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The Effect Of Coconut Fiber Ash And Rice Husk Ash As Cement Substitutes On The Compressive Strength Of Concrete F'c 20

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Abstract. Indonesia is known as a country rich in natural resources that can be utilized, and it is actively engaged in development across various regions. This increase in development has also led to a growing demand for concrete production materials. Cement is one of the essential components in concrete manufacturing, however, its production process requires significant energy. To ensure the availability of cement and reduce this energy demand, exploring alternative cement replacement materials is crucial. Among the alternative materials that can be used coconut and rice. This study used a mixture of Coconut Fiber Ash (CFA) and Rice Husk Ash (RHA) with variation 0% CFA + 0% RHA, 1% CFA + 7.5% RHA, 1% CFA + 10% RHA, 1% CFA + 12,5% RHA, and 1% CFA + 15% RHA. The compressive strength test for normal concrete and mixtures were conducted at 7 days, 14 days, and 28 days. The tes results showed 0% CFA + 0% RHA, 1% CFA + 7.5% RHA, 1% CFA + 10% RHA, 1% CFA + 12,5% RHA, and 1% CFA + 15% RHA at 28 days showed compressive strength of 22.45 MPa, 23.11 MPa, 21.50 MPa, 18.49 MPa, and 17.17 Mpa. Among these variations, variation of 1% CFA + 7.5% RHA have the optimum compressive strength compared to the others. This compressive strength meets the planned concrete strength requirement of F'ç 20. The result of this study concluded that the use of Coconut Fiber Ash (CFA) and Rice Husk Ash (RHA) can be an alternative substitute for sustainable cement that can improve concrete quality, support recycling, and save production costs.

Keywords: Coconut Fiber Ash, Rice Husk Ash, Concrete Compressive Strength

1 Beginning

Technology for producing high quality concrete has advanced quickly in Indonesia. Being a resource rich nation, Indonesia is home of a wide variey of plants, including coconuts. Almost evey portion of the coconut has significant benefits for human life in various aspects of daily living.

Coconut fiber waste can be used as a recycled material in concrete production. Coconut fiber. Coconut fiber forms a large percentage of the coconut fruit, making up 35% of the total weight. The materials that make up coconut fiber are fibers and the cork that joins them. After coconut fiber waste is processed, burned, and turned into

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ash, it is know as Coconut Fiber Ash (CFA). CFA includes silica and has pozzolanic qualities. Rice Husk Ash (RHA) contains SiO_2 93.65%, Fe_2O_3 2.74%, and AI_2O_3 0.78%. The high silica content in RHA can enhance the compressive strength of concrete, positively impacting the structural integrity of the concrete.

2 Research Overview

2.1 Concrete

The definition of concrete, in simple terms, is the hardened result of mixture of cement, coarse aggregate (crused stone), fine aggregate (sand), water, with or without additives. Concrete is a function of its constituent materials, which include hydraulic cement, coarse aggregate, fine aggregate, and additive [2].

2.2 Cement

Cement is the mixing material in concrete that chemically reacts upon contact with water. Aggregates do not play a significant role in this chemical reaction, but they serve a mineral fillers that can prevent volume changes in the concrete after mixing is complete, and enhance the durability of the resulting concrete [2].

2.3 Aggregate

Aggregate is a material derived from particles of crushed stone, gravel, sand, or other minerals, whether natural or manufactured. The composition of aggregates in a concrete mixture typically ranges from 60% to 70% of the total weight of the concrete mixture.

2. 4 Rice Husk Ash (RHA)

Rice husk ash is waste product from rice milling that is subsequently burned at high temperatures (600°C - 800°C) until it turns into ash [1]. RHA has a chemical composition consisting of SiO_2 ranging from 86.90% to 97.30%, K_2O from 0.58% to 2.50%, Na_2O from 0.00% to 1.75%, CaO from 0.20% to 1.50%, MgO from 0.12% to 1.96%, Fe_2O_3 from 0.00% to 0.54%, and SO_3 from 0.10% to 1.13%. The high silica content in rice husk ash gives it significant potential as a silica source in the production of silica based materials, which generally use quartz sand [3].

2.5 Coconut Fiber Ash (CFA)

Coconut fiber can be used as a fiber material in concrete mixtures due to its high strength. Coconut fiber has a relatively high water absorption capacity, approximately 8-9 times its mass, and is capable of absorbing surrounding moisture [4].

2.6 Compressive Strength Of Concrete

The compressive strength of concrete is the amount of load per unit area that causes a concrete test spicemen to fail when subjected to a certain compressive force, as produced by compression testing machine. Compressive strength is one of the primary performance indicators of concrete. The strength of concrete is determined by conducting compressive strength tests on cylindrical or cubic specimens at 28 days of curing, applying compressive forces until the maximum load is reached [5].

3 Research Methods

The Material Testing Laboratory of Sriwijaya State Polytechnic's Civil Engineering Department was the site of this research. The specifications for this testing conform to The General Specifications of Bina Marga 2018. The stage of the research include material and equipment testing, specimen manufacturing, testing of the specimen, and equipment and material preparation. The materials used in this research are type 1 portland cement, coarse aggregates from Lahat, fine aggregates and rice husk ash from Ogan Ilir, and coconut fiber ash from Banyuasin. The specimen made in this research were normal concrete test objects without a mixture of Coconut Fiber Ash (CFA) and Rice Hush Ash (RHA) as a cement substitute, and concrete test objects with the mixture of CFA and RHA as a cement substitute, with a CFA composition of 1% in each test object and a RHA composition that has variations of 7.5%; 10%; 12.5%; and 15%.

4 Results

4.1 Coarse Aggregates and Fine Aggregates Testing

The coarse aggregates and fine aggregates used in this research are sourced from Lahat Regency. The recapitulation of the coarse aggregate testing revealed in Table 1 and Table 2.

Table 1. Recapitulation of The Coarse Aggregate Testing

Name of Test	Results	Unit
Sieve Analysis	7.78	-
Bulk Specific Gravity	2.54	-
SSD Specific Gravity	2.56	-
Absorption	0.81	%
Loose Bulk Density	1.51	gr
Solid Bulk Density	1.63	gr
Water Content	4.13	%
Mud Content	0.79	%
Aggregate Hardness	1.90	%

Table 2. Recapitulation of The Fine Aggregate Testing

Name of Test	Results	Unit

Sieve Analysis	3.62	-
Bulk Specific Gravity	2.47	-
SSD Specific Gravity	2.57	-
Absorption	4.28	%
Loose Bulk Density	1.41	gr
Solid Bulk Density	1.51	gr
Water Content	3.85	%
Mud Content	3.89	%

4.2 Filler Testing

This research utilizes filler in the form of type 1 portland cement. The recapitulation of the filler testing results revealed in Table 3.

Table 3. Recapitulation of The Filler Testing

Name of Test	Results	Unit
Portland Cement Specific Gravity	3.12	gr/cm^3
Cement Consistency	10	mm
Coconut Fiber Ash (CFA) Specific Gravity	2.22	gr/cm^3
Rice Husk Ash (RHA) Specific Gravity	1.63	gr/cm^3

4.3 Concrete Mix Design

The following is the concrete mix design for normal concrete based on SNI 03-2834-2000, guidelines for the preparation of normal concrete mix design.

Table 4. Concrete Mix Design Form

No.	Description	Data
1	Specified Compressive Strength (Test Specimen Cube)	20 MPa ; k-250 kg/cm^2
2	Standard Deviation	7 MPa
3	Added Value (Margin)	1.64 x 7 = 11.5
4	Target Average Strength	(20 + 11.5) MPa = 31.5 MPa
5	Type Of Cement	Type 1 Cement Portland
6	Type Of Coarse Aggregate	Crushed Stone (Split)
7	Type Of Fine Aggregate	Natural Sand
8	Free Water – Cement Ratio	0.49
9	Maximum Water – Cement Ratio	0.60

10	Slump	60-180 mm
11	Maximum Aggregate Size	20 mm
12	Free Water Content	204.9 kg/m^3
13	Amount Of Cement	204.9 kg/m^3: 0.49 = 418.163 kg/m^3
14	Maximum Amount Of Cement	204.9 kg/m^3: 0.49 = 418.163 kg/m^3
15	Minimum Amount Of Cement	325 kg
16	Adjusted Water – Cement Ratio	-
17	Composition Of Fine Aggregate Particle Weight	Zone 2
18	Percentage Of Fine Aggregate	41%
19	Relative Density Of Aggregate (Oven Dry Surface)	2.571
20	Concrete Density	2320 kg/m^3
21	Combined Aggregate Content	(2320 – 418.163 – 204.9) kg/m^3 = 1696.937 kg/m^3
22	Fine Aggregate Content	1696.937 kg/m^3 x 41% = 695.744 kg/m^3
23	Coarse Aggregate Content	1696.937 kg/m^3 x 59% = 1001.193 kg/m^3

4.4 Concrete Slump Testing

The results of the slump test for normal concrete and concrete mixtures of 1% CFA + 7.5% RHA, 1% CFA + 10% RHA, 1% CFA + 12.5% RHA, and 1% CFA + 15% RHA are shown in the tables below.

Table 5. Normal Concrete Slump Testing

Normal Concrete Slump Testing			
No.	Slump Value	Average	Water Content
1	6	9.00 cm	10.60 ml
2	10		
3	11		

Table 6. Mixture Concrete Slump Testing - Combination 1% CFA + 7.5% RHA

Mixture Concrete Slump Testing 1% CFA + 7.5% RHA			
No.	Slump Value	Average	Water Content
1	11	9.50 cm	11.70 ml
2	9		
3	8.5		

Table 7. Mixture Concrete Slump Testing - Combination 1% CFA + 10% RHA

Mixture Concrete Slump Testing 1% CFA + 10% RHA			
No.	Slump Value	Average	Water Content
1	11		
2	10	9.67 cm	11.73 ml
3	8		

Table 8. Mixture Concrete Slump Testing - Combination 1% CFA + 12.5% RHA

Mixture Concrete Slump Testing 1% CFA + 12.5% RHA			
No.	Slump Value	Average	Water Content
1	11		
2	9.5	9.83 cm	11.73 ml
3	9		

Table 9. Mixture Concrete Slump Testing - Combination 1% CFA + 15% RHA

Mixture Concrete Slump Testing 1% CFA + 15% RHA			
No.	Slump Value	Average	Water Content
1	11.5		
2	10	10.16 cm	11.729 ml
3	9		

4.5 Results Of Concrete Compressive Strength Testing

The following are the results obtained from the compressive strength test for normal concrete and variations of concrete mixture using Coconut Fiber Ash (CFA) and Rice Husk Ash (RHA), tested with a hydraulic pump in Civil Engineering Department Laboratory of Sriwijaya State Polytechnic.

Table 10. Average Compressive Strength of CFA and RHA Mixtures at 7 Days

Mixtures	Test Specimen (MPa)			Compressive Strength (MPa)
	I	II	III	
0% + 0%	13.86	13.58	15.56	14.34
1% + 7.5%	14.15	15.00	16.13	15.09
1% + 10%	17.83	16.13	16.98	16.98
1% + 12.5%	12.45	14.15	13.30	13.30

1% + 15%	14.15	12.73	12.45	13.11

Figure 1 presented the compressive strength of concrete on 7 days shows that the mixtures of 1% CFA + 7.5% RHA and 1% CFA + 10% RHA exhibit an increase in strength compared to normal concrete. The compressive strength for these mixtures are 15.09 MPa and 16.98 MPa, respectively, which are higher than the normal concrete strength of 14.33 MPa. Then, the compressive strength for mixtures of 1% CFA + 12.5% RHA and 1% CFA + 15% RHA show a decrease compared to normal concrete, with values of 13.30 MPa and 13.11 MPa. These values are lower than the normal concrete strength of 14.33 MPa.

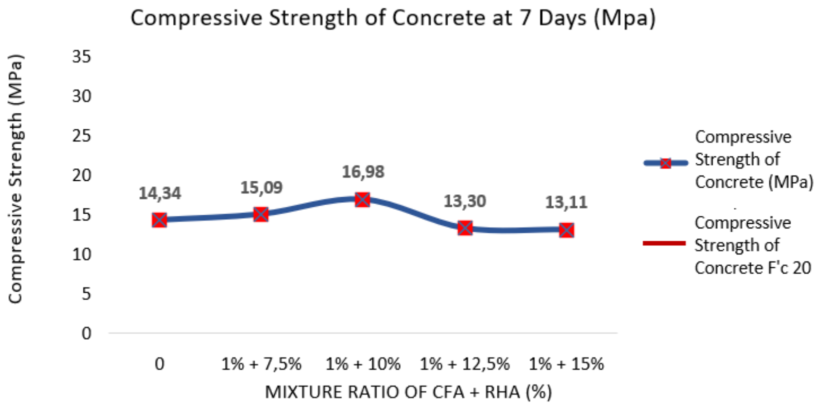

Fig.1. Compressive Strength Of Concrete At 7 Days

Table 11. Average Compressive Strength of CFA and RHA Mixtures at 14 Days

Mixtures	Test Specimen (MPa)			Compressive Strength (MPa)
	I	II	III	
0% + 0%	21.22	20.37	22.35	21.31
1% + 7.5%	21.50	21.22	21.79	21.50
1% + 10%	21.22	19.81	22.35	21.13
1% + 12.5%	17.26	16.41	18.39	17.35
1% + 15%	16.98	16.98	15.56	16.50

Based on Figure 2, the compressive strength of concrete on 14 days shows that the mixtures of 1% CFA + 7.5% RHA exhibit an increase in strength compared to normal concrete. The compressive strength for this mixtures are 21.50 MPa, which is higher than the normal concrete strength of 21.31 Mpa.

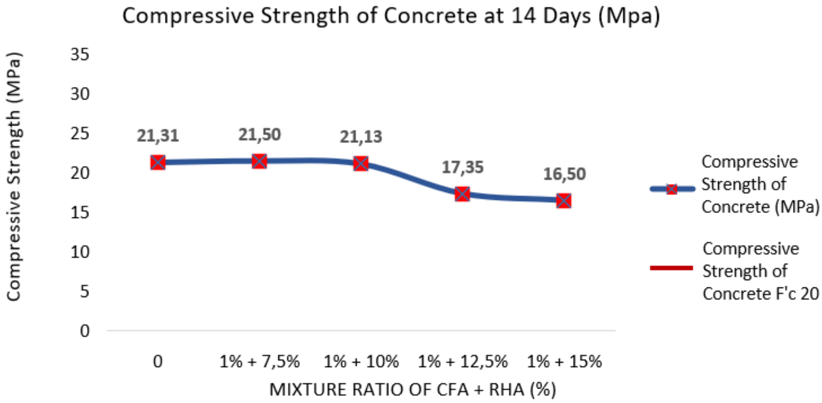

Fig.2. Compressive Strength Of Concrete At 14 Days

Table 12. Average Compressive Strength of CFA and RHA Mixtures at 28 Days

Mixtures	Test Specimen (MPa)			Compressive Strength (MPa)
	I	II	III	
0% + 0%	22.64	21.79	22.92	22.45
1% + 7.5%	23.20	22.64	23.48	23.11
1% + 10%	21.50	22.07	20.94	21.50
1% + 12.5%	19.81	18.39	17.26	18.49
1% + 15%	17.54	16.98	16.98	17.17

Based on Figure 3, the compressive strength of concrete on 28 days shows that the mixtures of 1% CFA + 7.5% RHA exhibit an increase in strength compared to normal concrete. In contrast, the concrete mixtures with variations of 1% + 10%, 1% + 12.5%, and 1% + 15% show a decrease in compressive strength compared to normal concrete.

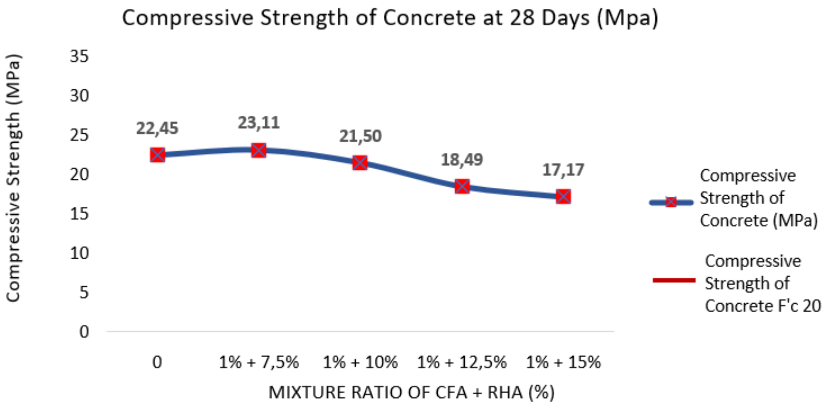

Fig.3. Compressive Strength Of Concrete At 28 Days

Based on Figure 4, it can be presented that the increase in compressive strength of the concrete is equivalent to its age. On day 7, mixture of 1% CFA + 10% RHA showed the highest compressive strength. However, on day 14, the highest compressive strength was achieved with the mixture of 1% CFA + 7.5% RHA. By day 28, the compressive strength of the mixture of 1% CFA + 7.5% RHA surpassed that of normal concrete and other mixtures.

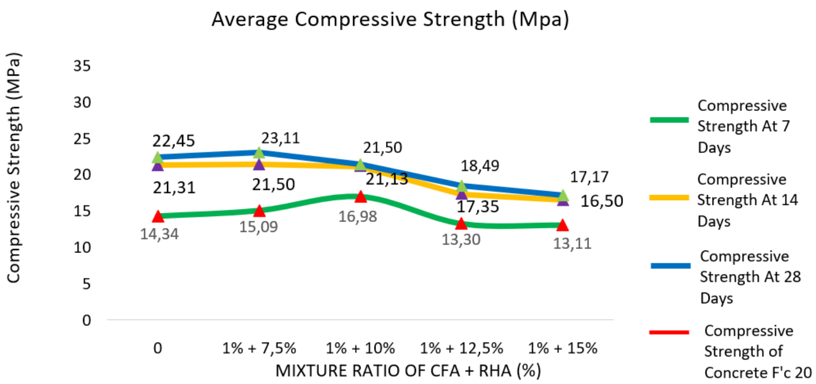

Fig.4. Average Compressive Strength of CFA and RHA Mixtures

5 Conclusion

From the analysis and discussion conducted, the researcher can draw the following conclusions :

1. The use of Coconut Fiber Ash (CFA) and Rice Husk Ash (RHA) as a substitute for cement in concrete with a target strength of f'c 20 affects the compressive strength of the concrete. The mixture of 1% CFA + 7.5% RHA shows an increase in compressive strength compared to normal concrete. In contrast, the mixtures of 1% CFA + 10% RHA, 1% CFA + 12.5% RHA, and 1% CFA + 15% RHA shows a decrease in compressive strength compared to normal concrete.
2. The concrete mixture of Coconut Fiber Ash (CFA) and Rice Husk Ash (RHA) with the mixture of 1% CFA + 7.5% RHA can be considered an alternative material for cement replacement in concrete mixtures, as it shows an improvement in strength compared to normal concrete. The compressive strength of 1% CFA + 7.5% RHA mixture is 23.11 MPa, while the compressive strength of normal concrete is 22.25 Mpa.
3. The final conclusion of this research is that the greater the addition of the percentage of Rice Hush Ask (RHA) to the concrete mixture, the lower the quality of the concrete produced. The use of CFA and RHA can be used as an alternative cement substitution in a concrete mixture of F'c 20 with the note that the percentage of RHA used is a maximum of 7.5%.

References

1. Aski, Hendramawat.: Green Concrete Using Rice Husk Ash As A Partial Substitute For Cement In The New Normal Era. Journal of Civil Engineering Research, ISSN 2579-7999, Vol. 4 No.2. Sebeleas Maret University, Semarang (2021)
2. Mulyono, Tri.: Concrete Technology. Andi Publisher, Yogyakarta (2003)
3. Raharjo, S., Purwaningsih, H., Susanti, D., & Pratiwi, V.M.: Analysis Of The Effect Of Hydrothermal Treatment Temperature On The Formation Of Mesoporous Silica MCM-41 From Rice Husk. Sepuluh November Institute Of Technology, Surabaya (2018).
4. Tjokrodimuljo, K.: Concrete Technology. Civil Engineering Department, Faculty Of Engineering, Gadjah Mada University, Yogyakarta (1996).
5. Van Gobel, F.M.: Compressive Strength Of Concrete At Certain Slumps Values. Radial, Journal of Science, Engineering, And Technology Civilzation (2019).

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