Materials Research and Technology*, vol. 23, pp. 3196-3218, 2023. https://doi.org/10.1016/j.jmrt.2023.01.197

[27] Q. Su and J. Xu, "Mechanical properties of rice husk ash and glass powder concrete: Experimental and mesoscopic studies," *Journal of Building Engineering*, vol. 95, p. 110278, 2024. https://doi.org/10.1016/j.jobe.2024.110278

[28] C. Liu *et al.*, "Recycled aggregate concrete with the incorporation of rice husk ash: Mechanical properties and microstructure," *Construction and Building Materials*, vol. 351, p. 128934, 2022. https://doi.org/10.1016/j.conbuildmat.2022.128934

[29] A. Najigivi, S. Abdul Rashid, F. Nora A. Aziz, and M. A. Mohd Salleh, "Water absorption control of ternary blended concrete with nano-SiO2 in presence of rice husk ash," *Materials and Structures*, vol. 45, pp. 1007-1017, 2012. https://doi.org/10.1617/s11527-011-9813-y

[30] P. G. Quedou, E. Wirquin, and C. Bokhoree, "Sustainable concrete: Potency of sugarcane bagasse ash as a cementitious material in the construction industry," *Case Studies in Construction Materials*, vol. 14, p. e00545, 2021. https://doi.org/10.1016/j.cscm.2021.e00545

[31] B. S. Thomas *et al.*, "Sugarcane bagasse ash as supplementary cementitious material in concrete–a review," *Materials Today Sustainability*, vol. 15, p. 100086, 2021. https://doi.org/10.1016/j.mtsust.2021.100086