OPEN ACCESS

DYNAMICS
Journal of Architecture and Engineering

Vol. 1, No. 1, July 2024, 8 – 18
P-ISSN: XXXX-XXXX and E-ISSN: XXXX-XXXX
https://jurnal.imat.ac.id/index.php/dynamics

UTILIZATION OF RICE HUSKS AS A CONCRETE MIXTURE: ITS EFFECT ON COMPRESSIVE STRENGTH OF CONCRETE

Nurmaidah[a], Rio Ricardo Tambunan[a]
[a]Civil Engineering Study Program, Faculty of Engineering, Universitas Medan Area, Indonesia,
email: nurmaidah@staff.uma.ac.id

Article Info:

- Received: 13/07/2024
- in revised form: 15/07/2024
- Accepted: 17/07/2024
- Available Online: 17/07/2024

ABSTRACT

This research aims to utilize rice husk waste whose use has not been optimized. Rice husks are known to contain high levels of silica (SiO2), around 93%, so they have the potential to be used as an additive in concrete mixtures. The main objective of this research is to determine the effect of adding rice husks on the compressive strength of concrete. The research method used was a concrete compressive strength test with variations in the addition of rice husks of 0%, 5%, 10%, 15%, 20%, 25% and 30%. The test object used was cylindrical with a diameter of 15 cm and a height of 30 cm, with a test age of 7 and 14 days. The research results showed that the addition of rice husks was less effective at a variation of 30% for normal quality and high-quality concrete. The reduction in compressive strength of normal concrete reached -85.07% at 7 days, and -84.53% at 14 days, compared to concrete without rice husks. This is due to the nature of rice husks which can absorb water, even though rice husks have a high silica content. It can be concluded that concrete mixtures with the addition of rice husks cannot be used, because they will significantly reduce the compressive strength of the concrete.
***Key Words**: Concrete, rice husk, compressive strength of concrete*

ABSTRAK

Penelitian ini bertujuan untuk memanfaatkan limbah sekam padi yang belum dioptimalkan penggunaannya. Sekam padi diketahui mengandung silika (SiO2) yang tinggi, sekitar 93%, sehingga berpotensi untuk digunakan sebagai bahan tambah dalam campuran beton. Tujuan utama penelitian ini adalah untuk mengetahui pengaruh penambahan sekam padi terhadap kuat tekan beton. Metode penelitian yang digunakan adalah uji kuat tekan beton dengan variasi penambahan sekam padi sebesar 0%, 5%, 10%, 15%, 20%, 25%, dan 30%. Benda uji yang digunakan berbentuk silinder dengan diameter 15 cm dan tinggi 30 cm, dengan umur pengujian pada 7 dan 14 hari. Hasil penelitian menunjukkan bahwa penambahan sekam padi kurang efektif pada variasi 30% untuk beton mutu normal maupun mutu tinggi. Penurunan kuat tekan beton normal mencapai -85,07% pada umur 7 hari, dan -84,53% pada umur 14 hari, dibandingkan beton tanpa sekam padi. Hal ini disebabkan sifat sekam padi yang dapat menyerap air, meskipun sekam padi memiliki kandungan silika yang tinggi. Dapat disimpulkan bahwa campuran beton dengan penambahan sekam padi tidak dapat digunakan, karena akan menurunkan kuat tekan beton secara signifikan.
***Kata Kunci:** Beton, sekam padi, kuat tekan beton*

1. INTRODUCTION

Concrete is one of the most widely used construction materials in the field of civil engineering. Concrete is composed of cement, coarse aggregate, fine aggregate, water, and other additives can be added (Neville, 2011). The quality of concrete is largely determined by the ratio of the composition of the constituent materials, as well as the correct work process.

One effort to improve the quality of concrete is by adding additional ingredients to the concrete mixture. These added materials can be natural materials or industrially processed products. Rice husks are an agricultural waste that has potential as an additional material in making concrete. Rice husks contain quite high levels of silica (SiO2), namely around 93% (Dawood & Ramli, 2011). This high silica content can give pozzolanic properties to rice husks, so it has the potential to be used as an additive in concrete mixtures.

The use of rice husks as an additive in concrete mixtures has been widely studied. Several previous studies have shown that the addition of rice husks can improve concrete properties, such as compressive strength, tensile strength, and durability (Feng et al., 2015; Tashima et al., 2012). One of the case studies conducted by Nurmaidah (2022) shows that adding up to 25% rice husk can increase the compressive strength of concrete, but excessive use of rice husk (30%) can significantly reduce the compressive strength of concrete.

The research results of Hanif et al. (2016) showed that the addition of 10% rice husk can increase the compressive strength of concrete by up to 15% compared to concrete without additional rice husk. Apart from that, the addition of rice husks can also increase the watertightness and resistance of concrete to sulfate attack.

Meanwhile, research by Bui et al. (2020) shows that using rice husks as a substitute for cement can produce concrete with compressive strength equivalent to normal concrete, but with lower cement consumption. Similar results were also found in the research of Madandoust and Mousavi (2012) where replacing part of the cement with rice husks could produce concrete with higher compressive strength compared to concrete without the addition of rice husks.

In addition, a study conducted by Givi et al. (2010) showed that the addition of rice husks can also increase the durability properties of concrete, such as resistance to sulfate attack and carbonation. In fact, Siddique's (2008) research found that using rice husks as a substitute for cement can reduce CO2 emissions resulting from cement production.

Therefore, this research aims to examine the effect of adding rice husks on the compressive strength of concrete, with varying percentages of different additions.

2. DATA AND METHODS

2.1. Materials and tools

The materials used in this research are:

1. Type I Portland cement according to SNI 15-2049-2004.
2. Fine aggregate in the form of natural sand that meets the requirements of SNI 03-6820-2002.
3. Coarse aggregate in the form of natural gravel that meets the requirements of SNI 03-2834-2000.
4. The water used meets the requirements of SNI 03-6817-2002.
5. Rice husks as additional material are taken from rice mill waste around the research location.

Material characteristics testing:

1. Cement: testing according to SNI 15-2049-2004.
2. Fine aggregate: testing according to SNI 03-6820-2002.
3. Coarse aggregate: testing according to SNI 03-2834-2000.
4. Rice husk: testing for water content, ash content and silica content (SiO2).
5. The test object used is a concrete cylinder with a diameter of 150 mm and a height of 300 mm, according to SNI 03-1974-1990.
6. The ages of concrete compressive strength testing are 7 days and 14 days, which represent the initial strength and advanced strength of concrete.

The tools used in this research are:
1. Concrete cylinder mold with a diameter of 15 cm and a height of 30 cm
2. Concrete compression testing machine
3. Scales
4. Measuring cup
5. Concrete mixer

2.2. Method

The concrete mix design (mix design) uses the SNI 03-2834-2000 method. Making concrete test specimens with variations in the addition of rice husks as a substitute for sand at 0%, 5%, 10%, 15%, 20%, 25%, and 30% of the total volume of fine aggregate.

Treatment of test objects by immersion in water according to SNI 03-1974-1990. Testing the compressive strength of concrete at 7 days and 14 days using a compression testing machine according to SNI 03-1974-1990.

Analysis of compressive strength test results of concrete with variations in the addition of rice husks, including trend analysis, reduction percentage, and comparison with normal concrete.

The development of the data and methods above is based on standards/references commonly used in the field of civil engineering, so that they can provide more scientific and replicable results.

3. RESULT AND DISCUSSION

6.1. Results

ConcreteWhen examining the concrete constituent materials, researchers obtained material data including specific gravity, water content, mud content, bulk density, absorption and sieve analysis. The materials that will be used in mixing concrete have several requirements that must be met, so it is necessary to check the materials that make up the concrete.

1) Fine Aggregate Inspection Results

In this research, fine aggregate in the form of natural sand obtained from Binjai was used. On fine aggregate, material inspection is carried out which includes sieve analysis testing, specific gravity and water absorption testing, water content testing, unit weight testing, and sludge content testing.

a. The results of the sieve analysis test are: In this test, a value of 2.72 was obtained, which means it meets the specified requirements. The results of the sieve analysis test, apart from determining the fine modulus value of the grains, are also used to determine the gradation of fine aggregate.
b. The results of testing the specific gravity and absorption of sand are Based on the results of the tests and analysis carried out, the results showed that the surface dry saturated specific gravity was 2.67 grams/cm^3 and the water absorption was 2.37%.
c. The results of testing the density of sand are: Based on the results of the tests and analysis carried out, the density for the loose method is 1.50 gr/cm^3 and the density method is 1.58 gr/cm^3. The required bulk weight for normal concrete is around 1.5-1.8 so that the solid volume weight of the fine aggregate used meets the requirements.
d. The results of testing the mud content of sand are Based on the results of the tests and analysis carried out, the percentage value of mud content was obtained at 4.22%, where the required percentage of mud content for sand should not exceed 5%, so from the results obtained that the mud content of sand does not exceed than required and the sand is suitable for use.

2) Coarse Aggregate Inspection Results

a. The results of the sieve analysis test are that in general the fine modulus of fine aggregate grains has a value between 5.5 to 7.5. In this test, a value of 7.04 was obtained, which means it meets the specified requirements. The results of the sieve analysis test, apart from determining the fine modulus value of the grains, are also used to determine the gradation of coarse aggregate.
b. The results of testing the specific gravity and absorption of gravel are: Based on the results of the tests

and analysis carried out, the dry surface saturated specific gravity was 2.60 grams/cm^3 and the water absorption was 0.8%. The absorption of coarse aggregate is smaller than fine aggregate, this shows that there are fewer cavities filled with water than fine aggregate. A normal aggregate specific gravity is between 2.4-2.7 grams/cm3 (Tjokrodimuljo, 2007). This states that the coarse aggregate used includes normal aggregate density because it is between 2.4-2.7 grams/cm3.

c. The results of testing the density of sand are: Based on the results of the tests and analysis carried out, the density for the loose method is 1.48 gr/cm^3 and the density method is 1.54 gr/cm^3. The required bulk weight for normal concrete is around 1.5-1.8 so that the solid volume weight of the coarse aggregate used meets the requirements.

d. The results of testing the sand mud content are: Based on the results of the tests and analysis carried out, the percentage value of mud content was obtained at 0.5%.

3) Mixture Calculation Results for Normal Concrete

Where the results obtained from the amount of grade required per m^3 of concrete, are as follows:

Table 1. The result is the amount of grade required per m^3 of concrete

Cement	Ag. Fine	Ag. Rough	Water
426,875 Kg/m^3	516.9675 Kg/m^3	1206.2575 Kg/m^3	204.9 Kg/m^3

Source: Research results, 2022

Based on the results obtained for the amount of content required per m^3 of concrete, the proportion of the mixture = 1 : 1.21 : 2.82 : 0.48 and it is known that the volume of the cylinder = 0.00583 m^3

The total results obtained are then multiplied by the percentage variation in Rice Husk, namely 0%, 5%, 10%, 15%, 20%, 25%, 30%. This multiplication is to obtain the required amount of fiber for each variation that will be mixed into the concrete mix. The results obtained are as follows:

1. 0% Variation = 0 Kg
2. 5% Variation = 0.15 Kg
3. 10% Variation = 0.30 Kg
4. 15% Variation = 0.45Kg
5. 20% Variation = 0.60 Kg
6. 25% Variation = 0.75 Kg
7. 30% Variation = 0.90 Kg

4. Slump Test Results

Slump is basically a test to determine the workability of fresh concrete before it is accepted and applied in casting work. However, apart from the slump value, what is considered to maintain the workability of fresh concrete is the visual appearance of the concrete, the type and nature of failure during the slump test. Slump of fresh concrete must be carried out before the concrete is poured and if there are indications that the plasticity of the fresh concrete has decreased a lot, to see whether the fresh concrete is still suitable for use or not.

There was a decrease in the slump value, namely from the highest, namely 14 cm for concrete without husk compared to concrete with a 30% variation in husk, namely a slump number of 6 cm. So it is possible that the more fiber you mix, the lower the slump number you will get.

The results of the slump value test can be seen in the table below:

Table 2. Data from slump value testing results

Variation	slump
0.%	14
5.%	12
10.%	11
15.%	9
20.%	9
25.%	7
30.%	6

Source: Research results, 2022

4) Test Object Weight Calculation Results

The results of the manufacture and maintenance of cylindrical test specimens measuring 150 mm x 300 mm with the weight of the test object are as follows:

Table 3. Weight results of cylindrical test objects aged 7 days

7 Day Old Concrete		
No. Object	Variation	Object Weight
Test	Test Objects (%)	Test (Kg)
1	0%	12.72
1	5%	12.26
1	10%	11.93
1	15%	11.90
1	20%	11.85
1	25%	10.89
1	30%	9.88

Source: Research results, 2022

Table 4. Results of the weight of a 14-ha cylindrical test object

14 Day Old Concrete		
No. Object	Variation	Object Weight
Test	Test Objects (%)	Test (Kg)
1	0%	12.30
1	5%	12,11
1	10%	11.78
1	15%	11.72
1	20%	11.62
1	25%	10.56
1	30%	9.57

Source: Research results, 2022

Table 4 shows the reduction in test object weight results, concrete without rice husks shows a figure of 12.30 Kg, while concrete using rice husks with the highest composition variation, namely 30%, shows a test object weight figure of 9.57 Kg. Based on the test results of the test objects, both 7 days and 14 days old, it shows that the more rice husks added, the lower the weight of the test objects obtained.

5) Concrete Compressive Strength Testing

Concrete compressive strength testing was carried out at 7 days and 14 days by applying compressive stress to the concrete. Compressive Strength of concrete. Basically, concrete compressive strength testing refers to SNI 03 – 2491 – 2002 "Concrete Compressive Strength Testing Method". If the procedure is followed, the compressive strength of normal concrete and the compressive strength of concrete mixed with rice husks can be compared.

Table 5. Test results for concrete compressive strength at 7 days

Variation	No. Object Test	Heavy	Date Making Test Objects	Date Testing Test Objects	Mark Concrete Compressive Strength (Mpa)
0%	1	12.72	September 02, 2022	09 September 2022	12.52
5%	1	12.26	September 02, 2022	09 September 2022	11.70
10%	1	11.93	September 02, 2022	09 September 2022	9.91
15%	1	11.90	September 02, 2022	09 September 2022	9.27
20%	1	11.85	September 02, 2022	09 September 2022	8.48
25%	1	10.89	September 02, 2022	09 September 2022	5.15
30%	1	9.88	September 02, 2022	09 September 2022	1.87

Source: Research results, 2022

How to find the compressive strength value of concrete using this formula:$Kt = \frac{F}{\pi . r^2}$

$$5\% = Kt = \frac{F}{\pi . r^2} = \frac{206{,}200}{3{,}14\ x\ (75)^2} = \frac{206{,}200}{17662{,}5} = 11{,}67\ N/mm^2$$

Table 6. Test results for compressive strength of concrete at 14 days

Variation	No. Object Test	Heavy	Date Making Test Objects	Date Testing Test Objects	Mark Concrete Compressive Strength (Mpa)
0%	1	12.30	September 02, 2022	September 16, 2022	12.22
5%	1	12,11	September 02, 2022	September 16, 2022	11.67
10%	1	11.78	September 02, 2022	September 16, 2022	11.32
15%	1	11.72	September 02, 2022	September 16, 2022	9.29
20%	1	11.62	September 02, 2022	September 16, 2022	7.30
25%	1	10.56	September 02, 2022	September 16, 2022	5.54
30%	1	9.57	September 02, 2022	September 16, 2022	1.89

Source: Research results, 2022

How to find the compressive strength value of concrete using this formula: $Kt = \frac{F}{\pi . r^2}$

$$5\% = Kt = \frac{F}{\pi . r^2} = \frac{206{,}600}{3{,}14\ x\ (75)^2} = \frac{206{,}600}{17662{,}5} = 11{,}70\ N/mm^2$$

6.2. Discussion

1) Compressive Strength of Concrete

Concrete compressive strength testing was carried out at 7 and 14 days, the tool used was a Compression Testing Machine. The results of testing the compressive strength of concrete with added rice husks show that the greater the percentage of rice husks, the lower the compressive strength value. The results obtained in the test are as explained in the following graph.

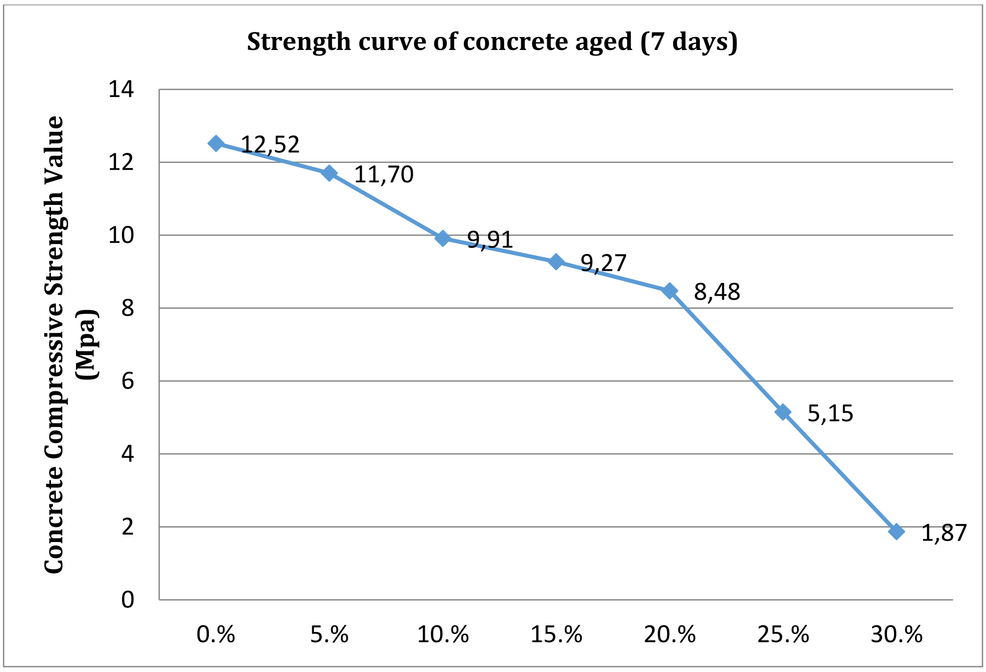

Figure 1. Compressive strength curve of concrete aged 7 days
Source: Research results, 2022

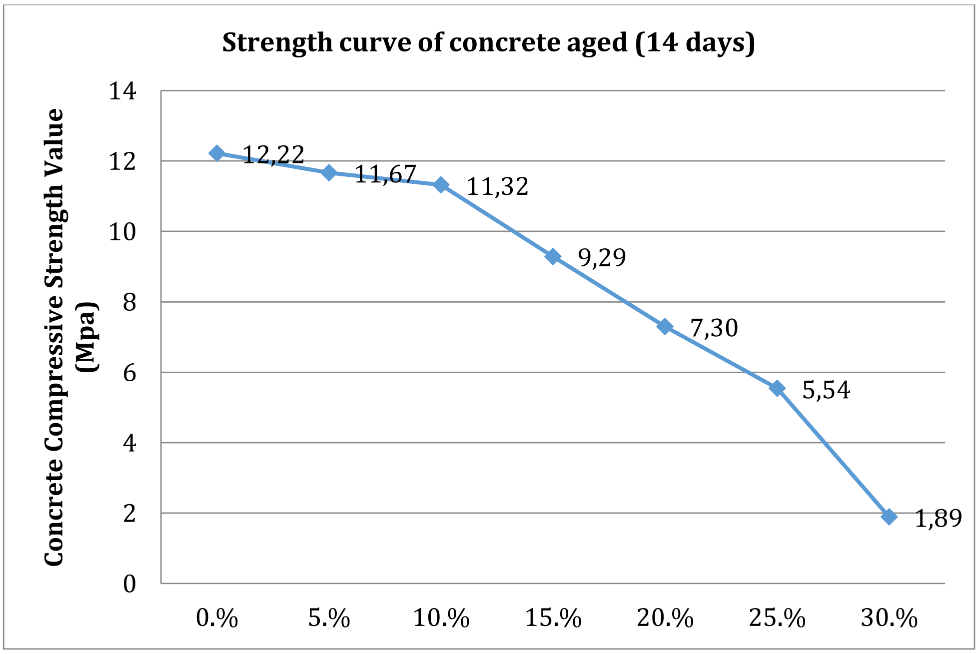

Figure 2. Compressive strength curve of concrete aged 14 days
Source: Research results, 2022

It can be seen in the graph that there is a decrease in the compressive strength of concrete in each variation where the maximum concrete compressive strength lies in the 30% variation which reaches 1.87 Mpa, when compared to the 0% variation with a concrete compressive strength of 12.52 Mpa there has been a decrease in concrete compressive strength of -85.07% for testing at 7 days of age.

Likewise, with testing at 14 days there was a decrease in the compressive strength of the concrete. each variation where the maximum split tensile strength lies in the 30% variation which reaches 1.89 Mpa, when compared to the 0% variation with a split tensile strength of 12.22 Mpa there has been a decrease of -84.53%.

2) Slump Test Value

The slump value test results can be seen in the table below:

Table 7. Data from slump value testing results

variation	slump
0.%	14
5.%	12
10.%	11
15.%	9
20.%	9
25.%	7
30.%	6

Source: 2022 research data

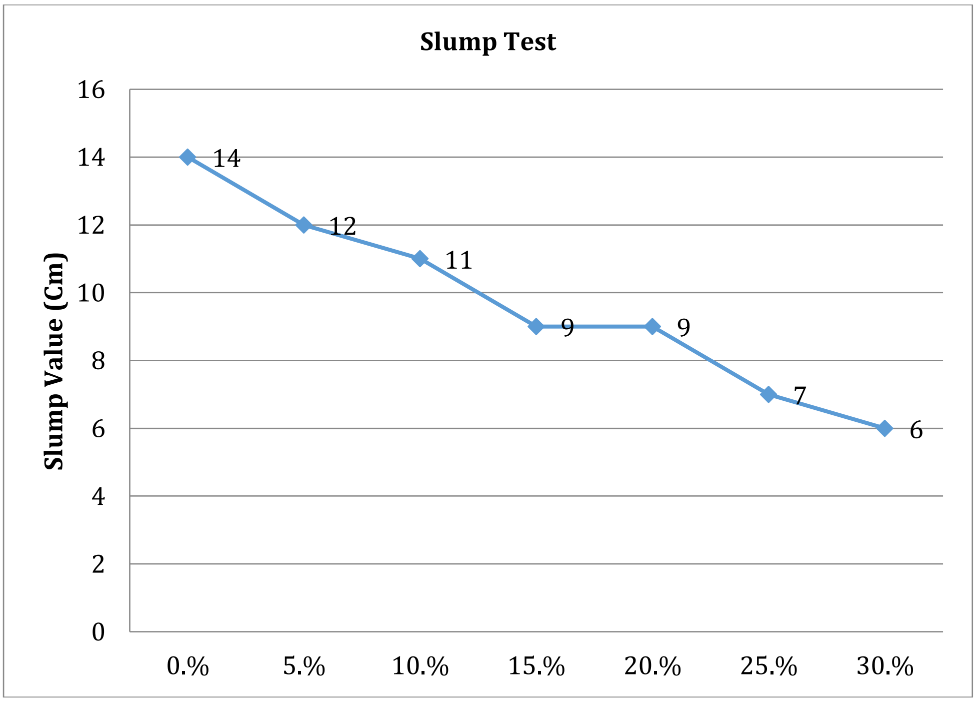

Figure 3. Slump test graph
Source: 2022 research data

From the results of the slump test, there has been a decrease in the slump value, namely from the highest, namely 14 cm for concrete without husk compared to concrete with a 30% variation in husk, namely a slump number of 6 cm.

3) Test results for the weight of the test object

The results of the manufacture and maintenance of cylindrical test specimens measuring 150 mm x 300 mm with the weight of the test object are as follows.

Table 8. Weight results of cylindrical test objects aged 7 days

7 Day Old Concrete		
No. Object Test	Variation Test Objects (%)	Object Weight Test (Kg)
1	0%	12.72
1	5%	12.26
1	10%	11.93
1	15%	11.90
1	20%	11.85
1	25%	10.89
1	30%	9.88

Source: Research results, 2022

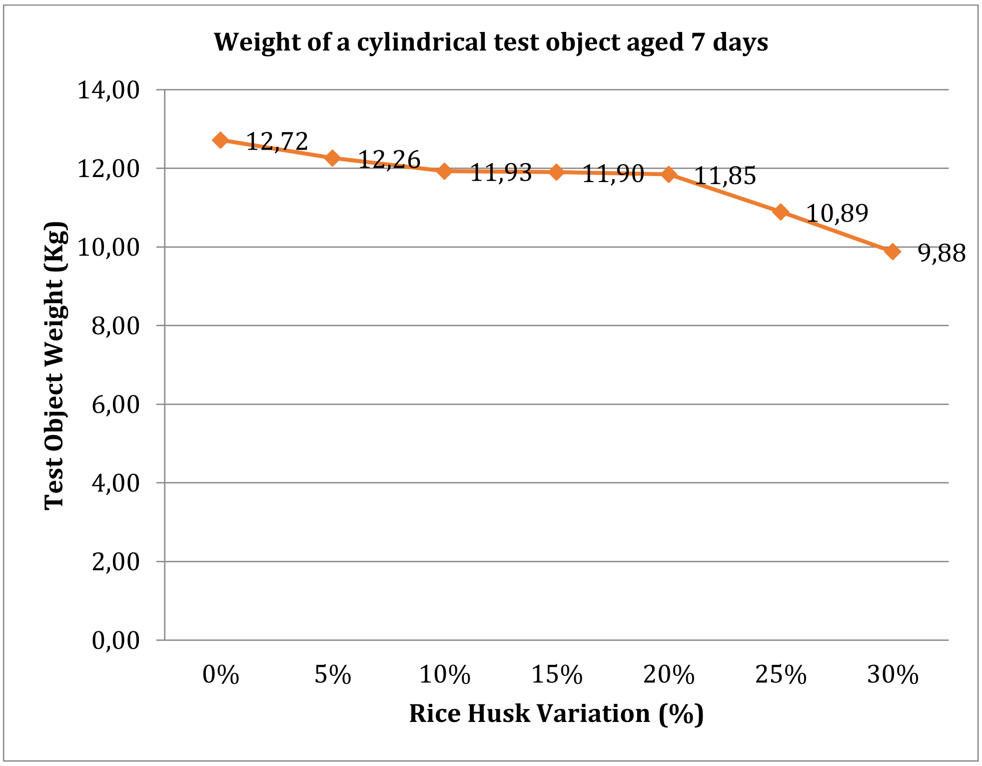

Figure 4. Graph of the weight of a cylindrical test object aged 7 days
Source: Research results, 2022

Table 9 shows the reduction in test object weight results, concrete without rice husks shows a figure of 12.30 kg, while concrete using rice husks with the highest variation, namely 30%, shows a test object weight figure of 9.57 kg. Based on the test results above, it shows that the more rice husks added, the lower the weight of the test object obtained.

Table 9. Results of the weight of cylindrical test objects aged 14 days

14 Day Old Concrete		
No. Object Test	Variation Test Objects (%)	Object Weight Test (Kg)
1	0%	12.30
1	5%	12,11
1	10%	11.78
1	15%	11.72
1	20%	11.62
1	25%	10.56
1	30%	9.57

Source: Research results, 2022

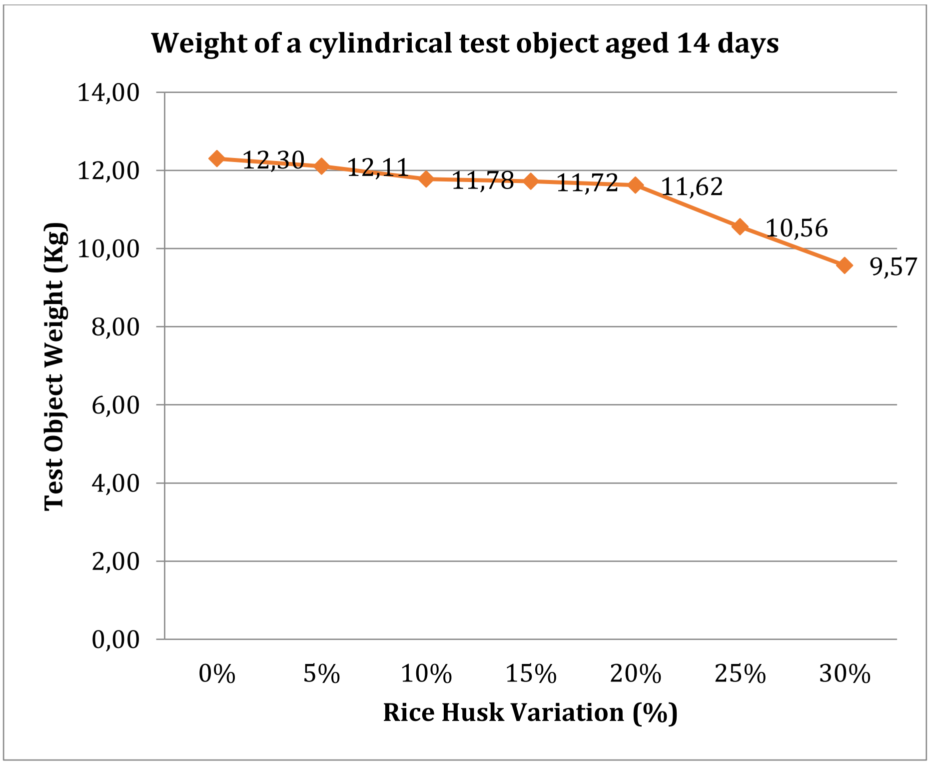

Figure 5. Graph of the weight of a cylindrical test object aged 14 days
Source: Research results, 2022

4. CONCLUSION

Based on the research results presented in the, it can be concluded that rice husk is rice milling waste which has not been utilized optimally, but contains high silica (SiO2) of around 93% which is pozzolanic in nature. This research aims to utilize rice husk waste as an additional material and partial replacement for sand in making concrete. The research method used was the compressive strength test of concrete with variations in the rice husk mixture of up to 30%. The test results showed that the addition of rice husks was less effective in increasing the compressive strength of concrete, and there was even a significant decrease in compressive strength in normal concrete.

The main conclusion that can be drawn is that rice husk additives cannot be used in making concrete, even though rice husks have a high silica content, because the nature of rice husks can absorb water, thus negatively affecting the performance of concrete. Further research is needed to explore the use of rice husks in concrete mixtures.

5. ACKNOWLEDGMENTS

On this occasion, the author would like to express his deepest gratitude to the parties who have helped and supported the research and writing of the article "Utilization of Rice Husks as a Concrete Mixture: Its Effect on Compressive Strength of Concrete".

6. REFERENCES

Badan Standardisasi Nasional. (1990). SNI 03-1974-1990: Metode Pengujian Kuat Tekan Beton.

Badan Standardisasi Nasional. (2000). SNI 03-2834-2000: Tata Cara Pembuatan Rencana Campuran Beton Normal.

Badan Standardisasi Nasional. (2013). SNI 2847:2013: Persyaratan Beton Struktural untuk Bangunan Gedung.

Bui, N. K., Satomi, T., & Takahashi, H. (2020). Improvement of mechanical and durability properties of concrete containing rice husk ash. Construction and Building Materials, 248, 118676. https://doi.org/10.1016/j.conbuildmat.2020.118676

Dawood, E. T., & Ramli, M. (2011). High strength characteristics of cement mortar reinforced with treated sugarcane bagasse fibres. Construction and Building Materials, 25(4), 1499-1507. https://doi.org/10.1016/j.conbuildmat.2010.08.010

Feng, Q., Yamamichi, H., Shoya, M., & Sugita, S. (2004). Study on the pozzolanic properties of rice husk ash by hydrochloric acid pretreatment. Cement and Concrete Research, 34(3), 521-526. https://doi.org/10.1016/j.cemconres.2003.09.005

Givi, A. N., Rashid, S. A., Aziz, F. N. A., & Salleh, M. A. M. (2010). Contribution of rice husk ash to the properties of mortar and concrete: a review. Journal of American Science, 6(3), 157-165.

Hanif, A., Parthasarathy, P., & Kim, Y. S. (2016). Beneficial use of rice husk ash-An industrial waste, in cement-based construction materials. Procedia Engineering, 145, 1110-1117. https://doi.org/10.1016/j.proeng.2016.04.143

Madandoust, R., & Mousavi, S. Y. (2012). Fresh and hardened properties of self-compacting concrete containing metakaolin. Construction and Building Materials, 35, 752-760. https://doi.org/10.1016/j.conbuildmat.2012.04.109

Neville, A. M. (2011). Properties of Concrete. Pearson.

Nurmaidah. (2022). Studi Kasus Pemanfaatan Sekam Padi Sebagai Bahan Tambah Campuran Beton. Jurnal Ilmiah Teknik Sipil, 6(2), 45-52.

Siddique, R. (2008). Waste materials and by-products in concrete. Springer Science & Business Media.

Tashima, M. M., Akasaki, J. L., Castaldelli, V. N., Soriano, L., Monzó, J., Payá, J., & Borrachero, M. V. (2012). New geopolymeric binder based on fluid catalytic cracking catalyst residue (FCC). Materials Letters, 80, 50-52. https://doi.org/10.1016/j.matlet.2012.04.051