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Optimization of Sugarcane Bagasse Ash for Paving Blocks Production

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Abstract. One of the sugar industries produces large quantities of bagasse ash. Sugarcane bagasse ash in the sugar industry cannot yet be utilized. Sugarcane bagasse ash has a relatively high silica content, namely 68.5%, which can be used as a substitute material to reduce the use of cement in making paving blocks. In this research, concrete bricks were made using the manual pressing method. Paving blocks are made from sand, cement, bagasse ash, stone ash, and water. The cement, stone ash, and sand ratio is 1:2:6, with variations in bagasse ash of 10, 20, and 30% of the sand composition. The test results showed that the highest quality concrete bricks were on the 7th day of drying, with 214 kg/cm^2, getting quality B based on SNI 03-0691-1996, and the compressive strength of the resulting concrete bricks would increase as the drying time increased. This innovation can improve the usability of bagasse ash and become a new business opportunity for the sugar industry.

Keywords: *bagasse ash, industrial, compressive strength, paving blocks*

1. Introduction

Pulp fiber, which functions as reinforcement, can be used to reduce cement use and industrial waste. One use of pulp fiber is ash from burning sugarcane bagasse [1]. Sugarcane bagasse ash is one of the wastes produced by the sugar industry. Bagasse ash is the result of boiler combustion in the sugar industry. Sugarcane bagasse ash still cannot be appropriately utilized; if left alone, it can cause pollution to the environment around the factory. Apart from that, bagasse ash contains aluminum oxide (Al_2O_3), iron(III) oxide (Fe_2O_3), lime (CaO), sodium oxide (Na_2O), potassium oxide (K_2O), magnesium oxide (MgO), and diphosphorus pentoxide (P_2O_5). This has the potential to be an alternative material to cement because it has tiny granules to fill pore holes in paving blocks [2].

Sugarcane bagasse ash has a reasonably high silica (SiO_2) content of 68.5% [3]. The silica content in bagasse ash can increase if burned and used as a cement substitute in paving block mixtures [4]. Sugarcane bagasse ash can be used as a cement substitute because it contains

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silica, but cannot wholly replace cement. This is because bagasse ash does not contain enough lime, alumina, and iron oxide to replace cement and will decrease the paving block's compressive strength [5]. Apart from that, paving blocks mixed with bagasse ash as a substitute for cement are environmentally friendly because they can reduce air pollution from excessive use of cement [6].

According to research by Muharja et al. (2022), adding lime to make paving blocks can increase compressive strength, but it is not significant and produces quality C according to SNI 03-0691-1996 [7,8]. Adding lime is considered less effective because it costs more money and is of lower quality. Therefore, this research uses stone ash as a substitute for lime. Stone ash has several advantages, such as being cheaper and containing high levels of calcium oxide (CaO), so it can improve the quality of paving blocks [9]. Calcium oxide (CaO) in stone ash can substitute lime, which is not present in bagasse ash, thereby improving the quality of paving blocks.

The calcium oxide (CaO) composition in stone ash, which is not contained in bagasse ash, can be of additional value to improve the quality of paving blocks. Based on the background described above, this research aims to utilize bagasse ash from burning boilers found in one of the sugar industries as a substitute for cement in making paving blocks. In this study, the bagasse ash used was 10%, 20%, and 30% of cement. Next, the paving blocks are dried for a drying time of 7 to 10 days, and testing will be carried out by pressing tests to determine the quality of the paving blocks.

2. Materials and Methods

2.1 Materials

The primary material used in this research is bagasse ash, which comes from the boiler process of one of the sugar industries in Banyuwangi, Indonesia. Other ingredients for the composition are sand, cement (Semen Gresik, Indonesia), stone ash, and clean water.

2.2 Paving Blocks Production

The process of making paving blocks, as referred to in the reference Nofrianto et al. (2023), is divided into two parts, the first part is making the top part of the paving block which aims to act smoother using cement, while the second part is the dough part for the body of the paving block [10]. Making the dough for paving block bodies is done by mixing sand, cement, bagasse ash, and stone ash until smooth and then adding water until a thick dough that should not be too runny or hard is formed. The use of water in making paving block dough is approximately 10% of the weight of the sand. The gabpensi used has dimensions of 20×10×6 cm. First, approximately one handful of cement is put into the gabpensi, which is helpful as a smoother on the top of the paving block, and then added to the mixture as the body material for the paving block. Pressing is done by hitting the compactor against the dough in the mold. When pressing, it is recommended to use greater force to produce dense and smooth paving blocks. The paving block can be removed from the mold and dried for 7 to 10 days if it is solid. The drying method used is the conventional method using sunlight. Paving blocks will be dried in the sun for 7 to 10 days and watered regularly every day so that the paving blocks can dry slowly, because if you don't water periodically, the paving blocks will reduce the quality value.

2.3 Test Sample Testing

The pressure test for paving blocks is a pressure quantity obtained from the outside in the form of pressure equal to the cross-sectional area of the sample to be tested. To determine the strength of paving blocks made from a mixture of bagasse ash that has been dried for 7 and 10 days, a compression test will be carried out on the samples using a Universal Testing Machine (UTM) based on references from Nofrianto et al. (2023) [10]. Calculation of the compressive strength of paving blocks can be calculated using the formula:

$$P = \frac{F}{A} \tag{1}$$

Where, P is the compressive strength (N/mm2), F is the maximum compressive load (N), A is the cross-sectional area to be tested (mm2) and 1 MPa= 1 N/mm2.

The conversion of compressive strength (kg/cm2) to MPa can be calculated using the formula:

$$compressive\ strength\ conversion = Compressive\ strength\ \times 0{,}0980665 \tag{2}$$

3. Results and Discussion

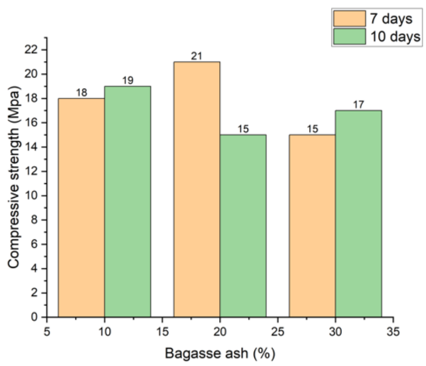

Figure 1. Paving Block Press Test Results

Figure 1 is a graph of the paving block compression test results based on variations in the use of bagasse ash. Using 10% of bagasse ash on average produces a higher compressive

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strength than using more than 10%. Using 10% bagasse ash on average produces a higher compressive strength than using more than 10% bagasse ash from either 7 days or 10 days of curing. This is due to the formation of a reaction between the silica (SiO_2) contained in the bagasse ash and the remaining lime, resulting from the reaction of cement compounds with water. The results of this reaction produce the compound calcium silicate hydrate (CSH), which is hard and has a low level of solubility in water. Suppose the amount of silica compound substituted increases. In that case, the compressive strength of the paving block will also increase, but only up to the optimum point, and then the compressive strength will decrease [11]. At 10 days of curing using 20% bagasse ash, the compressive strength value was lower than using 10% and 30% bagasse ash because the energy used for pressing during the manufacturing process was less, resulting in a decrease in value. Compressive strength of paving blocks is one of the key factors in making paving blocks. Meanwhile, according to Amiwarti et al. (2022), using more and more bagasse ash can reduce the compressive strength value of paving blocks because the water content is small, which can interfere with the hydration reaction [12]. The results obtained are directly proportional to research conducted by Rahmanto et al. (2023), where adding more than 10% bagasse ash will reduce the compressive strength value of the paving block [13].

From Figure 1, the paving block compression test results are also obtained based on the length of curing time—a curing time of 10 days results in a higher compressive strength of the paving block. The longer the curing time, the higher the compressive strength of the paving block, because according to Saputra et al. (2019), it requires a longer time, where the optimal time for ripening is 28 days [14]. The increase in compressive strength can also be caused by the cement covering all the aggregates. This is directly proportional to research conducted by Rokhman et al. (2022), where, during the curing time of 28 days, the compressive strength of the paving blocks increased. This was because the reaction between pozzolan and calcium hydroxide remained unchanged [15]. This is also reinforced by the results of research conducted by Loganayagan et al. (2021), the compressive strength of paving blocks is higher with a curing time of 28 days compared to a curing time of 7 days [16].

Table 1. Paving Block Quality Test Results

Test	Day 7		Day 10	
Sample	Maximum load (kg)	Quality	Maximum load (kg)	Quality
10%	36709.78	B	39768.93	B
20%	42828.08	B	31611.20	C

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Test Sample	Day 7		Day 10	
	Maximum load (kg)	Quality	Maximum load (kg)	Quality
30%	30591.49	C	34670.35	B

Table 1 shows that the quality is based on the National Standards Agency (1996) of paving blocks with several variations in the use of bagasse ash [8]. On average, when using 10% bagasse ash, the quality is in the B range. For quality B, paving blocks can be used as parking equipment, while quality C can only be used for pedestrians [17]. The quality of paving blocks at a curing time of 10 days using 20% bagasse ash is lower than that ok paving blocks using 10% and 30% bagasse ash because the energy used to press during the manufacturing process is less, resulting in a decrease. Quality of paving blocks. This is inversely proportional to the results of research conducted by Ulum et al. [18]

4. Conclusion

In this research, more bagasse ash variations will reduce the paving blocks' compressive strength. The curing time greatly influences the resulting compressive strength; the longer the curing time, the higher the compressive strength of the paving block will be. According to the experimental results, optimal results were obtained on 10-day-old paving blocks using 10% bagasse ash with a compressive strength of 19 MPa.

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