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EFFECT OF CANDLENUT SHELL ASH AS A SAND SUBSTITUTION ON COMPRESSIVE STRENGH OF PAVING BLOCK

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Abstract

Candlenut is a superior commodity with great opportunities. Processing of candlenut seeds produces candlenut shells which are hard with a calorific value of 4164 calg so can be used as fuel. Processing candlenut shells as fuel produces waste of ash and not been utilized optimally. In this research, candlenut shell ash was used as a new alternative in making paving blocks, namely to substitute sand by 13%, 18% and 25% by weight of sand. The method used to analyze the chemical content of candlenut shell ash through XRF testing and compressive strength testing with a Compression Testing Machine after 28 days of curing time. Based on the results of the XRF test, hazelnut shell ash has a CaO content of 93.3%, where CaO is the main ingredient for making cement. In addition, the results of the average compressive strength of paving blocks at 13% substitution of candlenut shell ash produced a compressive strength of 5.89 MPa, 18% substitution of candlenut shell ash of 8.72 MPa, and 25% substitution of candlenut shell ash of 11.07 MPa. The results of the compressive strength of paving blocks with the substitution of hazelnut shell ash produced standard standard paving block strength of D quality.

Keywords: Paving Block, Candlenut Shell Ash, XRF Testing, Compressive Strength

Introduction

Paving blocks or concrete bricks are building material products made from a mixture of water, aggregate and portland cement with additives that do not reduce quality (Standar Nasional Indonesia: Paving Block, 1996). Paving blocks are used as an alternative road surface covering such as sidewalks in cities, paving roads in housing complexes or residential areas, beautifying parks, yards and hardening parking areas, office areas, factories, parks and school yards (Fathurrahmaniah et al., 2022; Halim & Sepriyanna, 2022; Martina et al., 2019; Oktaviastuti & Leliana, 2020; Setiawan et al., 2021). Based on its classification, paving blocks have several qualities with their respective applications. The following is the classification of paving blocks according to the National Standardization Indonesia Indonesia (Standar Nasional Indonesia: Paving Block, 1996) listed in Table 1.

Table 1. Classification of paving blocks (SNI 03-0691-1996)

Quality	Function	Strong Press (MPa)	
		Average	Minimum
A	Street	40	35
B	Parking equipment	20	17
C	Pedestrian	15	12,5
D	Garden and other uses	10	8,5

The candlenut plant is a plant that is easy to grow and almost all parts of it can be used, especially the hazelnut seeds (Baharuddin, 2021). Based on National Leading Plantation Statistics Data 2020 – 2022, candlenut is one of the strategically superior plantation commodities that has a great opportunity to be developed, the largest candlenut plantations with superior commodities are in the regions of East Nusa Tenggara (706 Ha), West Java (439 Ha), and Maluku (46 Ha). Candlenut has 2 layers of skin, namely fruit skin and shell. Each kilogram of candlenut seeds produces 70% shell and 30% core (Bema et al., 2021). Candlenut shells have constituent compounds in the form of CaO, SiO_2, Al_2O_3, MgO, H_2O, Fe_2O_3 (Minanulloh et al., 2020). The processing of candlenut seeds produces candlenut shells which have hard properties with a calorific value of 4164 cal/g, so they can be used as fuel. Processing candlenut shells into ashes will produce waste that has not been used optimally (Ayu et al., 2019; Lathifah et al., 2019).

Utilization of candlenut shell ash as a substitute for cement by 5%, 10%, and 15% in K-300 concrete produces a maximum compressive strength of 42 MPa at 15% substitution of candlenut shell ash (Minanulloh et al., 2020). Research by (Murat Ozocak, 2017) do the addition of candlenut shell ash as a cement substitution by 5%, 10%, 15%, 20% of cement weight. The results showed that the more candlenut shell ash added to the cement, the lower the compressive strength of K-300 concrete by 4.7% - 11.7%.

This research, candlenut shell ash was used as a substitute for sand in paving blocks with the substitution of sand by 13%, 18%, and 25% of the weight of sand. Candlenut shell ash is expected to produce high compressive strength so as to produce quality and environmentally friendly Paving Blocks.

Research Methodology

The research method is experimental in the field by conducting research directly and through the literacy process to obtain data and results of the variables studied. Primary data used in the form of compressive strength test results and XRF test from candlenut shell ash. XRF testing aims to determine the chemical content of hazelnut shell ash carried out using a PANalytical tool. Secondary Data used in the specific gravity of each material used, cement water factor (FAS 0.5). According to (Simanjuntak et al., 2021) generally the FAS value used in making concrete is a minimum of 0.4 and a maximum of 0.65, if the FAS value is lower then the concrete is difficult to compact and if the FAS value is higher then it will reduce the strength of the concrete.

The test specimen made using fine aggregate in the form of lumajang sand passed a sieve size of 4.75 mm because this size is the maximum size of fine aggregate for paving blocks (Hendri Nofrianto, 2023; Indah Handayasari, 2018; Mohammad et al., 2017), portland cement, candlenut shell ash as a substitute for sand, and water. This study used a mixture of candlenut shell ash with variations of 13%, 18%, and 25%. The test objects used in the form of paving blocks measuring 21 cm x 10.5 cm x 6 cm in the amount of 2 pieces for each variation to test compressive strength. The size of the paving is a size that is available in the market and is commonly used for projects.

The tools and materials used in this study were shovels, scales, containers, paving molds with dimensions of 21 cm x 10.5 cm x 6 cm, 4.75 mm sieve, portland cement, lumajang sand, water, and candlenut shell ash as sand substitutes. After preparing the necessary tools and materials, the dough is made in accordance with the mix design that has been determined (Table 2), the next step is to print the dough and compact it in the available molds. The printed Paving is then removed from the mold and dried for 24 hours. Then the curing process is carried out for 28 days. The longer the time from the age of the compressive strength test, it is strong the resulting press is getting bigger (Dedyerianto et al., 2022; Diana, 2020; Hastuty, 2018; Yusuf et al., 2021) and the harder the cement that is formed and the curing time of up to 28 days is the maximum age for the hardness level in concrete compressive strength. The next step is to test the compressive strength in the ITS-Manyar concrete Laboratory on each paving and draw conclusions from the experiments that have been carried out.

Figure 1. Stirring mix design

Figure 2. Printing paving block

Figure 3. Compressive test of paving block

Table 2. Mixed design paving blocks

Test Object Code	Amount of Material			
	Sand (kg)	Candlenut shell ash (kg)	Cement (kg)	Water (liter)
P13 (13% Candlenut shell ash)	1.958	0.293	0.750	375
P18 (18% Candlenut shell ash)	1.845	0.405	0.750	375
P25 (25% Candlenut shell ash)	1.688	0.563	0.750	375

Research Results and Discussion

XRF test (X-ray of fluorescence) of the Candlenut shell ashes is intended to analyze the chemical components contained in the material. XRF test results can be seen at Table 3 and Table 4 as follows:

Table 3. XRF waste of the candlenut shell ash

Elements	Consentration	Oxide	Consentration
Al	0.3%	Al_2O_3	0.8%
Si	0.1%	SiO_2	0.3%
K	0.63%	K_2O	0.62%
Ca	93%	CaO	93.3%
Ti	0.07%	TiO_2	0.08%
Mn	0.89%	MnO	0.75%
Fe	1.82%	Fe_2O_3	1.69%
Cu	0.17%	CuO	0.14%
Sr	1.91%	SrO	1.5%
Mo	0.06%	MoO_3	0.05%
Ba	0.99%	BaO	0.79%

Based on the chart of the 3 chemical components of the dominant calcified Candlenut shell ash that is, a 93% calcium factor. Another high chemical component based on the XRF test results, iron 1.82% with Fe_2O_3 oxide compounds, 69%. Testing indicates that the calcium properties significantly dominate CaO compound at 93.3% where calcium oxide is a key component in the making of cement. Calcium is one of the Portland cement-forming chemicals usually obtained from lime and chalk alone to fill 85% of the cement mass (Citrasari, 2019; Do et al., 2019; Kareem, 2023; Ren et al., 2020; Zhang et al., 2019). CaO oxide is the major oxide which contributed to its formation clinker and the quality of cement produced (Damdelen, 2019; Jiang et al., 2021; Ma et al., 2018; Yang et al., 2022; Yusuf et al., 2021). In the process of making cement, Calcium Oxide is the largest component in quantity, and will react with Silicate Oxide, Aluminum Silicate, Alumina, and Iron Oxide and form mineral compounds that are potential constituents of strength in cement (Halin, 2018; Huang et al., 2019; Sharonova et al., 2019).

The compressive strength test of paving block was carried out when the paving block was 28 days old using Compression Testing Machine. Compressive strength paving block identifies the quality of a structure, the higher the level of strength of the desired structure, the higher the quality of paving blocks to be produced. From testing the compressive strength of the test specimen obtained maximum compressive strength (P). The compressive strength of paving blocks is obtained by dividing the maximum compressive strength by the cross-sectional area of the test object. Compressive strength testing of each variation of the composition of candlenut shell ash from the total sand weight as a sand substitute of 13%, 18%, and 25% was carried out when the paving block test object was 28 days. Compressive strength testing performed on each variation of the composition of the mixture consisting of 2 pieces of sample specimens. The compressive strength of paving block is shown in Table 5 and Table 6 as follows:

Table 4. Results of compressive strength testing paving block

Test Object Code	Day	Weight (kg)	Area (cm²)	Compressive Strength		Average Compressive Strength (MPa)
				kg/cm²	MPa	
P13	28	2.24	220.5	57.69	5.7	5.89
	28	2.24	220.5	62.49	6.1	
P18	28	2.54	220.5	105.76	10.4	8.72
	28	2.36	220.5	72.11	7.1	
P25	28	2.32	220.5	120.18	11.8	11.07
	28	2.32	220.5	105.76	10.4	

Graphic of compressive strength test results paving block can be seen in Figure 4:

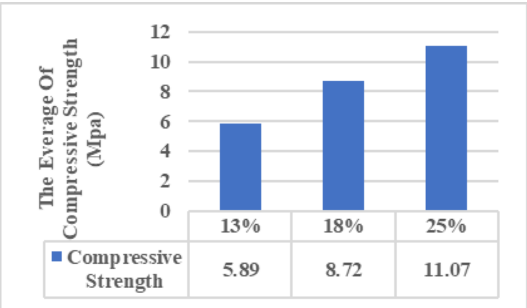

Figure 4. Graphic of compressive strength

Based on the results of the test specimen at the age of 28 days obtained the average compressive strength of paving blocks with a substitution of 13% candlenut shell ash to the weight of sand of 5.89 Mpa, the average compressive strength with a substitution of 18% candlenut shell Ash of 8.72 Mpa, and the optimum average compressive strength obtained from the substitution of 25% candlenut shell ash to the weight of sand of 11.07 Mpa. This happens because candlenut shell ash has calcium oxide content can increase the value of compressive strength in paving blocks with certain variations according to the type of material used. CaO compounds have a function as a strength enhancer in cement. CaO compounds can affect the content of C_3S, C_2S, C_3A and C_4AF. Where is C_3S in cement effect on the strength at the initial age of concrete, C_2S in cement has an effect on strength when concrete has reached its age of maturity, C_3A in cement has an effect to release heat of hydration in concrete and C_4AF gives color to cement (Soehartono et al., 2022; Syafpoetri et al., 2018; Yanette et al., 2019).

However, other research reveal excess CaO content can also have a negative impact on cement strength. If the CaO content excess cement, resulting in the cement is not strong and brittle. The higher the CaO content, the compressive strength decreases (Nath, 2020; Rashad, 2018; Vasić et al., 2020; Yusuf et al., 2021). This happens because the content of the compound 3CaO.SiO2.3H2O in the cement to increase so that the calcium hydroxide released by the cement when the cement reacts with water increases. the more calcium hydroxide that is formed, the less adhesive power of the cement so that the structure inside will be weak and result in low compressive strength (Abdel-Jaber et al., 2021; Cao et al., 2020; Diana, 2020; Giri, 2023).

Conclusion

Based on the results of the research that has been done, it can be concluded that:

1. XRF test results from candlenut shell ash showed that the CaO content in the sample was very high reaching 93.3%
2. The more candlenut shell ash added to the sand mixture, the more compressive strength the paving block can increase
3. The maximum compressive strength of paving blocks is obtained from the addition of 25% hazelnut shell ash, with an average compressive strength of 11.07 MPa
4. Based on (Standar Nasional Indonesia: Paving Block, 1996) standard, paving blocks in this research are included in quality D for use in gardens.

Based on the results of the research that has been done, there are several inputs for future research, including :

1. The procedures carried out must be appropriate and coherent in accordance with the compressive strength test steps.
2. Testing the compressive strength of the specimens should be carried out at the age of 7, 14, 28 days to determine the significant effect of adding candlenut shell ash as a substitute for sand.
3. Testing of the specimens is added to the wear resistance and water absorption tests so that the results obtained can be compared with the quality requirements that apply to SNI 03-0361-1996.

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