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Properties of Concrete Blocks Made from Sugar Mill Waste

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Abstract. This research is an experimental study of the properties of concrete blocks made from sugar mill waste. The properties that are reviewed are weight, water absorption, and compressive strength. The concrete blocks were made with five treatments for sand substitution with sugar mill waste (SMW) which were controls B0 (0%), B1 (6.25%), B2 (12.5%), B3 (18.75%) and B4 (25%) with a ratio of cement water of 0.4. Each treatment group was 30 samples so that the total sample was 150. The results showed that a high percentage of SMW caused a decrease in the weight of the blocks and increased water absorption. The addition of SMW on the aggregate affects the compressive strength of the blocks. A high percentage of SMW causes a decrease in the compressive strength of concrete blocks. The results of the statistical analysis showed that the addition of 12.5% SMW (B2) had an effect on the weight and absorption of the blocks, while the change in the compressive strength of the concrete block occurred with the addition of 6.25% SMW (B1).

Keywords: concrete blocks, SMW, weight blocks, water absorption, compressive strength

1. Introduction

The development of food ingredients processing industry is rapidly increasing in accordance with population growth and human needs. The Government of Indonesia states that industrial companies must utilize natural resources in an environmentally friendly and sustainable manner. It further states that sustainable and environmentally friendly use of natural resources is done by reduction and reuse waste [1]. In the sugar industry or the process of processing sugarcane into sugar, the by-products or waste in the form of a mixture of various materials including sugar cane fiber, sucrose, and thickened colloids [2]. The volume of this waste is quite large, ranging from 3% -4% of the weight of milled sugarcane. Several previous studies have shown that sugarcane is processing waste from the sugar industry which is high in fiber, is easy to form and becomes particles can be processed into particle boards, cement panels, light blocks or hollow concrete slabs [3][4].

One of the materials for building simple houses in Indonesia is blocks making which is the production of small and medium industries. Concrete is a wall construction material, either on the load-bearing wall or on a wall that does not carry a load [4]. The requirements of the building material have the characteristics of wall building material in terms of weight, water absorption, and compressive strength [5]. Blocks making is a hollow block made from a mixture of hydraulic adhesives or the like added with fine aggregate and water with or without other auxiliary materials. This material has a cross-sectional area that is greater than 25% of the cross-sectional area, and the contents of the hole are greater than 25% of the contents of the blocks.

The idea of using SMW as an added ingredient in making blocks making is to reduce waste stacks or pollutants [6]. The results of previous studies revealed that the use of bagasse ash as a material added to concrete could increase concrete density and have a better increase in compressive strength and flexural strength compared to normal concrete [7][8]. This study is an experimental analysis to examine the effect of the addition of sugar mill waste on the basic material for making blocks making.

2. Research method

2.1. Research design

This research is experimental research. Samples made consisting of materials: Portland cement, fine aggregate, and water. The concrete block was made with five treatments for sand substitution with sugar mill waste (SMW) which were controls B0 (0%), B1 (6.25%), B2 (12.5%), B3 (18.75%) and B4 (25%). The comparison of the volume of cement and fine aggregate is 1: 4 with a ratio of cement water of 0.4. Each treatment group was 30 samples so that the total sample was 150. In making the sample, the ingredients are mixed evenly by manual (hand), then the water is inserted slowly until it forms a mixture. Then the mixture is put into the printing machine within one minute after the blocks are formed it is dried within 14 days.

2.2. Research variables

The research variables are weight blocks, water absorption, and compressive strength. The weight measurement of blocks making is done by using the calipers three times in different places. Data of weight blocks making is taken twice and then averaged (kg). Water absorption is the amount of water absorbed by the test object from the oven dry state until it becomes saturated. Water absorption is taken from the average value of a number of samples (%). The compressive strength is the maximum load that can be carried by the sample until the crack or break is divided by the cross section of the sample press area. Compressive strength testing is done by using a compressive strength machine. The compressive strength is taken from the average number of samples (kg cm^{-2}).

2.3. Data analysis

Weight measurements are obtained from the average value, maximum and minimum values and standard deviations of 30 data. Measurement of water absorption [9]using the formula:

$$\text{Water absorption} = \frac{A - B}{B} \text{x} 100\% \quad (1)$$

where A = sample load after being immersed in water until saturated, B = weight of the sample after oven at 100° C - 105°C for 24 hours (up to a fixed weight). Measurement of compressive strength using the formula:

$$\text{Compressive strength} = \frac{P}{F} \quad (2)$$

where P = load destroyed (kg), F = gross compressive area (cm^2). The data obtained were analyzed using SPSS version 12.0.

3. Results and discussion

3.1. The weight of concrete blocks

The results of the weight of concrete blocks measurements can be seen in Table 1.

Table 1. Properties of the weight of concrete blocks

Properties of the weight	Treatments				
	B0	B1	B2	B3	B4
Maximum weight (kg)	7.95	7.65	7.25	7.25	7.25
Minimum weight (kg)	7.20	7.20	6.60	6.50	6.50
Standard deviation	0.22	0.14	0.18	0.19	0.21

Table 1 shows that the maximum weight of concrete blocks with the highest value is the sample B0 (0% SMW), while the lowest minimum weight is shown in the sample B4 (25% SMW). The weight standard deviation of concrete blocks in all treatments shows a value between 0.14 - 0.22. This means that the percentage of SMW affects the weight of concrete blocks produced. The lowest standard deviation was obtained in the B1 sample test. The results of statistical tests of differences in weight of concrete blocks can be seen in Table 2.

Table 2. Statistical tests of differences in weight of concrete blocks

Difference test of weight	Sig.	Conclusion
Control – 6.25% SMW	0.599	There is no difference between the weight of concrete blocks without SMW and the 6.25% blocks making of SMW
Control – 12.5% SMW	0.000	There is a difference between the weight of concrete blocks without SMW and the 12.5% blocks making SMW
Control – 18.25% SMW	0.000	There is a difference between the weight of concrete blocks without SMW and the 18.25% blocks making SMW
Control – 25% SMW	0.000	There is a difference between the weight of concrete blocks without SMW and the 25% blocks making SMW

Table 2 shows that samples with a 6.25% substitution of SMW did not show differences in weight of concrete blocks. Furthermore, with the SMW substitution of 12.5%, 18.25%, and 25% gives a difference in the weight of the concrete blocks. This indicates that the use of SMW as a substitute with a percentage that exceeds 12.5% affects the weight of concrete blocks.

3.2. Water absorption of concrete blocks
Water absorption of concrete blocks or the amount of water absorbed by the sample from the oven dry state to become saturated is measured when the concrete blocks are 7 days after making. The results of measurements of water absorption of concrete blocks are presented in Table 3.

Table 3. Properties of water absorption of concrete blocks

Properties of water absorption	Treatments				
	B0	B1	B2	B3	B4
Maximum water absorption (%)	14.93	14.49	15.79	16.42	19.40
Minimum water absorption (%)	13.64	7.14	10.17	10.45	10.94
Standard deviation	1.21	1.62	1.56	1.65	2.00

Table 3 shows that the maximum water absorption of concrete blocks is 19.40% in B4 treatment (25% SMW) and minimum water absorption is 13.64% in B1 treatment (6.25% SMW). The highest standard deviation of water absorption of concrete blocks is 2.00, or the level of sample diversity is relatively low. The results of statistical tests of differences in water absorption of concrete blocks can be seen in Table 4.

Table 4. Statistical tests of differences in water absorption of concrete blocks

Difference test of water absorption	Sig.	Conclusion
Control – 6.25% SMW	0.720	There is no difference between the water absorption of concrete blocks without SMW and the 6.25% blocks making of SMW
Control – 12.5% SMW	0.004	There is a difference between the water absorption of concrete blocks without SMW and the 12.5% blocks making SMW
Control – 18.25% SMW	0.000	There is a difference between the water absorption of concrete blocks without SMW and the 18.25% blocks making SMW
Control – 25% SMW	0.000	There is a difference between the water absorption of concrete blocks without SMW and the 25% blocks making SMW

Table 4 shows that samples with a 6.25% substitution of SMW did not show differences in water absorption of concrete blocks. Furthermore, with SMW substitution of 12.5%, 18.25%, and 25%, it gives a difference in the water absorption of concrete blocks. This indicates that the use of SMW as a substitution with a percentage that exceeds 12.5% affects the water absorption of concrete blocks.

3.3. The compressive strength of concrete blocks

The compressive strength of the concrete blocks shows the maximum load that can be carried by the sample until the crack or crush is divided by the cross-sectional area of the sample press. The results of testing the concrete blocks compressive strength of all treatments are presented in Table 5.

Table 5. Properties of compressive strength of concrete blocks

Properties of compressive strength	Treatments				
	B0	B1	B2	B3	B4
Maximum compressive strength (kg cm^{-2})	21.51	19.55	18.42	16.10	15.12
Minimum compressive strength (kg cm^{-2})	16.42	13.84	14.88	11.14	11.63
Standard deviation	1.15	1.06	0.87	0.96	0.75

Table 5 shows that the highest compressive strength of concrete blocks is 21.51 kg cm^{-2} in the sample B0 (0% SMW). Substitution of sand with 25% SMW gives a decrease in compressive strength of 6.39 kg cm^{-2}. The standard deviation value of the concrete blocks compressive strength in all treatments also indicates good sample uniformity. The analysis results show that the higher the percentage of SMW, the lower the compressive strength of the concrete blocks produced. The statistical tests of differences in compressive strength of concrete blocks can be seen in Table 6.

Table 6. Statistical tests of differences in compressive strength of concrete blocks

Difference test of compressive strength	Sig.	Conclusion
Control – 6.25% SMW	0.000	There is a difference between the compressive strength of the concrete blocks without SMW and the 6.25% blocks making of SMW
Control – 12.5% SMW	0.000	There is a difference between the compressive strength of the concrete blocks without SMW and the 12.5% blocks making SMW
Control – 18.25% SMW	0.000	There is a difference between the compressive strength of the concrete blocks without SMW and the 18.25% blocks making SMW
Control – 25% SMW	0.000	There is a difference between the compressive strength of the concrete blocks without SMW and the 25% blocks making SMW

Table 6 shows that samples with SMW substitution in all treatments showed differences in concrete blocks compressive strength. This indicates that the use of SMW as a substitute affects the compressive strength of the concrete blocks.

The analysis results showed that the use of SMW as a substitute for fine aggregates affected the properties of concrete blocks made. Significantly different properties are the concrete blocks compressive strength. Furthermore, the weight and absorption of water do not change if the use of 6.25% SMW (B1). If viewed at the concrete blocks compressive strength at 6.25% SMW, it appears that the decrease in compressive strength is relatively small and is still in the level of fulfilling the requirements for building wall materials. Therefore, the composition of 6.25% SMW can be used as a reference for the utilization of SMW in concrete blocks made.

Specifically, the absorption properties that increase due to the addition of SMW are due to the nature of the SMW that absorbs water. With the increase in absorption value, the nature of concrete is increasingly at risk of absorbing water and tends to be easily porous. This is in accordance with testing the compressive strength of concrete blocks which also decreased due to the addition of SMW.

The use of SMW in concrete blocks making is part of Green Concrete's efforts to minimize the use of natural resources and the use of waste without reducing the material properties of the building materials it produces [10].

4. Conclusion

The use of SMW has an effect on the nature of the concrete blocks produced. The higher the percentage of SMW, the absorption of concrete blocks increases, the weight and compressive strength of the concrete blocks decreases. Statistical test results show that the use of SMW as a substitute for fine aggregates affects the properties of concrete blocks made. Significantly different properties are the concrete blocks compressive strength. Furthermore, the weight and absorption of water do not change in the use of 6.25% SMW (B1).

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