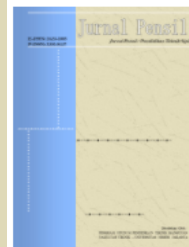


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PERFORMANCE ANALYSIS COMPRESSIVE STRENGTH AND WATER ABSORPTION OF RICE HUSK WASTE AS A MIXED MATERIAL IN PAVING BLOCK PRODUCTION FOR THE RICE MILLING INDUSTRY

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Abstract

The utilization of rice husk waste in Indonesia remains very limited, despite rice production being carried out three times a year, which significantly increases the volume of grain and straw. Rice husk waste can be processed through various methods, including its use as a mixture in compost and paving block production, with the aim of reducing environmental impacts. In the rice milling process, approximately 20–30% of the initial grain weight is obtained as husks, 8–12% as bran, and 50–65% as milled rice. The high proportion of husks generated can potentially cause environmental problems if not properly managed. Therefore, this research utilize rice husk waste by burning it at temperatures of 600°C, where the combustion process produces Rice Husk Ash (RHA) with pozzolanic properties. RHA contains a high silica content, making it a suitable supplementary material for paving block production. Based on the experimental results, paving blocks with a 10% addition of RHA achieved an average compressive strength of 15.4 MPa, which meets the criteria for C quality paving block. The water absorption values ranged from 9% to 21%, with an average of 14%. Based on the results of this research indicated that incorporating rice husk ash as an additive in paving block manufacturing can enhance material quality, producing compressive strength that exceed the standard requirements for C quality concrete.

Keywords: Rice Husk, Rice Husk Ash (RHA), Environmental, Paving Block, Compressive Strength

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Introduction

Based on data from the Central Statistics Agency (BPS), rice husk waste is estimated to be around 21% of the total production of Dry Milled Paddy (DMP) (BPS, 2018). With this conversion, the volume of rice husks in Indonesia is estimated to be in the range of 11.16-11.50 million tons per year. In 2020, rice production reached 54.65 million tons of GKKG, so rice husks are estimated at 11.48 million tons (BPS, 2021). The following year, the volume of husks decreased slightly to 11.43 million tons in line with the decline in rice production to 54.42 million tons of GKKG (BPS, 2022). Furthermore, 2022 recorded a slight increase to 11.50 million tons, becoming the highest point in the last five years (BPS, 2023). The downward trend reappeared in 2023 with an estimate of 11.34 million tons (BPS, 2024), and decreased further to 11.16 million tons in 2024 (BPS, 2025). This analysis shows that the availability of rice husk waste in Indonesia was relatively stable during this period. Figure 1. shows a graph of the estimated rice husk waste in Indonesia in 2020-2024.

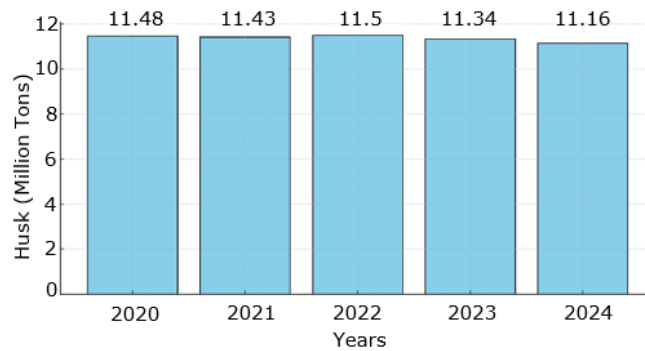


Figure 1. Graph of the Number of Rice Husk Waste in Indonesia in 2020-2024, (BPS Indonesia, 2023)

Source: Central Statistics Agency, CSA 2021-2024

The production of rice husk waste every year still cannot be used optimally until it reaches 100%. Based on Figure 1, it shows that the percentage of rice husk waste in the 2021–2024 period averages 11.16–11.50 million tons, while the utilization rate only ranges from 10–30%. The utilization distribution includes 30% for charcoal production, 25% as planting media, 20% for animal feed, 10% used as bioenergy, and 15% used as building materials as shown in Figure 2 (Badan Pusat Statistik, 2023). This fact shows that the use of rice husks as a mixture of building materials is still relatively low compared to other potential uses.

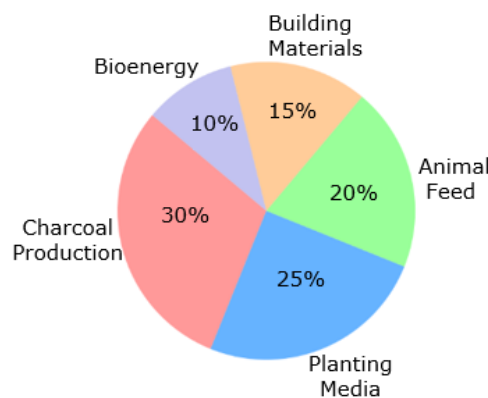


Figure 2. Graph of Rice Husk Waste Treatment in Indonesia in 2020-2024, (BPS Indonesia, 2023).

Source: Central Statistics Agency, CSA 2021-2024

The rice milling industry produces rice husks as waste in a considerable proportion of the total weight of the grain processed. Based on industrial data, around 65% of grain is produced into rice, while around 20% is in the form of rice husks as a by-product (Yusuf & Hijriah, 2019a). This condition shows that rice husk waste has a significant volume, but its utilization until now is still not optimal. Rice husk waste is one of the wastes that must be considered for its use and use in the rice milling industry (Sri Wahyuni & Firdaus, 2019). With the use of rice husk waste, it is hoped that rice husk waste has a selling value, is able to reduce environmental pollution, and can reduce rice husk deposits in every rice milling industry in the North Tambun area, Bekasi. Based on the field survey that has been carried out, information was obtained that the rice milling process produces two main types of waste, namely rice husk and bran, with a significant percentage of amounts. This condition is the basis for important considerations in the use of this waste, especially rice husk ash, as a proportional mixture material with cement. The use of rice husk ash (RHA) in the manufacture of paving blocks has the potential to reduce the need for cement, thereby reducing the impact of environmental pollution from rice milling waste (Sri Wahyuni & Firdaus, 2019; Suganda Wijaya et al., 2022).

Rice husk ash is obtained from the combustion of rice husks, where rice husk is the skin that wraps rice grains. Each rice mill for 1000 kg of rice will produce 220 kg of rice husks, meaning that when the rice grains are milled it will produce 78% into rice and 22% into husks. The rice husk obtained from the milling will obtain 75% flammable material, 25% will be turned into ash called Rice Husk Ash (RHA) which contains chemical content as in Table 1.

Table 1. Chemical Composition of Rice Husk Ash Under Different Temperature Treatment.

Chemical Content	Orgin ° (%)	400° (%)	600° (%)	700° (%)	1000° (%)
SiO ₂	88.01	88.05	88.67	92.15	95.48
MgO	1.17	1.13	0.84	0.51	0.59
SO ₃	1.12	0.83	0.81	0.79	0.09
CaO	2.56	2.02	1.73	1.60	1.16
K ₂ O	5.26	6.48	6.41	3.94	1.28
Na ₂ O	0.79	0.76	1.09	0.99	0.73
TiO ₂	0.00	0.00	0.00	0.00	0.00
Fe ₂ O ₃	0.29	0.74	0.46	0.00	0.43

(Source: Hwang et al., 2012)

In Table 1. Based on the results of research conducted by (Hwang et al., 2012), that rice husk ash contains silica compounds (SiO₂) up to 95.48%. In addition, the same research was also carried out by (Suhirkam and Latief 2006), that rice husk ash contains silica compounds (SiO₂) up to 89.64%, and (Putra, 2006) said that rice husk ash contains silica compounds (SiO₂) up to 88.92%, this shows that rice husk ash is a pozzolan that has a high silica content which is very good for cement mixtures as one of the materials for making concrete. Brick is one of the main construction materials that are widely used to build walls in residential houses, shophouses, and multi-storey buildings (Tunas et al., 2021). Meanwhile, paving blocks are used as cover materials and ground surface hardeners which are applied to sidewalks, parking areas, office areas, and roads with light traffic loads. Currently, the use of paving blocks has spread in various regions, ranging from urban centers at the provincial and district levels to rural areas, as an alternative material for paving roads, ground surface coatings, and building walls. Innovations in the development of paving blocks through the addition of waste-based materials have been widely studied because they provide a number of benefits, including reducing production costs and increasing product added value (Abriantoro & Simanjuntak, 2025; Nurfajrina Patunrangi et al., 2024; Tampubolon et al., 2024). One of the waste that has the potential to be used is rice husk ash, which functions to improve the

binding power of aggregates in the process of making paving blocks (Sherliana et al., 2016; Syuhada et al., 2025; Zain et al., 2011).

Paving blocks are building materials consisting of a mixture of portland cement or similar hydraulic materials, water, and aggregate, with or without the addition of other materials as long as they do not reduce the strength of the concrete (Cahyono et al., 2023). This product can have a natural color or be given additional dyes as needed, and is generally used for yard areas both indoors and outdoors (SNI 03-0691-1996). As a covering and ground surface hardening material, paving blocks have a wide range of uses, especially for hardening and aesthetics of roadsides in cities, yards, parks, and residential areas. Generally, the thickness of paving blocks (specification for precast concrete) that is often used has a thickness of 6 cm, used for light traffic loads with limited frequency, such as pedestrians, motorcycles while a thickness of 8 cm is used for super heavy traffic loads such as cranes, loaders. The National Standardization Agency (SNI 03-0691-1996) clarified that there are 4 types of paving blocks (Concrete Bricks) including grade A concrete bricks, used for roads, with a compressive strength value (f'_c) of 35-40 MPa, concrete bricks of grade B used for parking, with a compressive strength value (f'_c) of 17-20 MPa, concrete bricks of grade C used for pedestrians, with a compressive strength value (f'_c) 12.5-15 MPa, and D grade concrete bricks are used for parks and other users, with a compressive strength value (f'_c) of 8.5-10 MPa.

In addition, several other research results were also found that the variation of the use of the husk with a value of 10% - 12.5% increased the compressive strength of concrete with an average compressive strength of 31.85 MPa, (Febriyanti et al., 2023) and there are also those who conducted a study where with each addition of Rice Husk Ash (RHA) of 5% it is able to increase the compressive strength of concrete by about 6% from its initial condition, (Estu Yulianto & Mukti, 2015; Tunas et al., 2021). In addition, a study was also found where the compressive strength and tensile strength of concrete with a replacement of 2.5%; 5%; 7.5% and 10% of the cement part by rice husk ash is able to improve the strength of concrete when compared with normal concrete. From the results of this study, information was obtained that when the concrete age was 28 days had a normal concrete compressive strength of 34.368 MPa, with the replacement of husk ash 10% the compressive strength obtained ranged from 37.8-66 MPa, (Chao-Lung et al., 2011; Suhirkam & Latief, 2006). From the results of some of the studies above, it can be concluded that the use of rice husk ash with a percentage of 2.5% - 12.5% provides a good compressive strength value to be used as a substitute for cement in concrete mixtures (Bahri et al., 2018). Based on studies from various previous studies and literature, this research focuses on the analysis of the use of rice husk waste as a mixed material in the manufacture of paving blocks. The purpose of this research is to reduce the volume of rice husk waste in rice milling by utilizing it as a raw material, as well as increasing the compressive strength of paving blocks through the addition of rice husk ash that has undergone a combustion process at a temperature of 600 °C.

Research Methods

Rice Husk Incineration Tool

The design and fabrication of the rice husk incineration were carried out in the Mechanical Engineering Laboratory, Faculty of Engineering, Universitas Kristen Indonesia (UKI). The burner was designed in a cylindrical form with dimensions of 592 mm in height and 40 mm in diameter, as shown in Figure 3. The fabrication process consisted of several stages, including the construction of the combustion tube, the welding process, the fabrication of the combustion tray and the installation of the gas cylinder system as the combustion energy source.

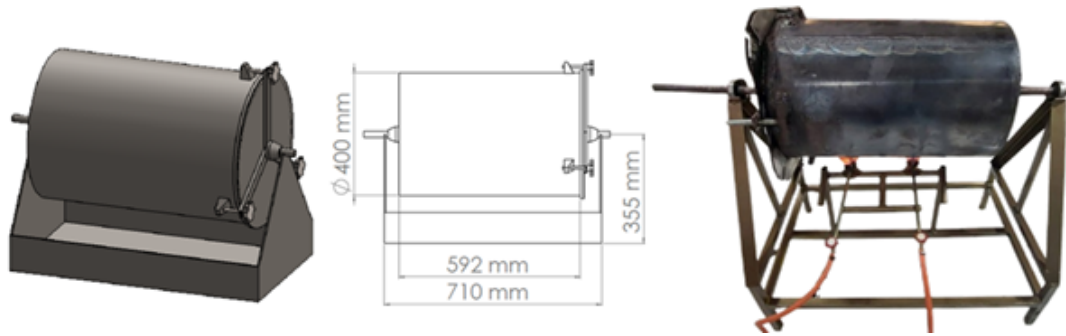


Figure 3. Design drawing and actual implementation of rice husk burner tool

Burning Rice Husks

After the rice husk burner is completed, the next stage is the rice husk burning process which is carried out in the laboratory of the Civil Engineering Study Program, Christian University of Indonesia (UKI). Before burning, the rice husk was dried at room temperature to avoid wet conditions that can slow down the burning process. This burning aims to produce rice husk ash as a substitute for cement in the manufacture of paving blocks. The combustion process lasts for six hours with a temperature 600°C. Figure 4. shows the burning stage of rice husk that reaches a temperature of 600°C. The results of burning rice husks show that the rice husk ash obtained has physical and chemical characteristics that are suitable for use as a mixed material in the manufacture of paving blocks (Yusuf & Hijriah, 2019b). The ash produced has a high silica content, which has the potential to increase the strength and durability of the final product, (Meigantara et al., 2022). In addition, the combustion process also significantly reduces the volume of rice husk waste, thereby contributing to reducing the accumulation of waste in the rice milling area.



Figure 4. The Process of Burning and Cooling Rice Husks at UKI Civil Engineering Laboratory Reaches 600 °C

The results of the combustion carried out in the laboratory showed that the ash of rice husk was black at the beginning and after combustion, but after being left for 5 hours, the color changed to white. This change occurs because rice husks that reach a burning temperature of 600 °C are transferred to a cooling container while they are still glowing hot. The remaining heat triggers a further oxidation process during the cooling period, resulting in a more perfect combustion and causing a change in color to white. Scientifically, the color variation of rice husk ash (RHA) is directly related to the carbon content left post-combustion. Ash that is dark or black in color generally contains higher unburned carbon, while ash with a white or gray color indicates almost

no carbon remaining indicating better cleanliness and purity (Wang et al., 2021). Thus, the change in color to pure white indicates an improvement in the quality of rice husk ash, characterized by a higher silica content and greater reactivity, making it more suitable for use as a cement substitute. Rice husks burned under various combustion temperatures and cooling durations exhibit different post-combustion color variations, the results of which are presented in Table 2.

Table 2. Combustion Temperature, Cooling Time (Soaking), and Color Characteristics of Rice Husk Ash After Finishing Combustion (Ananthi et al., 2016)

No	Component	Combustion Temperature (°C)	Cooling Duration (hours)	Observation
1	Rice husk ash	400 °C	5	Coarse powder, Incomplete combustion, Fully black
2	Rice husk ash	500 °C	5	Fine, Pinkish white
3	Rice husk ash	600 °C	5	Fine, white
4	Rice husk ash	700 °C	5	Fine, Pure White

(Source: Ananthi et al., 2016)

Mix Design Composition of Paving Block

After the rice husk burning process is completed, the next process is to conduct a mix design analysis. The design of the mixed composition is carried out based on SNI 7656:2012 to obtain the proportions of each mixed material used, (Arman. A, 2018; Hakim et al., 2021; SNI 03-2834-2000, 2000; SNI 7656:2012, 2012; Sukardi et al., 2022). Table 3. shows the composition of the mixture of paving block making materials with a proportion of rice husk ash of 10% instead of cement.

Table 3. Mixed Composition of Paving Block Making Materials with 10% Rice Husk Ash Mixture During Combustion 600 °C

No	Material	Composition of Concrete Mixture (kg/ m ³)	Volume Paving Block (0.2 x 0.10 x 0.06) m ³	Weight Composition of Concrete Mix for One Paving Block (kg)	Total Composition Weight of Concrete Paving Block Mix(kg)
1	Cement	387.87	0.0012	0.5	6
2	Sand	1757.99		2.1	25.2
3	Water	213.33		0.3	3.6
4	Rice Husk Ash (10%) from Cement Material	-		0.05	0.6

Molding paving blocks was carried out for 12 samples with a mixture of rice husk ash of 10%. Before molding, all sand, cement, rice husk ash, and water materials have been prepared in advance according to the results of the predetermined mix design, (Foulhudan et al., 2022). Paving block molding is carried out in the laboratory, after the paving block molding process is completed,

the paving block will be dried with a room temperature of 26-28 °C.

Hammer Test Testing

Hammer test is carried out to determine the strength of concrete on the planned paving block. This method includes a non-destructive test, in which the compressive strength value of the concrete is obtained without causing damage to the sample being tested (Bhanu Aribawa et al., 2019; Pratama et al., 2022; Tampubolon et al., 2022; Tugrul Tunc, 2025). Figure 5, shows a graph of the analysis of the hammer test to obtain the compressive strength value of concrete (f'_c). The hammer test is carried out based on the direction of reflection and the test angle, where the test position consists of 3 positions, namely position A with a horizontal direction 180°, position B in the downward direction with an angle of 90°, and position C in the upward direction with an angle of 90°.

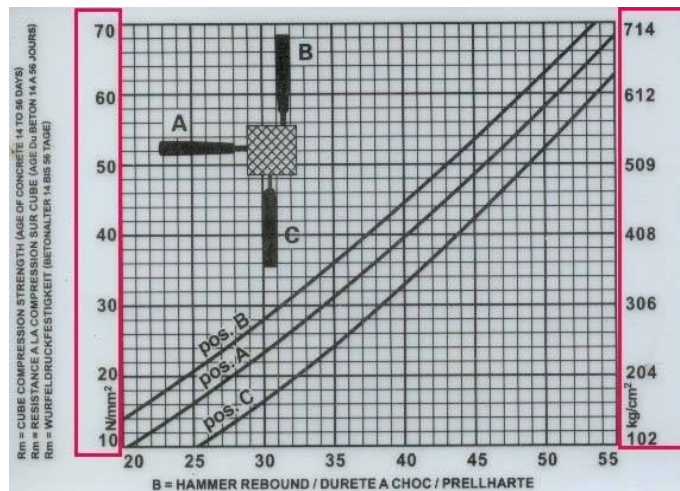


Figure 5. Hammer Test Chart to Get an f'_c Score, (Standar Nasional Indonesia Metode Uji Angka Pantul Beton Keras (ASTM C 805-02, IDT), 2012)

Water Absorption and Porosity Test

The permeability of the paving blocks is analyzed using the following formula:

$$\text{Water Absorption (\%)} = \frac{(W_2 - W_1)}{W_1} \times 100\%$$

Where:

W_1 = Weight Paving Block in dry conditions

W_2 = Weight Paving Block in wet conditions

The porosity of the paving block specimens was determined by measuring the dry weight and saturated weight after 24 hours of water immersion. The porosity value was calculated using the following equation:

$$P = \frac{W_b - W_k}{V \times \rho_{\text{water}}} \times 100\%$$

Where P is the porosity (%), W_b is the saturated weight, W_k is the oven-dry weight, V is the specimen volume, and ρ_{water} is the density of water.

Research Results and Discussion

Water Absorption Analysis of Paving Blocks

After the drying process is carried out in the laboratory, the next stage is to analyze the water absorption on the paving block. This analysis begins with mass weighing in dry conditions, then continues with soaking in water. The purpose of immersion is to determine the water absorption value and the immersion effect of each submerged test specimen (Andika Putra et al., 2020). After the soaking process is completed for 3 days, the analysis of the water absorption capacity from the paving block is carried out again. The purpose of this absorption test is to measure resistance to weather and the environment, check the quality of the mixture, determine the density and strength of the paving block and support the sustainability of the development of the material mixture (rice husk ash) used. Paving blocks with good water absorption performance tend to exhibit low water absorption percentages, (Badan Standardisasi Nasional, 1996; Wajdi et al., 2023). This parameter is critical because paving blocks are commonly used in open areas that are directly exposed to rainwater. Low water absorption enables the paving blocks to maintain their strength and resist weathering and deterioration caused by temperature fluctuations. The results of the calculation of water permeability in paving blocks are shown as shown in Table 4.

Table 4. Analysis of Water Absorption of Paving Block with Rice Husk Ash Mixture

No	Paving Name	Dry Weight (W1) (kg)	Weight After Soaking (W2) (kg)	Duration (day)	Dry-Wet Weight Difference (kg)	Water Absorption (%)
1	Paving Block 1	3.305	3.900	3	0.6	18
2	Paving Block 2	3.750	4.130	3	0.4	10
3	Paving Block 3	2.075	2.325	3	0.3	12
4	Paving Block 4	3.365	3.870	3	0.5	15
5	Paving Block 5	1.900	2.235	3	0.3	18
6	Paving Block 6	1.895	2.220	3	0.3	17
7	Paving Block 7	1.920	2.245	3	0.3	17
8	Paving Block 8	2.14	2.375	3	0.2	11
9	Paving Block 9	1.775	2.155	3	0.4	21
10	Paving Block 10	2.280	2.490	3	0.2	9
11	Paving Block 11	1.965	2.245	3	0.3	14
12	Paving Block 12	2.145	2.385	3	0.2	11
Average		2.376	2.715	3	0.3	14

From the results of the water absorption analysis carried out on 12 paving block samples using a mixture of rice husk ash with a percentage of 10% addition of rice husk ash, the value of water absorption was 9-21% with an average water pervasive value of 14%. The results of this study can also be compared with several previous studies, as shown in Table 5.

Table 5. Comparison of Water Paving Block Absorption Test Results Based on Soaking Length

No	Research Source	Immersion Length	Research Results
1	Wajdi et al. (UNISSULA),2023	0 – 48 hours	Water absorption increases; wear test meets SNI class A
2	Suardana et al. (Teknoka), 2021	15 – 60 Days	The longer the soaking → the absorption and damage increase

Based on Table 5 from the several previous studies, there is a significant difference in the effect of the length of immersion and the type of paving block material on water absorption. Wajdi *et al.* (2021) shows that in conventional concrete, the water absorption value increases as the immersion duration increases to 48 hours, but the wear resistance still meets the SNI 03-0361-1996 class A standard. Suardana *et al.* (2021), examined plastic-sand paving blocks with long-term soaking of up to 60 days, and found that increasing immersion time not only increased water absorption but also caused physical degradation of the test object. Based on the previous studies, Suardana *et al.* (2021), the same behaviour of material also happens in paving block mixtures using rice husk ash for this research, which one soaking carried out for 3 days (72) hours increases water absorption which is quite high causing a potential risk of physical degradation due to soaking (Badan Standardisasi Nasional, 1996; Mehta & Monteiro, 2005; Trimurtiningrum, 2021). This difference confirms that the soaking time and the type of material play an important role in determining the performance of the paving block against water penetration. Figure 6 shows a graph of the water absorption that occurs in paving blocks using rice husk mixtures.

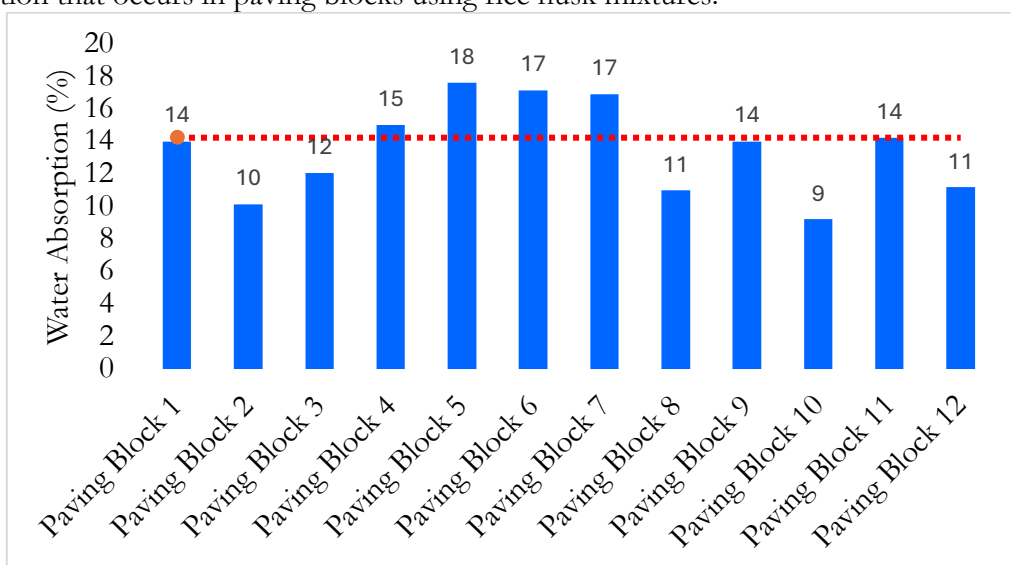


Figure 6. Water Absorption Analysis of Paving Blocks

Based on the previous studies as illustrated in Figure 6, it can be seen that the addition of rice husk ash to the concrete mixture is proven to increase water absorption, this is also obtained in this research, where the addition of 10% rice husk ash in the manufacture of paving blocks is

able to increase the average water absorption capacity by 14% in the 12 samples tested. This increase in absorption is influenced by the pore structure of the husk ash, the slowness of the Pozzolanic reaction, as well as the ratio of the concrete mixture.

Compressive Strength Analysis of Paving Block

After the water absorption analysis is completed, the next analysis is carried out to test the compressive strength of the paving block, (Bakhtiar, 2009; Meigantara et al., 2022). The test was carried out using a hammer test to obtain the value of the compressive strength of the paving block (*f'c*). Table 6. Show resulted of the compressive strength test of the paving block.

Table 6. Results of Compressive Strength Test of Paving Block

No	Paving Name	Dry Weight (W1) (kg)	Weight Soaked (W2) (kg)	Water Absorption (%)	Average Hammer Test score	Calibration Values	Compressive Strength Value (<i>f'c</i>)
1	Paving Block 1	3.305	3.900	18	14	1.04	14.6
2	Paving Block 2	3.750	4.130	10	14	1.04	14.6
3	Paving Block 3	2.075	2.325	12	14	1.04	14.6
4	Paving Block 4	3.365	3.870	15	14	1.04	14.6
5	Paving Block 5	1.900	2.235	18	15	1.02	15.3
6	Paving Block 6	1.895	2.220	17	15	1.02	15.3
7	Paving Block 7	1.920	2.245	17	14	1.02	14.3
8	Paving Block 8	2.140	2.375	11	18	1.02	18.4
9	Paving Block 9	1.775	2.155	21	17	1.02	17.3
10	Paving Block 10	2.280	2.490	9	14	1.02	14.3
11	Paving Block 11	1.965	2.245	14	18	1.02	18.4
12	Paving Block 12	2.145	2.385	11	14	1.02	14.3
Average		2.376	2.715	14	15	1.02	15.4

Several previous studies have shown that the use of Rice Husk Ash (RHA) as a partial substitution of cement in paving blocks has a significant effect on compressive strength. Research results (B. A, 2017) indicates that paving blocks with RHA 5–10% has a compressive strength ranging between 9.47–9.64 MPa, higher than paving blocks without RHA (8.45 MPa). Research by Mardiandra and Firdaus (2025), said that where the highest compressive strength of 10.26 MPa was obtained at an RHA level of 10%. Research by Hanifa et al. (2021) also supports this finding by showing that the RHA content of 10% has a compressive strength of 19.54 MPa. Based on some of the results of the study, when compared with the results of the research carried out, the

addition of rice husk ash (RHA) of 10% is able to produce an average paving block compressive strength of 15.4 MPa and concrete is of quality class C (Badan Standardisasi Nasional, 1996) which is shown in Table 6 and Figure 7. This indicates that, based on several previous studies and the present research, the addition of rice husk ash in optimal proportions particularly in the range of 8–16% can significantly improve the compressive strength of paving blocks.

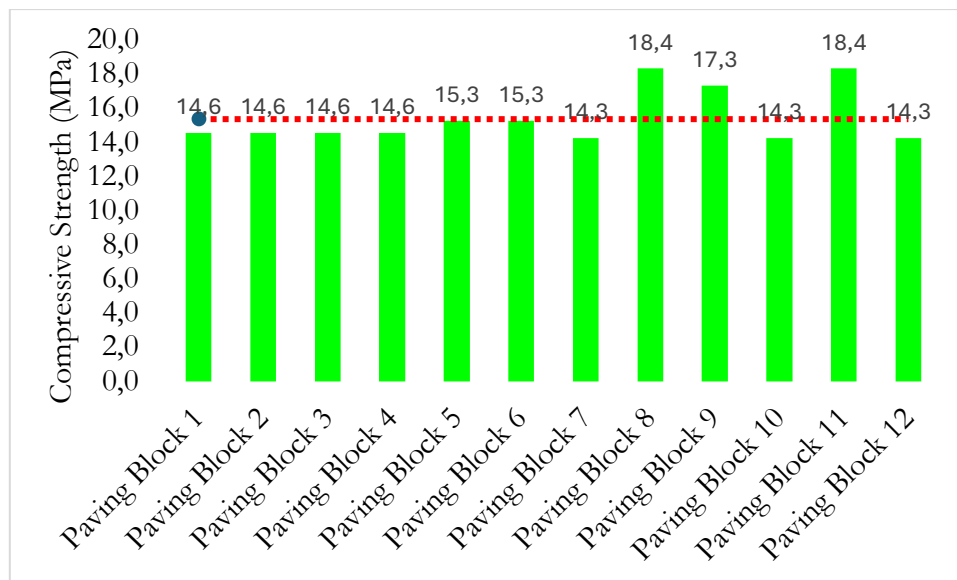


Figure 7. Compressive Strength Analysis of Paving Blocks

The Relationship Between Compressive Strength, Water Absorption, and Porosity of Paving Blocks

The relationship between porosity, water absorption, and compressive strength is an important parameter in evaluating the quality of paving blocks. Higher porosity generally leads to higher water absorption due to the increased volume of voids within the material (Rangan et al., 2025). Consequently, the compressive strength decreases because the internal pores reduce the density and bonding of the matrix. Therefore, paving blocks with lower porosity and water absorption tend to exhibit higher compressive strength and better durability (Subashi De Silva & Priyamali, 2022). According to Table 7, the average values of compressive strength, water absorption, and porosity are 15.4 MPa, 14%, and 28%, respectively. The incorporation of Rice Husk Ash (RHA) in paving block mixtures affects these properties due to its physical and chemical characteristics. The RHA content generally increases the porosity because of the porous structure of RHA particles, which consequently leads to higher water absorption. Higher porosity and water absorption indicate a greater volume of internal voids within the paving block. As a result, the compressive strength decrease with increasing porosity and water absorption during the immersion of the paving blocks. Figure 8 shows the test results of 12 paving block specimens. The results indicate that the compressive strength ranges from 14.3 to 18.4 MPa, while the water absorption values range from 11% to 21%, and the porosity values range from 21% to 34%. The results show that the incorporation of Rice Husk Ash (RHA) in the paving block mixture is able to improve the compressive strength, with the paving blocks falling within quality classes B and C. However, the water absorption values remain relatively high, exceeding the maximum allowable limit for the lowest quality paving block (quality D), where the maximum water absorption specified by SNI 03-0691-1996 is 10%. All specimens recorded water absorption values above this limit. Meanwhile, the porosity values obtained range from 21% to 34%, which indicates medium to high porosity, with some specimens falling within the medium range (20–25%) and others within the high range (25–30% or higher).

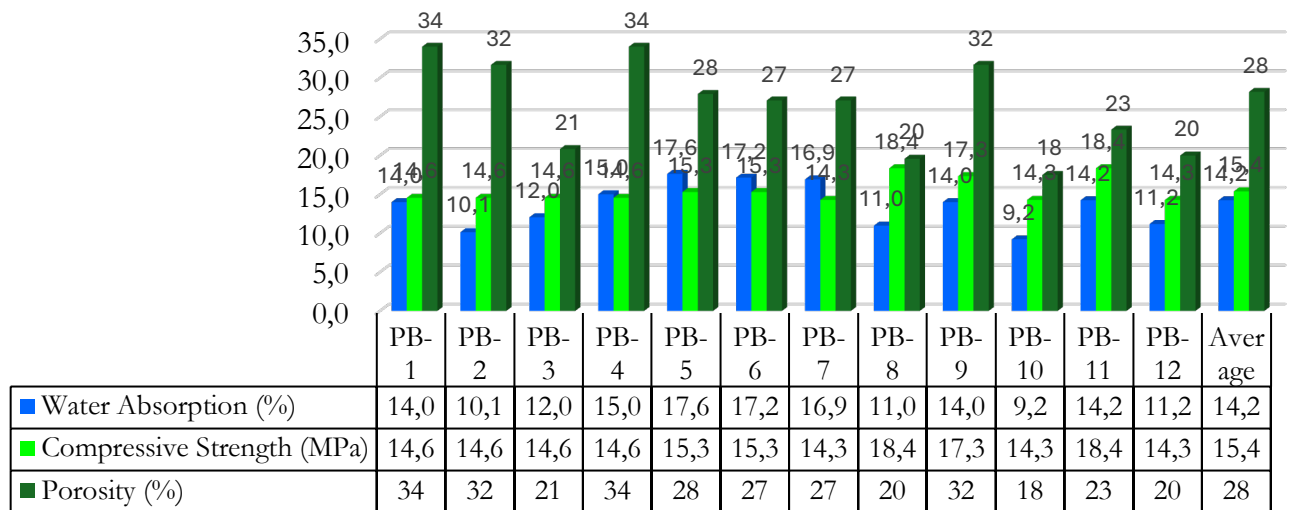


Figure 8. Relation Graphs of Compressive Strength, Water Absorption, and Porosity Analysis of Paving Blocks

Conclusion

Based on the results of the research it was concluded that the mixed results of burning rice husks with a combustion temperature of 500-600°C, were able to produce rice husk ash pozzolan which is used as one of the mixed materials for making paving blocks. With the addition of rice husk ash of 10%, produced an average concrete compressive strength (f'c) of 15.4 MPa, category of concrete bricks C. The value of water permeability of paving blocks is obtained at 9% to 21% with an average value of water absorption 14.2% and porosity 28%, where the soaking time carried out for 3 days (72) hours is able to increase water absorption which is quite high causing the potential risk of physical degradation due to soaking. For this reason, based on the results of research conducted with the use of rice husk waste as one of the mixed materials for making paving blocks, it is able to provide good results for compressive strength and reduce rice husk waste in rice mills.

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References

A, Arman. (2018). Kajian Kuat Tekan Beton Normal Menggunakan Standar SNI 7656-2012 DAN ASTM C 136-06. Rang Teknik Journal, 1(2). <https://doi.org/10.31869/rtj.v1i2.760>

A, B. (2017). Studi Peningkatan Mutu Paving-Block dengan Penambahan Abu Sekam Padi. Portal: Jurnal Teknik Sipil, 1(2). <https://doi.org/10.30811/portal.v1i2.447>

Abriantoro, A. P., & Simanjuntak, M. R. A. (2025). The Effect Of Alkali Activator Molarity on The Mechanical Performance Of Geopolymer Paving Blocks Based on Waste Glass Powder and Fly Ash. Jurnal PenSil, 14(1). <https://doi.org/10.21009/jpensil.v14i1.50676>

- Ananthi, A., Geetha, D., & Ramesh, P. S. (2016). Preparation and Characterization of Silica Material from Rice Husk Ash-An Economically Viable Method. *Chemistry and Materials Research*, 8(6).
- Andika Putra, R., Suardana, N. P. G., & Kencanawati, C. I. P. K. (2020). Pengaruh Waktu Perendaman terhadap Daya Serap Air dan Drop Test pada Paving Block Plastik-Pasir. *Prosiding Seminar Nasional Teknoka*, 5. <https://doi.org/10.22236/teknoka.v5i.376>
- Badan Pusat Statistik. (2023). *Statistik Pendidikan 2023*. Badan Pusat Statistik, 12.
- Badan Standardisasi Nasional. (1996). SNI 03-0691-1996: Bata Beton (Paving Block).
- Bahri, S., Mahmud, H. B., & Shafigh, P. (2018). Effect of utilizing unground and ground normal and black rice husk ash on the mechanical and durability properties of high-strength concrete. *Sadhana - Academy Proceedings in Engineering Sciences*, 43(2). <https://doi.org/10.1007/s12046-018-0795-0>
- Bakhtiar, A. (2009). Studi peningkatan mutu paving-block dengan penambahan abu sekam padi. *Jurnal Portal*, 1(No.2).
- Bhanu Aribawa, B., Wijatmiko, I., & Martin Simatupang, R. (2019). Studi Evaluasi Pengaruh Variasi Mutu Beton Terhadap Kekuatan Struktur Beton Normal Menggunakan Metode Non-Destructive Test dan Destructive Test. *Rekayasa Sipil*, 13(3). <https://doi.org/10.21776/ub.rekayasasipil.2019.013.03.5>
- BPS Indonesia, S. I. (2023). *Statistik Indonesia. Statistik Indonesia 2023*, 1101001.
- Cahyono, L., Sinta, Y. R. D., Jannah, N. R., Fikriyah, I. A., Anwar, P. N., Putri, D. R. S., & Utomo, A. P. (2023). Effect Of Candlenut Shell Ash As a Sand Substitution on Compressive Strength of Paving Block. *Jurnal PenSil*, 12(2).
- Chao-Lung, H., Anh-Tuan, B. Le, & Chun-Tsun, C. (2011). Effect of rice husk ash on the strength and durability characteristics of concrete. *Construction and Building Materials*, 25(9). <https://doi.org/10.1016/j.conbuildmat.2011.04.009>
- Estu Yulianto, F., & Mukti, M. H. (2015). Pengaruh Penambahan Abu Sekam Padi pada Kuat Tekan Beton Campuran 1 pc : 2 ps : 3 kr. *Jurnal Saintek Universitas Airlangga*, 12(2).
- Febriyanti, E., Wardi, & Khaidir, I. (2023). Pengaruh Penggunaan Abu Sekam Padi dari Kecamatan Tebo Tengah sebagai Pengganti Sebagian Semen terhadap Kuat Tekan Beton. *Abstract of Undergraduate Research, Faculty of Civil and Planning Engineering, Bung Hatta University*, 1(1).
- Foulhudan, J., Nurtanto, D., & Krisnamurti, K. (2022). Perbandingan Mix Design SNI 03-2834-2000 Dan Sni 7656:2012 Ditinjau Dari Proses Pengecoran Beton Normal. *Jurnal Riset Rekayasa Sipil*, 5(2). <https://doi.org/10.20961/jrrs.v5i2.48172>
- Hakim, M. L. N., Roestaman, R., & Permana, S. (2021). Pengaruh Pemakaian Agregat Kasar Ex Pecahan Keramik Terhadap Mutu Beton. *Jurnal Konstruksi*, 19(1). <https://doi.org/10.33364/konstruksi/v.19-1.898>
- Hwang, C. L., Bui, L. A. T., & Chen, C. T. (2012). Application of Fuller's ideal curve and error function to making high performance concrete using rice husk ash. In *Computers and Concrete* (Vol. 10, Number 6). <https://doi.org/10.12989/cac.2012.10.6.631>
- Mehta, P. K., & Monteiro, P. J. M. (2005). *Concrete: Microstructure, Properties, and Materials*. <https://api.semanticscholar.org/CorpusID:137162988>
- Meigantara, I. K. A. H., Widnyana, I. N. S., & Laintarawan, I. P. (2022). Pemanfaatan Limbah Abu Sabut Kelapa dan Abu Sekam Padi Sebagai Bahan Pengganti Sebagian Semen Dalam

- Pembuatan Paving Blok. *Jurnal Teknik Gradien*, 14(02).
<https://doi.org/10.47329/teknikgradien.v14i02.936>
- Nurfajrina Patunrangi, S. J., Bahar, T., & Setiyawan, A. (2024). Pemanfaatan Abu Sekam Padi Sebagai Bahan Tambahpada Pembuatan Paving Blok Di Kota Palu. *Jurnal Pengabdian Ilmu Teknik*, 1(2).
- Pratama, E., Kadir, Y., Siregar, C. A., & Gumilang S., A. A. (2022). Pemeriksaan Mutu Beton Terpasang Menggunakan Pengujian Nondestruktif (NDT) dan Destruktif, Studi Kasus: Bangunan Beton Bertulang 4 Lantai. *Jurnal Permukiman*, 17(1).
<https://doi.org/10.31815/jp.2022.17.1-8>
- Putra, D. (2006). Penambahan Abu Sekam Pada Beton Dalam Mengantisipasi Kerusakan Akibat Magnesium Sulfat Pada Air Laut. *Jurnal Ilmiah Teknik Sipil*, 10(2).
- Rangan, P. R., Sunarno, Y., Mapiley, Y. S., & Tumpu, M. (2025). Investigation of Water Absorption Characteristics in Fly Ash and Bottom Ash-Based Geopolymer Paving Blocks. *Annales de Chimie: Science Des Materiaux*, 49(5). <https://doi.org/10.18280/acsm.490512>
- Sherliana, Iswan, & Setyanto. (2016). Studi Kuat Tekan Paving Block dari Campuran Tanah , Semen , dan Abu Sekam Padi Menggunakan alat Pematik Modifikasi. *Jurnal Rekayasa Sipil Dan Desain*, 4(1).
- SNI 03-2834-2000. (2000). SNI 03-2834-2000: Tata cara pembuatan rencana campuran beton normal. Sni 03-2834-2000.
- SNI 7656:2012. (2012). Tata Cara Pemilihan Campuran untuk Beton Normal, Beton Berat dan Beton Massa. Badan Standarisasi Nasional.
- Sri Wahyuni, D., & Firdaus. (2019). Pengaruh Penambahan Abu Sekam Padi Dalam Campuran Paving Block Untuk Meningkatkan Kuat Tekan. *Jurnal TEKNO*, 16(1).
- Standar Nasional Indonesia Metode uji angka pantul beton keras (ASTM C 805-02, IDT). (2012). www.bsn.go.id
- Subashi De Silva, G. H. M. J., & Priyamali, M. W. S. (2022). Potential use of waste rice husk ash for concrete paving blocks: strength, durability, and run-off properties. *International Journal of Pavement Engineering*, 23(7). <https://doi.org/10.1080/10298436.2020.1851029>
- Suganda Wijaya, Daryati, & Rosmawita Saleh. (2022). Pemanfaatan Abu Sekam Padi dan Plastik Pet Menjadi pengganti Sebagian Agregat Halus Dalam Pembuatan Paving Block. *Menara: Jurnal Teknik Sipil*, 17(2). <https://doi.org/10.21009/jmenara.v17i2.26082>
- Suhirkam, D., & Latief, A. (2006). Pengaruh Penggantian sebagian Semen dengan Abu Sekam Padi terhadap Kekuatan Beton K-400. *Teknik Sipil Politeknik Negeri Sriwijaya*, 6.
- Sukardi, F., Usamah, M., & Hermanto, J. (2022). Studi Rancangan Campuran Beton Mutu K-300 Menurut SNI 03-2834-2000 dan SNI 7656 : 2012. *Jurnal Sains, Sosial dan Humaniora (JSSH)*, 2(1). <https://doi.org/10.52046/jssh.v2i1.1247>
- Syuhada, S., Prayogi, G. R., Sembiring, S. D. A., & Kurniawan, R. (2025). Optimalisasi Paving Block: Penggunaan Limbah Polimer dan Abu Sekam Padi Sebagai Material Substitusi. *JMTS: Jurnal Mitra Teknik Sipil*. <https://doi.org/10.24912/jmts.v8i2.31278>
- Tampubolon, S. P., Lase, F. J., Sudarwani, M. M., Sari, D., Nataldo, B. T., & David, C. (2024). Pengembangan Usaha Mandiri Masyarakat Desa Srimahi Kecamatan Tambun Utara Dengan Pemanfaatan Limbah Sekam Padi Sebagai Campuran Beton Paving Block dan Batako. *Jurnal Abdi Insani*, 11(4). <https://doi.org/10.29303/abdiinsani.v11i4.2150>
- Tampubolon, S. P., Sarasantika, I. P. E., & Suarjana, I. W. G. (2022). Analisis Kerusakan Struktur

- Bangunan dan Manajemen Bencana Akibat Gempa Bumi, Tsunami, dan Likuifaksi di Palu. *Bentang: Jurnal Teoritis Dan Terapan Bidang Rekayasa Sipil*, 10(2). <https://doi.org/10.33558/bentang.v10i2.3263>
- Trimurtiningrum, R. (2021). Pengaruh Pemanfaatan Abu Sekam Padi sebagai Bahan Pengganti Semen terhadap Workabilitas, Resapan dan Kuat Tekan Beton. *Pawon*, 5(2), 201–212. <https://doi.org/10.36040/pawon.v5i2.3470>
- Tugrul Tunc, E. (2025). Relationship Between Schmidt Hammer Rebound Hardness Test and Concrete Strength Tests for Limestone Aggregate Concrete Based on Experimental and Statistical Study. *Materials*, 18(6). <https://doi.org/10.3390/ma18061388>
- Tunas, I. G., Asrafil, A., & Suwitri Parwati, N. M. (2021). PKM Pemanfaatan Sekam Padi Sebagai Alternatif Campuran Material Dinding Ringan Untuk Mendukung Hunian Tahan Gempa di Kota Palu. *Jurnal Pengabdian Magister Pendidikan IPA*, 4(3). <https://doi.org/10.29303/jpmpi.v4i3.926>
- Wajdi, B. A., Mudiyo, R., & Soedarsono, S. (2023). Pengaruh Lamanya Perendaman Terhadap Absorpsi, Ketahanan Aus, dan Kuat Tekan Paving Block. *Proceedings Series on Physical & Formal Sciences*, 6. <https://doi.org/10.30595/pspfs.v6i.849>
- Wang, J., Xiao, J., Zhang, Z., Han, K., Hu, X., & Jiang, F. (2021). Action mechanism of rice husk ash and the effect on main performances of cement-based materials: A review. In *Construction and Building Materials* (Vol. 288). <https://doi.org/10.1016/j.conbuildmat.2021.123068>
- Yusuf, A. R., & Hijriah, H. (2019a). Teknologi pemanfaatan limbah abu sekam padi menjadi paving blok. *DEDIKASI*, 21(2). <https://doi.org/10.26858/dedikasi.v21i2.11484>
- Yusuf, A. R., & Hijriah, H. (2019b). Teknologi pemanfaatan limbah abu sekam padi menjadi paving blok. *DEDIKASI*, 21(2). <https://doi.org/10.26858/dedikasi.v21i2.11484>
- Zain, M. F. M., Islam, M. N., Mahmud, F., & Jamil, M. (2011). Production of rice husk ash for use in concrete as a supplementary cementitious material. *Construction and Building Materials*, 25(2). <https://doi.org/10.1016/j.conbuildmat.2010.07.003>