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The Effect of Rice Husk Ash and Pineapple Leaf Fiber on Physical and Mechanical Properties of Concrete

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ABSTRACT
This study used the cast-in-situ method to make concrete based on rice husk ash and pineapple leaf fiber. Rice husk ash and pineapple leaf fiber were used as the cement substitutes with different variations: 0%, 2.5%, 5%, and 7.5%. Parameters examined in this study included density, porosity, water absorption, flexural strength, and compressive strength using a universal testing machine and Material Testing equipment, which were then analyzed morphologically using SEM-EDX. The result showed a density of $2.510 \times 10^3 - 2.451 \times 10^3$ kg/m^3, porosity of 7.64 – 5.73 %, water absorption of 0.296 % – 0.243 %, compressive strength of 23.66 – 16.45 MPa, flexural Strength of 33.3 – 25.3 MPa. The morphological analysis showed that the rice husk ash and pineapple leaf fiber addition was responsible for the concrete's porous structure in this study has a porous structure. The EDX analysis result exhibited a high carbon percentage.

Keyword: Construction concrete, mechanical property, physical property, pineapple leaf fiber, rice husk ash

ABSTRAK
Penelitian ini mencoba membuat beton berbahan dasar abu sekam padi dan serat daun nanas dengan metode cast in situ. Abu sekam padi dan serat daun nanas digunakan sebagai pengganti semen dengan variasi yang berbeda: 0%, 2,5%, 5%, dan 7,5%. Parameter yang diperiksa dalam penelitian ini meliputi densitas, porositas, daya serap air, kuat lentur, dan kuat tekan menggunakan Universal Testing Machine dan alat Material Testing, yang kemudian dianalisis secara morfologi menggunakan SEM-EDX. Hasil penelitian menunjukkan densitas 2,510 × 10^3 – 2,451 × 10^3 kg/m^3, porositas 7,64 – 5,73 %, daya serap air 0,296 % – 0,243 %, kuat tekan 23,66 – 16,45 MPa, kuat lentur 33,3 – 25,3 MPa. Analisis morfologi menunjukkan bahwa penambahan abu sekam padi dan serat daun nanas menyebabkan struktur pori beton pada penelitian ini memiliki struktur pori. Hasil analisis EDX menunjukkan persentase karbon yang tinggi

Kata Kunci: Abu sekam padi, Konstruksi beton, Serat daun nanas, sifat fisik, sifat mekanik

1. Introduction

Today's technological development has given significant advancements in concrete types. Most buildings use concrete as their primary structure materials, especially buildings and long-span structures that require concrete with high compressive strength. Innovation should be continuously made to ensure the produced concrete is suitable for today's conditions [1].

Concrete is a composite of coarse and fine aggregates. Its shape is easily modifiable, depending on the materials. Concrete is fireproof, relatively cost-effective, easy-to-maintain, and easy to obtain. It can also hold a heavy load [2]-[5]. Concrete is needed in all construction sites, such as foundations, bridges, roads, columns, floor plates, story buildings, and dams.

Various innovations have been made to improve concrete quality, including eggshell, clamshell, palm bunch ash, durian skin, lemon grass ash leaf, volcanic ash, pineapple leaf fiber, water hyacinth, fly ash, etc.[6] Pineapple leaf fiber (PALF) is underutilized despite its high fiber content. Rice husk ash (RHA) is a biomass waste with a specific property containing a pozzolanic compound that is rich in silicic acid (SiO2). It is used as the primary material of cement as an additional construction material in order to add the concrete production value [7]

2. Materials and Methods

2.1. Treatments for Rice Husk Ash and Pineapple Leaf Fiber

The tools and materials were prepared before conducting the study. Rice husk ash and PALF were put into a dish. The former was sieved using a 200 (0.0075 mm) sieve to prevent contamination. The specific gravity of RHA and PALF was tested after the sieving process.

2.2. Concrete Making Process

Cement, sand, 3/4 rock, RHA, and PALF were mixed following certain variations (Table 1). The cement, RHA, and PALF were mixed in a pan according to the predetermined composition to make them homogeneous. After that, the homogeneous RHA, PALF, and cement were then put into a mixer with crushed stone, sand, and water. The mixing was conducted for approximately 2-5 minutes to ensure the concrete paste was stirred evenly and inter-binding. Then, the concrete paste was poured into a cart. One-third of the concrete paste was poured into a 10 x 20cm cylinder cast and a 50 x 50 x 15 block cast. The concrete was then mashed using an iron nail rod to ensure density. A vibrator was used to homogenize the mixture. It was reconfigured until the mold was complete. The sample was soaked in a tub after the mold surface was smoothened using a scrape. After being placed for 24 hours in a mold, the sample was soaked in a tub for 28 days. The casted concrete was then taken from the mold and coded accordingly. The concrete was left to dry for 24 hours and tested for its mechanical and physical properties.

Table 1. The stress condition and parameters of samples

Sample Code	Portland cement (kg)	Sand (kg)	Coarse aggregate (kg)	Rice husk ash (kg)	Pineapple leaf fiber (kg)	Water (l)
A1	7.027	15.283	20.236	0	0	3.705
A2	6.851	15.283	20.236	0.158	0.017	3.705
A3	6.675	15.283	20.236	0.316	0.035	3.705
A4	6.5	15.283	20.236	0.474	0.052	3.705

3. Result and Discussion

3.1. Density Test

Table 2. Concrete density test result.

Item number	Sample Code	Mk (kg)	Volume (m^3)	Density (kg/m^3)
1.	A1	3941	1.57×10^{-3}	2.510×10^{3}
2.	A2	3865	1.57×10^{-3}	2.461×10^{3}
3.	A3	3856	1.57×10^{-3}	2.456×10^{3}
4.	A4	3849	1.57×10^{-3}	2.451×10^{3}

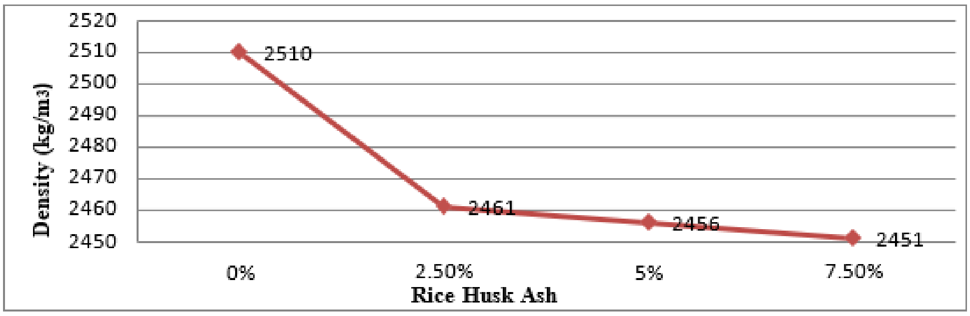


Figure 1. Density under variation of rice husk ash and pineapple leaf fiber.

Figure 1 and Table 1 display the density values of concrete with various rice husk ash-pineapple leaf fiber compositions with the cast-in-situ method. The density value decreased as the composition of rice husk ash and pineapple leaf fiber increased, where sample A1 (composition = 0%) showed a density value of 2.510 x 10^3 kg/m^3, sample A2 (composition = 2.5 %) showed a density value of 2.461 x 10^3 kg/m^3, sample A3 (composition = 5 %) showed a value of (2.456 x 103 kg/m3), and sample A4 (composition 7.5 %) showed a value of 2.451 x 10^3 kg/m^3. As RHA and PALF have a lower density than typical concretes, adding these two materials may increase the pores in concrete, leading to a lower density. In this regard, [8] show that more pineapple leaf fiber addition results in a lower density, whereas fewer PALF addition results in a higher density value.

3.2. Porosity Test

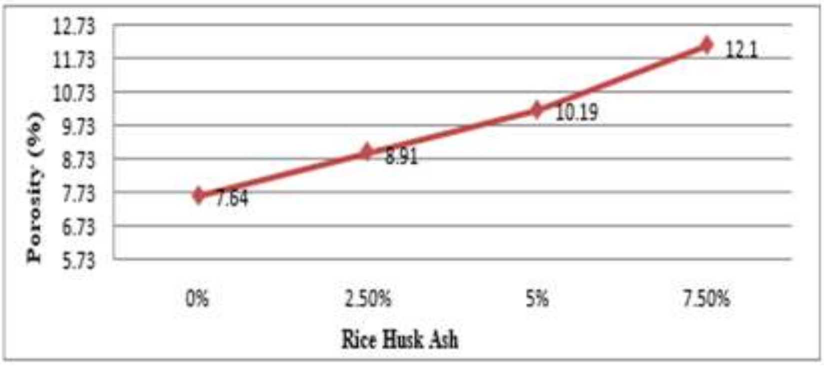


Figure 2. Porosity under variation of rice husk ash and pineapple leaf fiber composition

Figure 2 displays the porosity of concretes made with additional RHA-PALF compositions. Porosity of samples A1 (composition = 0%), A2 (Composition= 2.5%), A3 (composition = 5%), and A4 (composition =7.5%) was 7.64%, 8.91%, 10.19%, and 12.02 %, respectively. Adding RHA and PALF was found to increase The concrete porosity. Therefore, the concretes tended o increase as a higher RHA-PALF ratio was added [9]. This stated that the compressive strength tends to decrease as the porosity increases.

3.3. Water Absorption Test

Table 3. Water absorption test result

Item number	Sample Code	Mb (kg)	Mk (kg)	DSA (%)
1.	A1	3721	3709	0.323
2.	A2	3888.5	3874.5	0.361
3.	A3	3871.5	3855.5	0.414
4.	A4	3701.5	3692.5	0.513

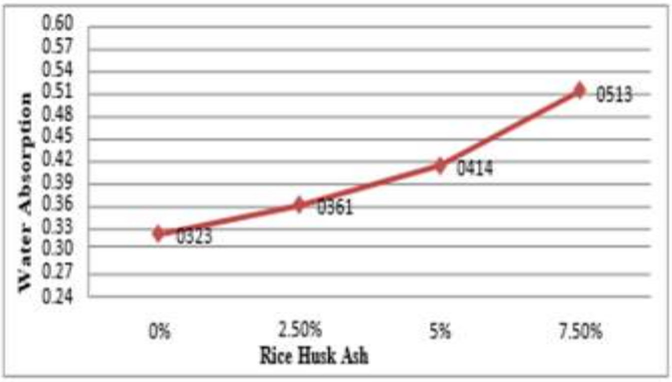


Figure 3. Water absorption under variation of rice husk ash and pineapple leaf fiber

As shown in Figure 3, every RHA-PALF concrete variation with the cast-in-situ method exhibited a high water absorption. Samples A1 (composition =0 %), A2 (composition = 2.5 %), A3 (composition = 5 %), and A4 (composition=7.5%), show the water absorption value of 0.323%, 2.5%, 0.361%, and 4.14%, respectively. Adding RHA and PALF was found to result in more porosity. A previous study found that higher RHA-PALF composition will likely result in larger pores, affecting the compressive strength test [10].

3.4. Compressive Strength Test

Table 4. Compressive strength test result

Item number	Sample Code	Load (*N*)	The section area (*mm*)	Compressive Strength (*MPa*)
1.	A1	185731	7850	23.66
2.	A2	153600	7850	19.96
3.	A3	137300	7850	17.48
4.	A4	129200	7850	16.45

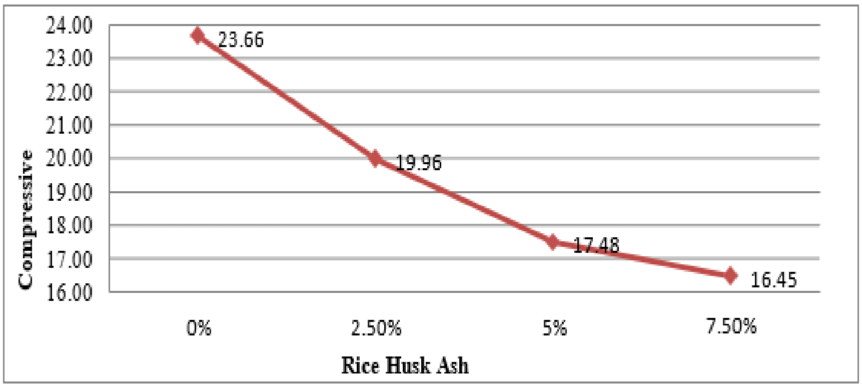


Figure 4. Compressive strength under variations of RHA and PALF

Figure 4 and Table 4 show that adding more RHA and PALF to the concrete results in lower compressive strength. Higher RHA-PALF composition causes more pores and lower compressive strength than typical concrete. Samples A1, A2, A3, and A4 exhibited a compressive strength of 23.66 Mpa, 19.96 Mpa, 17.48 Mpa, and 16.45 MPa. This result is consistent with the previous research finding, showing that adding PALF decreases compressive strength.

3.5. Flexural Strength Test

Table 5. Flexural Strength Test result

Item number	Variation	Width b (*mm*)	Thickness d (*mm*)	Length L (*mm*)	Weight P (*mm*)	UFS (*MPa*)
1.	A1	150	150	450	25000	33.3
2.	A2	150	150	450	23000	30.6
3.	A3	15	150	450	21500	28.6
4.	A4	150	150	450	19000	25.3

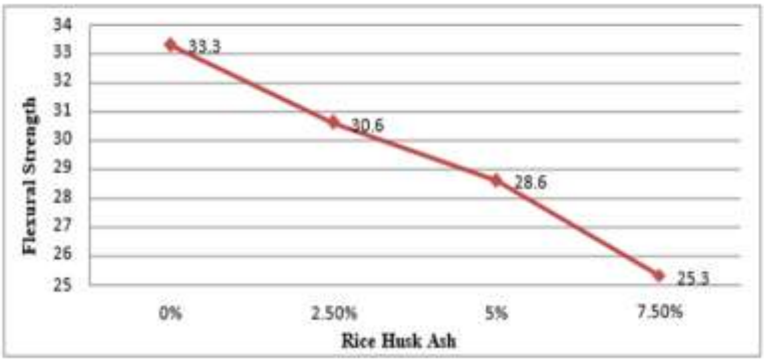


Figure 5. Flexural strength under variation of rice husk ash and pineapple leaf fiber

As shown in Figure 5 and Table 5, the flexural strength decreased as the RHA-PALF percentage increased, with samples A1, A2, A3, and A4 showing a value of 33.3 MPa, 30.6 MPa, 28.6 MPa, and 25.3 MPa, respectively. The pineapple leaf fiber's poor mechanical properties and increased porosity due to RHA and PALF are responsible for the concrete's decreased flexural strength.

3.6. Element and Microstructure Analyses of Sample A2

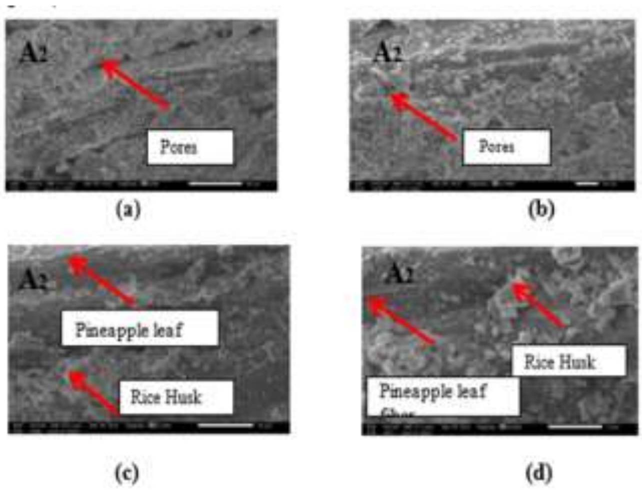
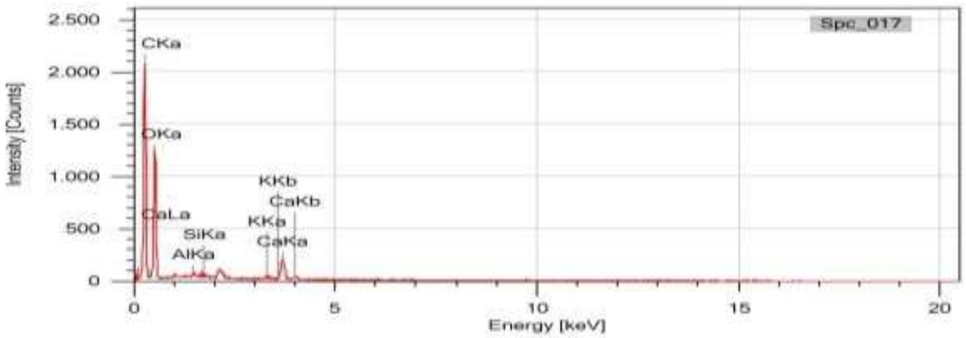


Figure 6. Morphology of concrete sample A2 with (a) 500x magnification, (b) 1000x magnification, (c) 2500x magnification (d) 5000x magnification.

Figure 6 displays the morphology of Sample A2 using SEM-EDX from 500x, 1000x, 2500x, and 5000x magnifications with a ten µm diameter. In general, the samples in this study contained a homogeneous RHA silica lump, allowing sample A2 to have excellent mechanical properties. As displayed, the SEM-EDX test results contain elements like Al, Ca, O, C, and K from the Portland cement. SEM-EDX result showed that the sample contains 0.23± 0.03 % of silica, in addition to other Figure 7, which shows that the concrete was synthesized. The SEM-EDX analysis result shows a pitch-black color and pores formed on the surface, while the grayish white represents the distribution of RHA. This condition indicates that the samples can absorb the excess water.



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Measurement detector	First
Live time	30,00 seconds
Real time	30,61 seconds
Dead time	2,00 %
Count rate	1794,00 CPS

Display na	Standard data	Quantification method	Result Type
Spc_017	Standardless	ZAF	Metal

Element	Line	Mass%	Atom%
C	K	48,33±0,23	56,59±0,27
O	K	47,67±0,52	41,90±0,46
Al	K	0,38±0,04	0,20±0,02
Si	K	0,23±0,03	0,11±0,02
K	K	0,35±0,04	0,12±0,01
Ca	K	3,04±0,09	1,07±0,03
Total		100,00	100,00
Spc_017			Fitting ratio 0,0510

Figure 7. SEM-EDX results

Figure 7 shows that the concrete was synthesized. The SEM-EDX analysis result shows a pitch-black color and pores formed on the surface, while the grayish white represents the distribution of RHA. This condition indicates that the samples can absorb the excess water

4. Conclusion

This study used the cast-in-situ method to make concrete based on rice husk ash and pineapple leaf fiber. Rice husk ash and pineapple leaf fiber were used as the cement substitutes with a different variation: Parameters examined in this study included density, porosity, water absorption, flexural strength, and compressive strength using a universal testing machine and material testing equipment, which were then analyzed morphologically using SEM-EDX. The result showed a density of $2.510 \times 10^3 - 2.451 \times 10^3$ kg/m^3, porosity of 7.64 – 5.73 %, water absorption of 0.296 % – 0.243 %, compressive Strength of 23,66 – 16,45 MPa, flexural Strength of 33.3 – 25.3 MPa. The morphological analysis showed that rice husk ash and pineapple leaf fiber mixed with concrete in this study has a porous structure. The EDX analysis result exhibited a high carbon percentage.

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