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Effects of Adding Coal Ash vs Rice Husk Ash on Compressive Strength of Mortar

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Abstract .
Coal is widely used as an energy source in several industries, especially for power plants (PLN), but on the other hand this causes waste problems or environmental impacts. Several studies have been carried out to utilize coal ash waste (fly ash) as an additional material [or as a partial substitution material] in making mortar. This research aims to determine the effect of adding coal ash and rice husk ash with variations of 5%, 10% and 15% of cement weight respectively (at ages 3 days, 7 days, 14 days, 21 days and 28 days). on the 'compressive strength' and 'absorption capacity' values of the mortar. This research uses quantitative methods through a series of experiments on 60 samples or test objects with the addition of coal ash (fly ash) and rice husk ash in the mortar mixture with reference to the Indonesian National Standard (SNI 03-6825-2002). Next, a series of tests were carried out at the age of 3 days, 7 days, 14 days, 21 days and 28 days to calculate the ' strong ' value. press' and ' power absorb' mortar. The research results showed that with the addition of coal ash and rice husk ash, the mortar experienced a significant increase in 'compressive strength' when compared to ordinary mortar, the strength of the mortar reached the optimum level at a variation of 15% addition of the cement weight, reaching 240.96 kg /cm ^{2} . Meanwhile, with the addition of husk ash in the same variation, the compressive strength of the mortar reached 204.82 kg/cm ^{2} .

Key words *: coal ash, rice husk ash, mortar, compressive strength.*

BACKGROUND

"Burning coal produces air emissions that contain pollutants such as dust and gas (NO2, CO, CO2, and SO2) which can pollute the environment. Waste from coal burning is one of the biggest contributors to pollution which causes an increased risk of lung cancer, stroke, heart disease and respiratory diseases. [Source: Google Search]

"One type of coal burning waste consists of *fly ash* and *bottom ash* (FABA). *Fly ash* is ash that flies above the coal burning furnace, while *bottom ash* is the result of burning coal that settles in the coal burning furnace." 4 July 2022. [Source: Google Search, cited in January 19 , 2023].

Therefore, it is necessary to conduct studies or research on how to utilize and increase the usability of industrial waste , while on the other hand creating a healthier living environment

"Especially in the world of construction, several examples of the use of coal ash are the use of coal ash as a mixture for concrete, soil stability, portland pozzolanic cement, and so on." [Source: Google Search, cited January 19 th , 2023]

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According to the Government of the Republic of Indonesia Regulation number 22 of 2021 concerning the Implementation of Environmental Protection and Management , namely regarding waste with code N106, non - B3 *Fly Ash* waste type , Waste Source : Coal burning process at generating facilities Steam Powered Electricity (PLTU) or from other activities that use technology other than Stocker *Boilers* and/or Industrial Furnaces.

According to SNI 03-6414-2002 , fly ash (fly ash) coal is waste resulting from burning coal in steam power generator furnaces which is smooth, round and pozzolanic in nature. Fly *ash* is a material that has fine granular size, grayish color and is obtained from burning coal. In essence, *fly ash* contains chemical elements including silica (SiO2), aluminia (Al2O), ferrous oxide (Fe2O3), and calcium oxide (CaO), it also contains other additional elements, namely magnesium oxide (MgO), titanium oxide. (TiO2), alkaline (Na2O and K2O), sulfur trioxide (P2O5) and Carbon (Anonymous, 2008) [Source: Wikipedia (2010) .]

Coal ash *(f ly a sh)* used in this research is fly ash which is the result of burning coal in a Steam Power Plant (PLTU) furnace . The sampling location is located at Barru Operation and Services Unit (OMU) Bawasalo Hamlet, Lampoko Village, Balusu District, Barru District, South Sulawesi.

Roni Adiwijaya , Septi Wijayanti, and Yayuk Astuti, 2021, in their research entitled " Fly Ash from Coal Burning Waste as an Additional Mineral Substance (Additive) to Improve the Quality and Compressive Strength of Cement ." explained that the addition of *fly ash* increases the SiO2 content of cement, thereby increasing the amount of cement C3S and C2S compounds are components of the compressive strength of cement. The addition of *fly ash can improve cement* quality by increasing chemical components, thereby increasing ' compressive strength ' , and reducing cracking or cement expansion.

Dahri Kabir , Imran, Mufti Amir Sultan , 2018 , in his research entitled " Use of Fly Ash as an Additive Material in the Mortar Making Process with Quicksand as a Basic Material ." It is stated that the greater the *fly ash added material,* the higher the **compressive strength value, for the** *fly ash* added material as an added material for cement, it produces ' compressive strength ' of bricks of 133.88 kg/cm ^{2} , 150.87 kg/cm ^{2} , 161.06 kg /cm ^{2} , 196.40 kg/cm ^{2} , 243.29 kg/cm ^{2} , and 243.29 kg/cm ^{2}

Apart from coal ash, rice husk ash can also be used as an alternative mixture to increase the 'compressive strength' of mortar. Rice husk ash is the result of burning rice husk waste which has not been utilized optimally by the community. Rice husk ash has the potential to

increase the strength of concrete because it has **pozzolanic properties** like cement, has a silica compound (SiO2) content of 87-97%, and alumina compound (Al2O3) of 3-8% (Yoga **Sandya** , et al ., 2019). Rice husk ash has high pozzolanic properties, because pozzolanic properties are generally obtained with a dominant silica content. In general _ n value of silica content in husk ash is 94-96%.

Wenno et.al. (2014:252) explains that mortar is a mixture consisting of aggregate (sand), water and cement in certain proportions as an adhesive. The application of mortar tends to be in non-structural work such as wall plastering, brick masonry adhesive, river stone foundations, plastering for ceramic installations, bricks, paving blocks, concrete blocks, rosters and so on. In practice in the field, mortar **mixing** still tends to follow the old method , people still use Portland cement as the main binding material. At certain mixture proportions, the compressive strength value of **the mortar** actually shows a decrease in compressive strength. To improve the quality of mortar, materials can be used which has pozzolanic properties as an *additional ingredient* or as *a substitute material partial* cement in order to produce **mortar** that has **compressive strength** higher . _

In an article " Mortar Thermobond" (2015) it is explained that **The benefits** and **function of** mortar as an adhesive can cover uneven brick surfaces to distribute the load , while the function of mortar in plastering is to protect the durability of the brick masonry, level the surface of the wall, bind one brick pair to another so that a composite action between the two can be formed.

Based on the ingredients used, mortar can be divided into several types, including: 1) *Portland cement mortar* , or often known as cement mortar, is made by mixing Portland cement (OPC), sand and water ; 2) *Mortar Polymer cement* , made by replacing part of the cement binder in conventional cement mortar by polymer as an additional ingredient. This polymer additive has the advantage of low permeability and reduces the incidence of drying cracks due to shrinkage, especially designed to repair damaged concrete building structures ; 3) *Lime mortar* , is a type of mortar whose mixing ingredients consist of lime, sand and water ; and 4) *Pozzolan mortar* , pozzolan is an additional material , either derived from nature or industrial waste containing silica and alumina which, when mixed with water, will react with free lime. *Pozzolan mortar* is a mixture of cement mortar added with pozzolan.

Tjokrodimuljo in Simanullang (2014:623) stated that A good mortar must have the following characteristics: 1) cheap ; _ 2) durable (durable) ; 3) m easy to work on (mixed,

transported, installed, leveled) ; 4) adheres well to brick, stone and so on ; 5) c quickly dry or hard ; 6) resistant to water seepage ; and 7) No cracks appear after installation .

Mortar is a combination of its constituent materials consisting of hydraulic cement *(Portland Cement),* fine aggregate, water and added materials (*admixture* or *additives*) which form a solid mass. (**Boni** et.al., 2019:31). The use of this **added material** has several requirements that must be met. These requirements are regulated in SNI 03-6882-2002, namely, additional materials such as coloring materials, forming materials, air bubbles, reaction accelerators or slowdowns, water repellents and other additional materials may not be added to mortar unless the requirements are specified : 1) *Cement ,* SNI 15-2049-2004 defines Portland cement as hydraulic cement produced by grinding clinker consisting of calcium 12 hydraulic silica. Hydraulic cement is cement that hardens when it reacts with water and forms a watertight product, while clinker is granules with a diameter of 5-25 mm which are produced when a mixture of raw materials from the initial composition is heated to a high temperature. Cement functions as a binder between the aggregate grains to form a solid mass and fills the air spaces between the aggregate grains. 2) *Fine Aggregate (Sand ,* Fine aggregate (sand) is aggregate whose grains all pass through sieve No.4 (4.8 mm) and are retained on sieve No.100 (0.15 mm). In selecting fine aggregate (sand) it must be considering several criteria to produce good quality mortar, good quality fine aggregate is needed as a filler component in the mortar mixture ; 3) *Water ,* Water has an important influence in the formation of cement paste which affects workability *, shrinkage* strength and mortar durability.

At certain mixture proportions, the compressive strength value of the mortar actually shows a decrease in compressive strength, so several things must be taken into account during the process. **Boni** et.al. (2019:31) further explains that the properties, characteristics of the materials that make up the mortar, the ratio value of the ingredients, the mixing method and the work method during the pouring of the mortar, the compaction method and the care method during the hardening process will influence the properties, strength, durability, from the mortar made.

In this research, **mortar** was made using *fly ash* from the power generation industry, while rice husk ash was taken directly from the rice mill factory, with the hope that the results of this research can increase knowledge for society , so that have broader insight into utilizing coal waste (*fly ash*) and rice husk ash as mortar mixtures.

RESEARCH METHODS

The method used in this research is a quantitative method, through a series of experiments carried out on a number of test objects with the addition of coal ash , in a mortar mixture with variations of 5%, 10% and 15% (group A), as well as with the addition of husk ash. rice with variations of 5%, 10% and 15% (group B), referring to the Indonesian National Standard (SNI 03-6825-2002).

Each sample group was tested at the age of 3 days, 7 days, 14 days, 21 days and 28 days to calculate the value ' compressive strength ' and the 'absorption capacity' of each sample. The test object used In this study there were 60 pieces, 30 mortar samples with the addition of coal ash *(fly ash)* and 30 mortar samples with the addition of rice husk ash , (see Table 2)

Research Flow Chart

The stages of this research were carried out based on the Flow Chart below.

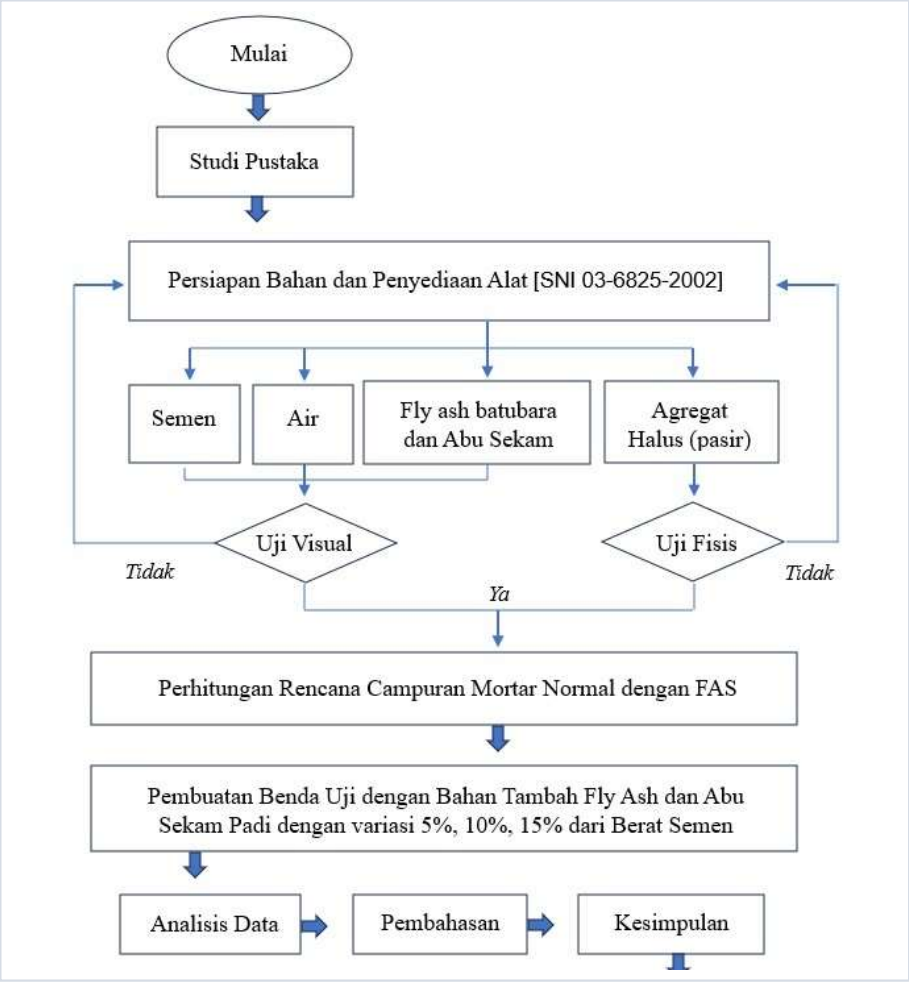

Figure 1. Research flow chart

Table 2. Number of Mortar Samples Used as Test Objects

NO.	Variation/Composition	Mortar + Fly Ash aged 3, 7, 14, 21 and 28 days	Mortar + Rice Husk Ash aged 3, 7, 14, 21 and 28 days
1	5%	10	10
2	10%	10	10
3	15%	10	10
Number of Samples		30	30
Total		60	

Source: Analysis Results, 2023

Research place , _ Material preparation , physical testing, molding, treatment of the constituent materials and testing of the ' compressive strength ' of the mortar were carried out in the Structure and Materials Laboratory of the Civil Engineering Study Program , Faculty of Engineering, Andi Djemma Palopo University.

Mortar Compressive Strength .

According to SNI 03-6825-2002 , Mortar **compressive strength** is the maximum force per unit area that acts on a cube-shaped mortar specimen of a certain size and a certain age. **The maximum force** is the force that acts when the cube specimen breaks. The compressive strength of mortar is greatly influenced by the mixture proportions. Apart from that, water has a big influence on the compressive strength of mortar. The compressive strength of mortar can be determined using the following formula :

$$\sigma m = Pmaks\ A \qquad \text{…….…… 2.3}$$

Where:

σm : Compressive strength of mortar (MPa)

$Pmax$: Maximum Pressing Force (N)

A : Cross-sectional area of the test object (mm^2)

Water Cement Factor (FAS)

According to **Mulyono** in Visal Darmawan & Ikram Pratama (2019:8) The cement water factor is the ratio between the weight of the water used and the weight of the cement in the paste or mortar mixture.

In general, it is known that the higher the value of the Water Cement Factor (FAS), the lower the strength quality of the concrete or mortar. However, a lower FAS value does not always mean that the mortar strength is higher. A low FAS value will cause difficulties in workmanship , namely difficulties in compacting which will cause the quality of the mortar to decrease , so that in making mortar the water cement factor (FAS) has a quite important role in *the workability* and quality aspects of the mortar. Generally the minimum FAS value given is around 0.4 and the maximum is 0.65.

Mortar Absorption

Absorption or absorbency of mortar is the ability of mortar to absorb water through capillary tubes or pores on the surface of the mortar. The water absorption or infiltration value is a value at which water can enter or penetrate porous mortar and this value is usually expressed in the form of a percentage (%). According to **Tjokrodimuljo** in Pribadi Arowi (2010), the amount of **water absorption** in mortar can be measured using the comparison value between the dry weight and the weight of the mortar in SSD conditions during the predetermined soaking time and can be formulated as follows:

w – wk

R = x 100% ……………………………………….………… 2.4

wow

Source: SNI 03-6433-2000

Where :

R : Absorption value or water uptake in mortar (%)

Wk: Weight of dry mortar (grams)

W : Weight of mortar in SSD condition (grams)

Data analysis technique

Data analysis was carried out by calculating the ' compressive strength ' of the mortar and the ' absorptive capacity ' of the mortar with the addition of coal ash (fly ash) And rice husk ash 5%, 10% and 15% of the cement weight at 3 days, 7 days, 14 days, 21 days and 28 days using the formula for compressive strength of mortar and mortar absorption capacity according to equations 2.3 and 2.4 based on SNI 03 -6825-2002 (Testing method for compressive strength of Portland cement mortar for civil works) using Ms. Excel 2019.

Standard Deviation . **Standard deviation** describes how much the value of each sample differs from the average value. S standard deviation is a method of analyzing quality levels by measuring deviation values or deviations in concrete samples. The following tab e l standard deviation classification recommended by *ACI* (*The American Concrate Institute*).

Table 3 . ***ACI* Recommended Standard Deviation Classification**

Supervision Standards	**Recommended Standard Deviation**	
	Implementation of the project	**Experiments in the Laboratory**
Perfect	< 30	< 15
Very good	30 - 35	15
Good	35 - 40	15 - 20
Enough	40 - 35	20 - 25
Bad	> 50	> 25

Source: ACI Standard Deviation

Table 3 above shows that the size of **the standard deviation** is influenced by the level of supervision . The better the level of supervision, the smaller the standard deviation value will be On the other hand, if the level of supervision is poor , the standard deviation value will be greater.

Deviation standard formula according to SNI 03-2834-2004 .

$$S=\sqrt{\frac{\Sigma\,(Xi-Xr\,)^2}{(n-1)}}$$

Information:

S = Standard Deviation

Xi = Compressive Strength Value of Concrete at Each Point

N = Number of Data

Xrt = Average Compressive Strength Value.

RESULTS AND DISCUSSION

Compressive Strength Test Results of Mortar with Coal Ash and Paddy Husk Ash i

' Compressive Strength ' Testing _ M mortar was carried out on test objects with the addition of coal ash *(fly ash)* and test objects with the addition of rice husk ash , respectively 5%, 10% and 15% of cement weight (at 3 days, 7 days, 14 days, 21 days and 28 days) using *a*

Compression Testing Machine (CTM) . The test results showed that the cracks occurred as a result of loading the test object until it reached the maximum limit of its strength to withstand the load [the pointer stopped then moved down], so that the value obtained **the maximum load** that the test object can withstand. Then the ' compressive strength ' of the mortar is calculated mathematically , namely the amount of load per unit area using equation 2.3. Data on the results of testing the ' compressive strength ' of mortar with the addition of coal ash variations of 5%, 10% and 15% (at ages 3 days, 7 days, 14 days, 21 days and 28 days) can be seen in Table 4 .

Table 4 . Test results for compressive strength of mortar with the addition of coal ash (at 3 days, 7 days, 14 days, 21 days and 28 days)

Umur Pengujian (Hari)	Variasi Fly Ash (Abu Batu Bara) (%)	Kuat Tekan (kg/cm²)
3	5	96.39
	10	108.43
	15	120.48
7	5	132.53
	10	144.58
	15	156.63
14	5	156.63
	10	168.67
	15	168.67
21	5	180.72
	10	192.77
	15	204.82
28	5	204.82
	10	216.87
	15	240.96

Source: Analysis Results, 2023

Test result data ' Compressive Strength ' M mortar with the addition of rice husk ash with variations of 5%, 10% and 15% (at 3 days, 7 days, 14 days, 21 days and 28 days) can be seen in Table 5.

Table 5 . Results of testing the compressive strength of mortar with the addition of rice husk ash (on aged 3 days, 7 days, 14 days, 21 days and 28 days)

Umur Pengujian (Hari)	Variasi (Abu Sekam Padi) (%)	Kuat Tekan (kg/cm^2)
3	5	96.39
	10	108.43
	15	120.48
7	5	108.43
	10	120.48
	15	132.53
14	5	120.48
	10	144.58
	15	156.63
21	5	156.63
	10	168.67
	15	180.72
28	5	180.72
	10	192.77
	15	204.82

Source: Analysis Results, 2023

The following is a graph of the 'Compressive Strength' value of Mortar with the addition of coal ash:

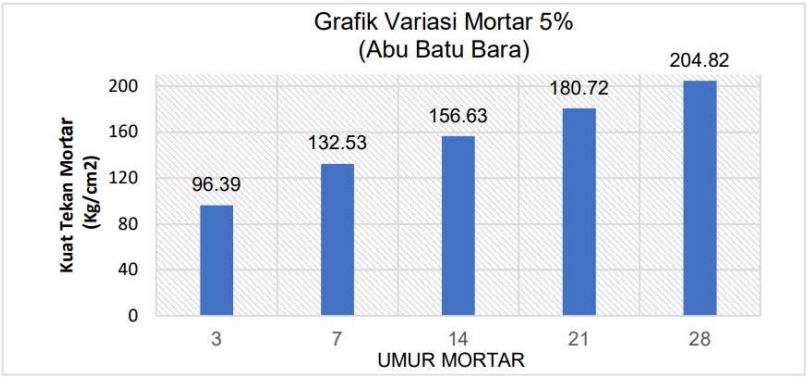

Figure 2 . Diagram of Compressive Strength Values for Mortar with Variation of 5% Coal Ash

Source: Analysis Results, 2023

Figure 2 _ show that ' Press Force ' _ M otar with The addition of 5% variation of coal ash increased , namely at 3 days old it became 96.39 kg/cm ^{2} , at 7 days old it became 132.53 kg/cm ^{2} , at 14 days old becomes 144.58 kg/cm ^{2} , at 21 days of age it becomes 156.63 kg/ cm ^{2} , and at 28 days of age it becomes 192.77 kg/ cm ^{2} .

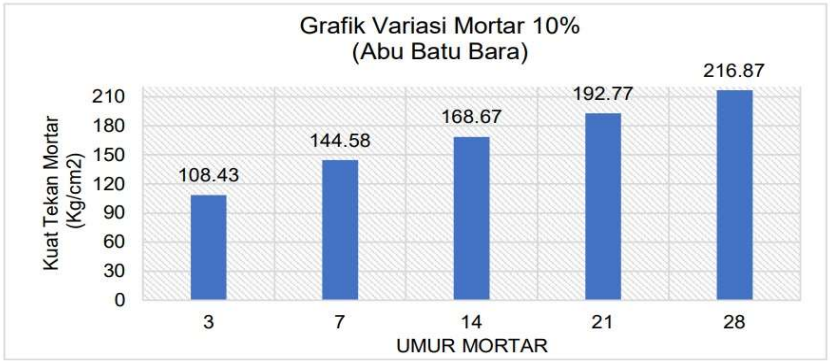

Figure 3 . Diagram of Compressive Strength Values for Mortar with Variation of 10% Coal Ash

Source: Analysis Results, 2023

Picture 3 indicates that ' Compressive Strength ' M mortar with a mixture of 10% coal ash at the age of 3 days increased to 108.43 kg/cm ^{2}, at the age of 7 days it became 1 44 .5 8 kg/cm ^{2}, at the age of 14 days it became 16 8 .6 7 kg/cm ^{2}, at the age of 21 days it becomes 1 92 .7 7 kg/cm ^{2}, and at the age of 28 days it becomes 2 16 . 87 kg/cm ^{2}.

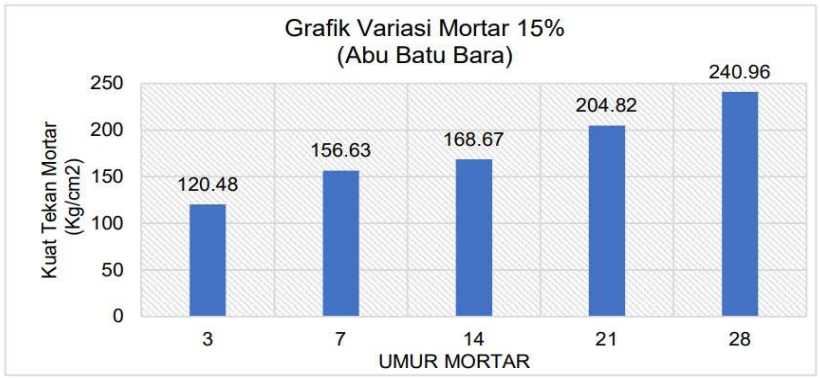

Figure 4 . Diagram of Compressive Strength Values for Mortar with Variation of 15% Coal Ash

Source: Analysis Results, 2023 .

Figure 4 shows that ' Compressive Strength ' Mortar mixed with 15% coal ash , At the age of 3 days the compressive strength value increased to 120.48 kg/cm ^{2}, at the age of 7 day becomes 1 56 . 63 kg/cm ^{2}, at 14 days of age it becomes 168.67 kg/cm ^{2}, at 21 days of age it becomes 204.82 kg/cm ^{2}, and at 28 days of age it becomes 204.82 kg/cm ^{2}.

The following is a graph of the 'compressive strength' value of mortar with the addition of rice husk ash.

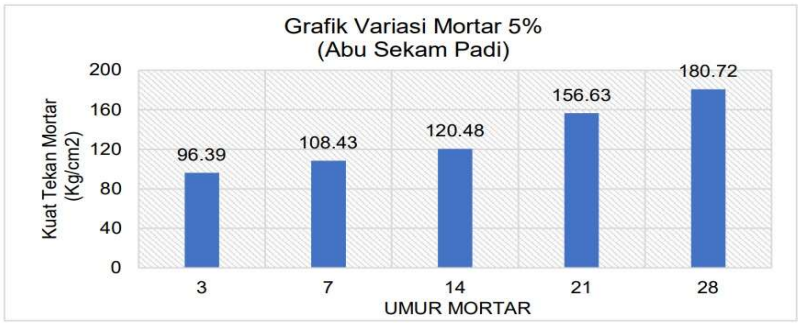

Figure 5 . Diagram of Compressive Strength Values for Mortar Variations of 5% Rice Husk Ash

Source: Analysis Results, 2023 .

Figure 5 _ indicates that ' Compressive Strength ' M mortar with a mixture of 5% rice husk ash , the compressive strength value at the age of 3 days increased to 96.39 kg/cm ^{2} , at the age of 7 days to 108.43 kg/cm ^{2} , at the age of 14 days to 120.48 kg/cm ^{2} , at the age of 21 day it becomes 156.63 kg/cm ^{2} , and at 28 days it becomes 180.72 kg/cm ^{2} .

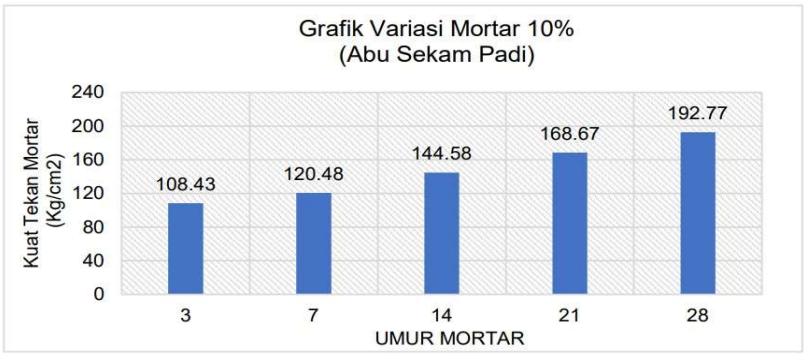

Figure 6 . Diagram of Compressive Strength Values for Mortar Variations of 10% Rice Husk Ash

Source: Analysis Results, 2023

Figure 6 _ show that ' Press Force ' _ M mortar with a mixture of 10% rice husk ash at 3 days of age increased to 108.43 kg/cm ^{2} , at 7 days of age it became 12 0 . 48 kg/cm ^{2} , at the age of 14 days it becomes 144.58 kg/cm ^{2} , at the age of 21 days it becomes 16 8 .6 7 kg/ cm ^{2} , and at the age of 28 days it increases to 192.77 kg/ cm ^{2} .

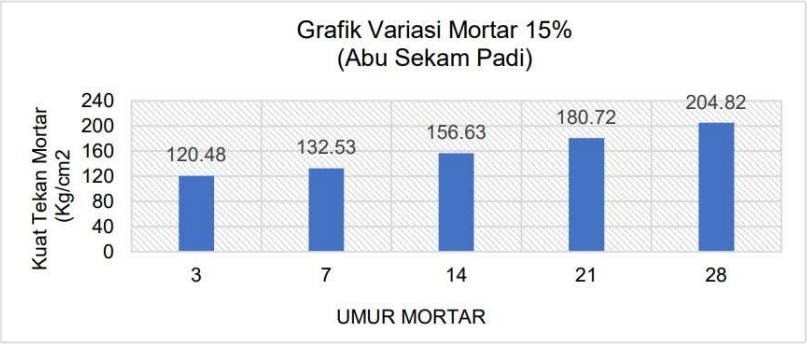

Figure 7 . Diagram of Compressive Strength Values for Mortar Variation of 15% Rice Husk Ash

Source: Analysis Results, 2023

Figure 7 _ shows that the value of ' Compressive Strength ' Mortar mixed with 5 % rice husk ash , at 3 days of age it increases to 120.48 kg/cm ^{2} , at 7 days of age it becomes 132.53 kg/cm ^{2} , at 14 days of age it becomes 1.56 . 63 kg/cm ^{2} , at 21 days of age it becomes 180.72 kg/cm ^{2} , and at 28 days of age it becomes 204.82 kg/cm ^{2} .

Results of testing the absorption capacity of mortar with additional coal ash and additional rice husk ash

Absorption Testing Mortar is carried out at 3 days, 7 days, 14 days, 21 days and 28 days with a mixture of coal ash of 5 %, 10% and 15% of the cement weight , as described in Table 6.

Table 6 . Results of Testing Absorption Capacity of Mortar with Added Coal Ash

PASIR SUNGAI LATUPPA				
Umur Pengujian (Hari)	Variasi Campuran Abu Batu Bara (%)	Sampel Mortar	Resapan Air (%)	Rata - Rata (%)
3	5%	A	3.906	3.752
		B	3.597	
	10%	A	3.817	3.707
		B	3.597	
	15%	A	3.704	3.638
		B	3.571	
7	5%	A	3.876	3.686
		B	3.497	
	10%	A	3.731	3.664
		B	3.597	
	15%	A	3.788	3.719
		B	3.650	
14	5%	A	3.731	3.704
		B	3.676	
	10%	A	3.472	3.472
		B	3.472	
	15%	A	3.571	3.651
		B	3.731	
21	5%	A	3.521	3.461
		B	3.401	
	10%	A	3.521	3.612
		B	3.704	
	15%	A	3.623	3.61
		B	3.597	
28	5%	A	3.817	3.694
		B	3.571	
	10%	A	3.650	3.65
		B	3.650	
	15%	A	3.597	3.623
		B	3.623	

Source: Analysis Results, 2023

Absorption Capacity test result data Mortar at ages 3 days, 7 days, 14 days, 21 days and 28 days with a mixture of rice husk ash of 5%, 10% and 15% of the weight of cement , as described in Table 7.

Table 7 . Mortar Absorption Test Table with Addition of Rice Husk Ash

PASIR SUNGAI LATUPPA				
Umur Pengujian (Hari)	Variasi Campuran Abu Sekam Padi (%)	Sampel Mortar	Resapan Air (%)	Rata - Rata (%)
3	5%	A	3.597	3.752
		B	3.788	
	10%	A	3.650	3.707
		B	3.704	
	15%	A	3.650	3.638
		B	3.906	
7	5%	A	3.704	3.686
		B	3.731	
	10%	A	3.676	3.664
		B	3.546	
	15%	A	3.968	3.719
		B	3.704	
14	5%	A	3.650	3.704
		B	3.846	
	10%	A	3.676	3.472
		B	3.497	
	15%	A	3.906	3.651
		B	3.731	
21	5%	A	3.597	3.461
		B	3.650	
	10%	A	3.759	3.612
		B	3.676	
	15%	A	3.571	3.61
		B	3.623	
28	5%	A	3.876	3.694
		B	3.597	
	10%	A	3.817	3.65
		B	3.906	
	15%	A	3.937	3.623
		B	3.597	

Source: Analysis results, 2023

Mortar ' ***Standard Deviation '*** *Calculation Results*

After carrying out calculations using the formula 'Compressive Strength ' , next Test objects are analyzed using the Standard Deviation formula. Standard Deviation describes how much the sample value compares to the average value. Before the mortar is used , its quality is first assessed by determining the Standard Deviation (S). The results of calculating the Standard Deviation for Mortar mixed with Coal Ash can be seen in Table 8.

Table 8 . Calculation Results of Standard Deviation of Mortar with Mixtures Coal Ash

Umur Sampel	Variasi Campuran (Abu Batu Bara)	Kuat Tekan (Kg/Cm2)	Standar Deviasi	Keterangan
3 HARI	5%	96.39	12.05	Sempurna
	10%	108.43		
	15%	120.48		
7 HARI	5%	132.53	12.05	Sempurna
	10%	144.58		
	15%	156.63		
14 HARI	5%	156.63	6.95	Sempurna
	10%	168.67		
	15%	168.67		
21 HARI	5%	180.72	12.05	Sempurna
	10%	192.77		
	15%	204.82		
28 HARI	5%	204.82	18.4	Baik
	105%	216.87		
	15%	240.96		

Source: Analysis Results, 2023

Data on the results of calculating the Standard Deviation for Mortar mixed with Rice Husk Ash can be seen in Table 9.

Table 9 . Calculation Results of Standard Deviation of Mortar with Mixtures Rice Husk Ash

Umur Sampel	Variasi Campuran (Abu Sekam Padi)	Kuat Tekan (Kg/Cm2)	Standar Deviasi	Keterangan
3 HARI	5%	96.39	12.05	Sempurna
	10%	108.43		
	15%	120.48		
7 HARI	5%	108.43	12.05	Sempurna
	10%	120.43		
	15%	132.53		
14 HARI	5%	120.48	18.41	Baik
	10%	144.58		
	15%	156.63		
21 HARI	5%	156.63	12.05	Sempurna
	10%	168.67		
	15%	180.72		
28 HARI	5%	180.72	12.05	Sempurna
	105%	192.77		
	15%	204.82		

Source: : Analysis Results, 2023

CONCLUSIONS AND RECOMMENDATIONS

The test results show that ' Compressive Strength ' Mortar with added coal ash experienced a greater increase, when compared with 'Compressive Strength' Mortar with added rice husk ash at varying percentages . The maximum increase in the 'Compressive Strength' value occurred when coal ash was added with a percentage variation of 15% , namely increasing to 240.96 kg/cm2 , while for mortar with the addition of rice husk ash with the same variation the 'Compressive Strength' value became 204.82 kg /cm2. The results of the ' absorption capacity ' test of the mortar show that the lower the level of water absorption, the

higher the compressive strength value of the mortar . In general ' Absorptive Capacity ' minimum found in additional variations of 1 5% .

The author recommends that future research be carried out focused on several problems as follows:

1. Testing the 'Compressive Strength ' of mortar at an age of more than 28 days.
2. Use of materials t additional with different variations.
3. Use of different Water Cement Factor (FAS) value variations .

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