The Utilization of Muara Badak Sand and Palm Kernel Shell in The Mixture for Paving Blocks

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ABSTRACT

Paving block is a building material composition made from a mixture of portland cement or other hydraulic adhesives, water and aggregate with or without other additives which do not reduce the quality of the concrete. This study aims to analyze the compressive strength of paving blocks from the utilization of local sand and palm shell waste. Palm shell waste is obtained from PT. Tapian Nadenggan who processes palm oil into palm oil. The large amount of waste can be used as an added ingredient in the manufacture of paving blocks. This research method is an experimental research, by making hexagon-shaped paving blocks with a mold size of 20 cm wide, 12 cm side and 6 cm thick using estuary sand and palm oil shell ash waste with variations of 0%, 25%, 50%, 75%, 100%. The addition of ash from palm shell waste resulted in an effective compressive strength test at 28 days of age with the highest value at 50%, namely 17,64 MPa, then 25% variation, namely 17,38 MPa and 75% variation with a value of 16,03 MPa, classified as quality B can be used for parking lots. Meanwhile, the 100% variation with a yield of 11,03 MPa is included in grade D and can be used for garden.

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1. INTRODUCTION

Indonesia has made significant progress in structural engineering technology. This has led to concrete being widely used in new structures, including roads, dams and buildings. The aesthetic appeal of sidewalks is a key component of their construction. As a result, road construction requires a large demand for paving blocks. These blocks help maintain the overall quality and durability of the road by serving as an alternative to surface hardness coatings. In terms of cost, it is relatively affordable, easy to install and maintain, and does not require additional layers [1], [2], [3], [9].

Paving block is a mixture of building materials such as a mixture of portland cement or other hydraulic adhesives, fine aggregate such as sand and coarse aggregate but not of concrete quality and also water as other mixed ingredients [6]. Paving blocks are an alternative that is widely used in the field of construction as a coating for soil pavements or road pavements. Paving blocks are used as an alternative to pavement because of their ease of installation, maintenance which is relatively inexpensive in terms of cost and of course the added aesthetic value which makes them more preferred. In terms of its use, paving blocks are generally used on highway pavements and also roads in housing, parking lots, sidewalks, parks, and can also be used in container areas at ports and other industrial areas. The use of paving blocks supports "go green" initiatives because the water absorption during the installation of these paving blocks can help maintain the water balance in the soil [4], [10], [11].

East Kalimantan is one of the largest palm oil-producing provinces in Indonesia. For example, PT. Tapian Nadengga, as one of the palm oil processing factories, produces palm oil shells up to 63 tonnes/week, and this can lead to a buildup of waste if it is not utilized, and this can lead to a buildup of waste if it is not utilized. The accumulation of palm oil waste in this factory is probably very rare for people or groups who process this waste and even just throw it away without producing any benefits [5], [7]. This oil palm shell is classified as organic waste, even so the waste is not easy to decompose because the texture tends to be hard. The fact is that a lot of palm oil waste can pollute the environment, so it is important to maximize the use of this waste.

Therefore, proper handling, especially as a processed material that can be used for road pavement mixtures, which if possible can overcome the pile of waste. This research was carried out by utilizing oil palm shells as a construction material and local sand materials in the Muara Badak sub-district which are used for aggregate or additional materials which are of course very environmentally friendly in mixing the manufacture of paving blocks [3], [8].

2. METHODS

This research method is experimental research, namely research on making paving block test specimens, by carrying out activities or experiments utilizing palm oil shell waste as a mixture addition to fine aggregate, which is seen from how compressive strength is produced. 1) The initial stage of preparing the material, fine aggregate in the form of a collection of crushed stone, gravel, sand both in the form of natural products and others, is used estuary sand which is white in color, with a slightly fine texture and rather coarse grains with a small amount of coal dust mixed in. Sand from Muara Badak was taken from Muara Badak Village, East Kalimantan. Palm oil waste is the result of processed waste from one of the palm oil factories of PT. Tapian Nadenggan Muara Wahau, East Kalimantan, which is used as a mixture for fine aggregate. The shell part of the oil palm is hard so that the part is very thick and there is no fiber. The water used in this research is water from PDAM. The cement used is portland cement type 1 with the Tiga Roda brand. 2) Preparation of tools for conducting research including sieves, scales, tweezers, measuring cups, ovens, paving block molds, compressive strength testing machines. 3) The material inspection stage, the process of testing the material to be used in mixing the paving block mix with the aim of knowing the characteristics of the ingredients making up the paving blocks are in accordance with the standards. 4) Making the test object, is done by making hexagon-shaped paving blocks with a mold size of 20 cm wide, 12 cm side and 6 cm thick using estuary sand and oil palm shells with variations of 0%, 25%, 50%, 75 %, 100%, PDAM water, and portland cement type 1 [2][17]. 4) Then the compressive strength test was carried out at the age of paving blocks 7 days, 14 days, 28 days. The total sample is 45 pieces.

Prior to testing the compressive strength, the paving blocks were first weighed with a digital scale.

$$K=P/A \quad (1)$$

$$A = (3\sqrt{3}.\ S^2)/2 \quad (2)$$

K : Concrete compressive strength (N/mm^2 atau Mpa)
P : Axial compressive force, expressed in newtons (N)

A : The cross-sectional area of the test object, expressed in mm²

3. RESULTS AND DISCUSSION

3.1 Materials Inspection

The initial step of inspecting the material from fine aggregate to mixing paving block mortar. The specific gravity of Muara Badak sand is 2.356 gr/cm3 according to the standard specific gravity of SNI 03-1970-1990 which is 2.30-2.60, fine grain modulus is 2.755%. The requirement for fine aggregate silt content from SNI 04-1998-F.1989 must be below 5% and from inspection it is obtained 0.147%, meaning that it is suitable for use as a mixture for making paving blocks. Based on SNI 03-1970-1990 the standard volume weight is 1400 kg/dm³ -1900 kg/dm³ while the results of the volume weight examination are an average without a joist of 1227.07 kg/dm³, and the average volume weight using a joist is 1418.47 kg/dm³ then the volume weight test that meets the standard is the test using a rolling pin which is equal to 1418.47 kg/dm³[3], [6] ,[13], [14], [20].

Then testing the ash from palm shell waste. According to the British Standard (BS EN 206-1), boiler ash, which is the byproduct of burning shell and fuel fiber, falls into the category of natural materials with a specific gravity of less than 1.20 g/cm3, with a value as low as 0.160 g/cm3. The low specific gravity of boiler ash has the potential to be used as an additive material in the production of lightweight concrete bricks or paving blocks, which can help reduce their weight, meeting one of the main requirements in the production of lightweight concrete bricks or paving blocks. In this study, the waste was treated with various processes so that it can produce ash which can be used as a mixed material for paving block mortar. Palm shell waste ash is used as an added material for the mortar mixture with reference to the weight of the fine aggregate used in each mortar or every one paving block. This test is carried out after the shells go through the drying process of the oil palm shells and are burned after which they are ground to a fine powder so that they turn into ashes, then the oil palm shells are moistened and then dried using an oven, after that the ashes of the oil palm shells are then weighed as needed, namely 500 gr. After the oil palm shells are weighed, the oil palm shells are sieved using a sieve and a vibratory machine to determine the gradation of the oil palm shell ash. It can be seen in Figure 1. The fine grain modulus of 2.088% was obtained with a moisture content of 14.8% [15], [16], [18], [21].

Figure 1 Processing of Palm Shell Ash Waste

3.2 Mix Design

Based on the data from the results of testing the material used in the manufacture of paving blocks, then a mix design of normal paving blocks and palm shell paving blocks and estuary sand was carried out as additional ingredients as substitution materials. Paving blocks are made in the form of a hexagon with a length of 20 cm with a side of 12 cm and a height of 6 cm [6], shown in Figure 2.

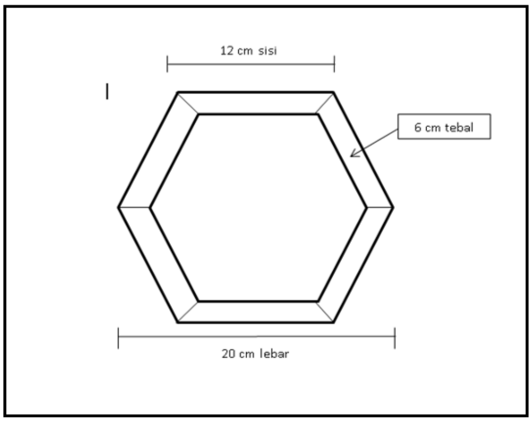

Figure 2 Paving Block Moulds

Calculations with a mix based on units so that the mix design values are obtained as follows [6], [20]:

• Volume Paving Blocks = (0,5 x $3\sqrt{3}xS^2$) $x\ t$
= (0,5 x $3\sqrt{3}x12^2$) $x\ 6$
= (2244,74) x 6
= 2244,74 cm³ = 0,0022 m³

• Cement

Requirement of cement in the specimen:
100% = $\frac{1}{(1+3)}$ x 0,0022 x 2,25 = 1,2626 kg
Waste Factor 15% x 1,2626 kg = 0,1894 kg
The need for cement after adding the waste factor:
1,2626 + 0,1894 = 1,425

• Sand

The need for estuary sand for the test object :
100% = $\frac{3}{(1+3)}$ x 0,0022 x 1227,07 = 2,0658 kg
Waste Factor 15% x 2,0658 kg = 0,3098 kg
2,0658 + 0,3098 = 2,3757 kg

75% = $\frac{3-(0,25x3)}{(1+3)}$ x 0,0022 x 1227,07 = 1,5493 kg
Waste Factor 15% x 1,5493 kg = 0,2324 kg
1,5493 + 0,2324 = 1,78179 kg

50% = $\frac{3-(0,5x3)}{(1+3)}$ x 0,0022 x 1227,07 = 1,0329 kg
Waste Factor 15% x 1,0329 = 0,1549 kg
1,0329 + 0,1549 = 1,1878 kg

25% = $\frac{3-(0,75x3)}{(1+3)}$ x 0,0022 x 12227,07 = 0,5164 kg
Waste Factor 15% x 0,5164 = 0,0774 kg
0,5164 + 0,0774 = 0,5939 kg

- Oil Palm Shells

The need for Palm Oil Shells as test specimens:
100% = $\frac{1\ x\ 3}{(1+3)}$ x0,0022 x 614,883 = 1,0351 kg

Waste Factor 15% x 0,2588 = 0,1552 kg
1,0351 + 0,1552 = 1,1904 kg

75% = $\frac{0,75\ x\ 3}{(1+3)}$ x 0,0022 x 614,883 = 0,7763 kg
Waste Factor 15% x 0,7763 = 0,1164 kg
0,7763 + 0,1164 = 0,8928 kg

50% = $\frac{0,50\ x\ 3}{(1+3)}\ x\ 0,0022\ x\ 614,883$ = 0,5175 kg
Waste Factor 15% x 0,5175 = 0,0776 kg
0,5175 + 0,0776 = 0,5952 kg

25% = $\frac{0,25\ x\ 3}{(1+3)}\ x\ 0,0022\ x\ 614,883 = 0,2588\ kg$
Waste Factor 15% x 0,2588 = 0,0388 kg
0,2588 + 0,0388 = 0,2976 kg

- Water
  The cement water factor used is 40% by weight of cement:
  Need = $\frac{40}{100}\ 1,4520 = 0,5808\ kg$

Table 1 Mixing needs for paving blocks

Variation	0%	25%	50%	75%	100%
Cement	1,452	1,452	1,452	1,452	1,452
Sand	2,139	1,604	1,069	0,535	0,000
Palm Shell	0,000	0,298	0,595	0,893	1,190
Water	0,581	0,581	0,581	0,581	0,581

Source: Calculation Analysis of Mixed Paving Block Requirements

Table 2 Total Needs for Palm Shells

25%	50%	75%	100%
2,678	5,357	8,037	10,714

3.3 Preparation of test objects

At this stage it aims to analyze and obtain results for testing the compressive strength of the specimens that have been made. In the manufacture of this test object has been designed for the material mixture plan, and the test object is made of 45 test objects.

Figure 3. Paving Block Making Process

3.4 Concrete Curing

At this stage Figure 5, it is carried out after all the test objects have been printed and dry until the specified time is 7, 14 and 28 days. The treatment carried out aims to get the results in this study, namely water absorption and continue to be tested for compressive strength.

Figure 4. Concrete Curing

3.5 Compressive Strength Test

In testing the compressive strength of paving blocks with variations of 0%, 25%, 50%, 75% and 100% and testing of compressive strength at the age of 7 days, 14 days and 28 days is shown in Figure 6. The test equipment used is the Compression Testing Machine [2], [19].

Figure 5. Paving Block Compressive Strength Test

Prior to testing the compressive strength, the paving blocks were first weighed with a digital scale.

$A = \frac{3\sqrt{3}\,s^2}{2} = \frac{3\sqrt{3}\;12^2}{2}$ = 748,245 / 2 = 374,123 cm² = 37412,3 mm²
Example:
P = 715,6 KN = 715,600 N
$K = \frac{P}{A}$ = 715,600/37412.3 = 19,13 Mpa

Table 3. Compressive Strength Testing

Age (day)	Variation	Weight (Kg)	Dial Reading (KN)	Compressive Strength (Mpa)	Coefficient	Compressive Strength (MPa)
7	0%	3,99	603,8	16,14	0,65	10,49

	25%	3,769	545,6	14,58		9,48
	50%	3,317	483,1	12,91		8,39
	75%	3,165	441,5	11,80		7,67
	100%	2,873	303,1	8,10		5,27
	0%	3,99	640,1	17,11	0,88	15,06
	25%	3,384	695,6	18,59		16,36
14	50%	3,744	707,8	18,92		16,65
	75%	3,280	527,1	14,09		12,40
	100%	2,805	436,1	11,66		10,26
	0%	3,978	640,2	17,11	1	17,11
	25%	3,385	650,4	17,38		17,38
28	50%	3,496	659,8	17,64		17,64
	75%	3,236	599,6	16,03		16,03
	100%	2,899	412,8	11,03		11,03

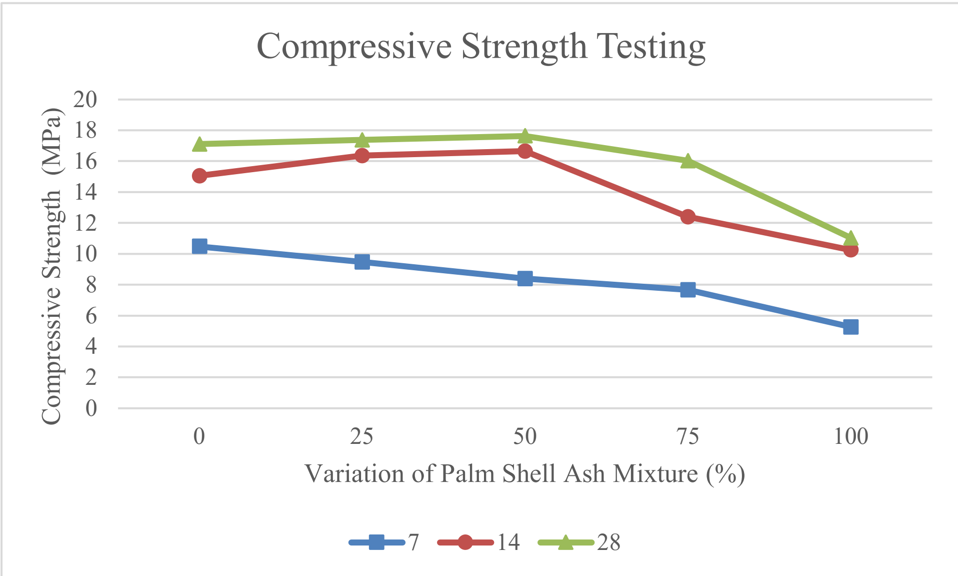

Figure 6. Chart of Compressive Strength Testing

The compressive strength testing of paving blocks aims to assess whether they meet the specified requirements for lightweight structural use. Compressive strength refers to the amount of load per unit area that causes cracks or damage to the test specimens when subjected to a specific pressure by a testing machine. This testing is conducted on various paving block mixtures containing palm kernel shell waste ash at percentages of 0%, 25%, 50%, 75%, and 100%, at ages of 7, 14, and 28 days. Each mixture variation is tested using 3 test specimens, resulting in a total of 45 paving block test specimens. The test results reveal variations in the compressive strength of the paving blocks. Generally, paving blocks with added palm kernel shell waste ash have lower compressive strength compared to those without such additions. At 7 days, the paving blocks with a higher percentage of palm kernel shell waste ash exhibit lower compressive strength. However, at 14 days, the paving blocks reach their highest compressive strength of 16,36 MPa with 50% palm kernel shell waste ash mixture. At 28 days, there is an increase in compressive strength with 25% mixture, reaching 17,38 MPa, and it further increases to 17,64 MPa with 50% mixture of palm kernel shell waste ash. However, a decrease in strength is observed in mixtures with 75% and 100% palm kernel shell waste ash. The maintained relatively high compressive strength of the paving blocks, despite some decreases, may be attributed to the high silica content in the palm kernel shell waste ash used.

According to Ismeik (2009), silica in the form of silicon dioxide (SiO_2) with high solid particle characteristics can enhance the binding properties, durability, strength, and hardness of aggregates. Silica in palm kernel shell waste ash serves as a filler material that can increase material density, which is related to compressive strength. Additionally, silica plays a crucial role in influencing the bond between cement and other aggregate materials.

In comparison to paving blocks without the addition of palm kernel shell waste ash, using the same procedures in this study, a compressive strength of 17,11 MPa was obtained. Paving blocks with 25% mixture of palm kernel shell waste ash achieved a compressive strength of 17,38 MPa, while those with a 50% mixture reached 17,64 MPa. However, a decrease in strength was observed in the 75% mixture, with value of 16,03 MPa, and a more significant decrease occurred in the 100% mixture of palm kernel shell waste ash, with a value of 11,03 MPa. The lower and even decreasing compressive strength with an increasing amount of ash can be explained by the fact that the addition of a large quantity of ash with very low density leads to an increased number of voids, resulting in weaker bonding between particles in the mixture.

However, when compared to the SNI 03-3449-2002 standard, which requires a minimum compressive strength of 6,89 MPa for all paving blocks intended for lightweight structural use, the paving blocks from the study met these quality criteria. Additionally, the paving blocks from the study can be categorized as falling within the medium strength lightweight concrete category, ranging from 6,9 to 17,3 MPa, while those with a compressive strength exceeding 17,3 MPa are classified as structural lightweight concrete (Simanjuntak, 2011). The inclusion of palm kernel shell waste ash at the age of 7 days proved to be ineffective for variations of 50%, 75%, and 100%, as it resulted in compressive strength values below 8,5 MPa, failing to meet the paving block quality standards. However, the addition of palm kernel shell waste ash at a 25% variation was effective, yielding a value of 9,48 MPa and falling into quality grade D suitable for landscaping purposes. At the age of 14 days, the addition of palm kernel shell waste ash proved effective for all variations in the 25% and 50% mixtures, qualifying for quality grade B, which is suitable for parking areas, while the 75% and 100% mixtures were classified as grade C, suitable for pedestrian use. At the age of 28 days, the addition of palm kernel shell waste ash was effective for all variations in the 25%, 50%, and 75% mixtures, also falling within quality grade B for use in parking areas, while the 100% mixture was categorized as grade D, suitable for landscaping [19].

4. CONCLUSION AND SUGGESTION

4.1 Conclusion

At the age of 7 days the addition of palm oil waste ash resulted in a maximum compressive strength test at a mixture variation of 25% with a value of 9,48MPa including grade D which can be used for park. At the age of 14 days the addition of palm oil waste ash resulted in a maximum compressive strength test at a mixture variation of 50% with a value of 16,65 MPa including grade C which can be used for pedestrian. The addition of palm oil waste ash resulted in an effective compressive strength test at 28 days of age with the highest value at 50%, namely 17,64 MPa, then a 25% variation, namely 17,38 MPa and 75% variation with a value of 16,03 MPa, classified as grade B can be used for parking lot. While the 100% variation with a yield of 11,03 MPa is classified as grade D and can be used for park.
The quality of the paving blocks still has the potential for improvement to reach grade A, with an average compressive strength of 40 MPa and a maximum water absorption rate of 3%. To achieve this level of quality, it is necessary to consider the following aspects: uniformity of the mixture, the ratio of raw material composition between cement and sand, increased pressure during the molding process, and a more optimized level of refinement for the palm kernel shell waste ash.

4.2 Suggestion

In order to get better results, it is recommended to use a special paving block printing machine so as to get a better density value. In the research that has been carried out using a manual paving block printer, it takes longer time than using a machine so that it produces results that differ in density quality. From the results of the study it is recommended to use palm shell waste ash with a mixture of 50% and a treatment age of 28 days because the water absorption capacity obtained is low and the resulting compressive strength is high.

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