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Utilization of Plastic Waste as a Substitutional Material for Paving Block Manufacturing

Yance Kakerissa[1], Reinyelda D. Latuheru[2]

[1,2]Musamus University Merauke, Indonesia

ABSTRACT: Besides reducing environmental pollution, the use of garbage or plastic waste can also be used as an alternative to building materials. The potential for utilizing plastic waste still needs to be developed, by conducting research on plastic waste to be substituted into paving block making materials, by replacing some of the sand material in normal paving blocks. The research used is an experimental method. In this test the test object was made by adding additives/mixture of plastic waste as a filler/mixture in the paving block mix with a percentage of plastic mixture of 2.56%, 5.26%, 8.11%, 10.11%. Then the paving block is tested for compressive strength at the age of 28 days which is possible to have reached the maximum compressive strength value. The results of the paving block compressive strength test will increase according to the increase in the percentage of plastic mixture. The compressive strength of paving blocks with a plastic mixture of 0%, 2.56%, 5.26%, 8.11% and 10.11% obtained compressive strengths of 10.44 MPa, 10.64 MPa, 10.95 respectively MPa, 11.15 MPa and 11.33 MPa. The increase in compressive strength of normal paving blocks (0% mixture of plastic waste) was 1.83%, 4.6%, 6.35% and 7.86%. The highest compressive strength occurs in paving blocks with a mixture percentage of 10.11% plastic waste, according to the SNI-03-0691-1996 standard the compressive strength is included in the quality level D which can be used for parks and other uses.

KEYWORDS: Paving blocks; plastic waste

A. INTRODUCTION

Paving block is a building material that is used as a road surface pavement, both roads for courtyard purposes, vehicle parking, highways, or for decorative purposes in making parks. Making paving blocks using water and aggregate with or without other additives that do not reduce the quality of the paving blocks. Paving block is a building material which is also known as concrete brick.

The factory industry in this modern era tends to produce its own products with plastic packaging to be marketed to the public. Plastic is considered the most effective material for packaging food and other products. The human need for plastic results in a lot of waste from products that use plastic packaging, plastic waste actually becomes a disaster that is not easy to deal with, it should need to be managed properly. Utilization of garbage or plastic waste besides being able to reduce environmental pollution can also be used as an alternative to building materials. The potential for the use of plastic waste which still needs to be developed, by conducting research on plastic waste to be substituted into paving blocks, by replacing some of the functions of sand in normal paving blocks, the plastic waste is first melted to form plates and then smoothed to resemble the physical form of sand. so that later the plastic waste can be substituted to replace some of the sand in the making of the paving block. The purpose of this study was to determine the effect of the compressive strength of paving blocks by mixing plastic waste of 2.56%, 5.26%, 8.11% and 10.11%.

B. RESEARCH METHODOLOGY

The research method used is the experimental method. This test is intended to test a treatment of an object of research. In this test, the test object was made by adding added ingredients/mixture of plastic waste as a filler/mixture in the paving block mix. Then the paving block is tested for compressive strength at the age of 28 days which is possible to have reached the maximum compressive strength value.

1. Research material

The materials used in the manufacture of paving block specimens are:

a. Sand (fine aggregate)
b. The cement used was Gresik PPC cement in 50 kg packaging
c. Clean water
d. Plastic waste uses HDPE (High Densty Polyethylene) plastic types

2. Research process

The research process used is the experimental method. This study was intended to examine the influence of the mix composition factor. In this study, the test specimens were made by adding plastic additives by reducing the amount of

sand as a filler/mixture in the paving block mix, then the paving block was tested for its compressive strength at 28 days of age which made it possible for the bricks to have reached the maximum compressive strength value, this research was carried out with the following steps: steps as follows:

a. Preparation of tools and materials
b. Inspection and testing of basic materials
c. Mix design and material requirements
d. Manufacture of test objects
e. Material weighing
f. The process of mixing and printing the test object

This process is carried out in an orderly manner with pre-laying where the paving block mixture is first placed with a plastic mixture that has been shaped as paving blocks into the paving block mold according to the variation in the thickness

a. The stage of mixing the mix and molding the inside
b. The stage of mixing the mortar and printing the outer layer
c. Treatment stage of the test object

Treatment of the test object can be done by placing the test object in a damp room in the laboratory.

3. Population and sample

The population is all test objects related to research conducted at the Civil Engineering Laboratory, Musamus University, Merauke.

The samples tested were 25 paving blocks made with a mixture of plastic waste at 28 days old. The sample by comparison :

a. 1 Pc : 5 Ps : 0% plastic waste
b. 1 Pc : 4.875 Ps : 2.56% plastic waste
c. 1 Pc : 4.75 Ps : 5.26% plastic waste
d. 1 Pc : 4.625 Ps : 8.11% plastic waste
e. 1 Pc : 4.5 Ps : 10.11% plastic waste

4. Types and sources of data

In this study, two sources of data were used, including:

a. Data source

The data source in this study was the results of the compressive strength test on a number of specimens in the form of plastic paving blocks aged 28 days.

b. Techniques for obtaining data

To obtain data regarding compressive strength, a compressive strength test was carried out. The object is paving blocks with plastic waste added with a mixture of 5 sand, 1 cement. The stages of this research are planned to carry out several stages of work which are described as follows:

- Phase I, preparing equipment and materials which includes checking the availability of equipment, providing paving block printing equipment, including conducting material testing.
- Phase II, the stage of making paving block mixes with variations, continued with the production of paving block mixes, carried out by testing the added ingredients of plastic waste.
- Phase III, curing of the paving block specimens by letting them dry openly indoors for 28 days.
- Phase IV, analysis of the results obtained from the compressive strength of paving blocks with added plastic waste to determine the values needed to make conclusions about the formulation of the problem presented.
- Stage V, drawing conclusions from the results of research data analysis.

5. Analysis Techniques

For paving block thickness requirements use SNI-03-0691-1996.

In fine aggregate testing using the following formula:

a. Fine aggregate moisture content testing

$$\text{Water content} = \frac{Wa-W1}{Wa} \times 100 \rightarrow (\%)$$

With :

Wa = Natural sample weight
W1 = Weight of sample at constant weight

b. Testing of fine aggregate silt content

$$\text{Sludge levels} = \frac{W1-W2}{W1} \times 100 \rightarrow (\%)$$

With :

W1 = Fixed weight sample weight → (grams)
W2 = Weight of dry sand after washing → (grams)

c. SSD absorption test and specific gravity of fine aggregate

$$\text{water absorption} = \frac{Bj-Bk}{Bj} \times 100$$

With :

Bj = SSD sample weight
Bk = SSD dry sample weight

$$\text{SSD specific gravity} = \frac{Bj-Bk}{(Bj+Bp)-(Bj)} \text{ gr/cm}^3$$

With :

Bj = SSD sample weight
Bp = Weight of measuring cup + water

C. RESULTS AND DISCUSSION

a Material quality and requirements

1. Material quality

Fine aggregate

In this study, fine aggregate was tested in several tests which included testing for moisture content, silt content, SSD absorption, specific gravity, and fine aggregate gradation testing. The test results are made in table 1 as follows:

Table 1. Fine Aggregate Test Results

No.	Test Type	Test Result
1.	Natural Fine Aggregate Moisture Content	1,523 %
2.	SSD Fine Aggregate Water Absorption	3,644 %
3.	SSD Fine Aggregate Specific Gravity	2,598 gr/ml
4.	Fine Aggregate Sludge Content	4,399 %
5.	Fine Aggregate Gradation	Zona 1

The results of the fine aggregate gradation test produce images in the form of graphical curves and the gradation limits required by SK.SNIT-15-1990-03 as follows:

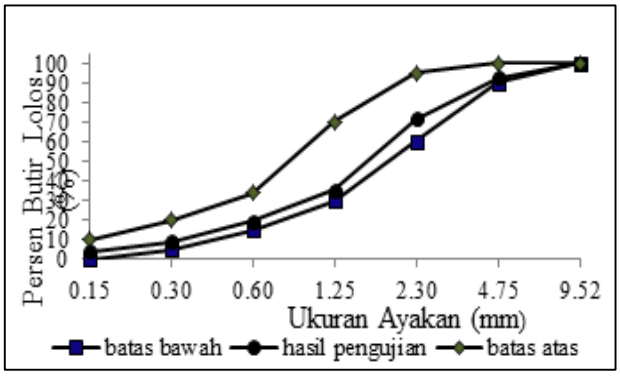

Figure 1. Fine aggregate (sand) gradation curve

From Figure 1 above it shows that fine aggregate (sand) is included in zone 1 (coarse sand).

- **Plastic waste**

In this test, plastic waste was used as a partial replacement for sand. Testing plastic waste in this study is testing the gradation of plastic waste, while to determine the specific gravity of plastic taken from similar test data, the test results can be seen in the following table:

Table 2. Plastic Waste Testing Results

No.	Test Type	Test Result
1.	Gradation of Plastic Waste	Zona 1
2.	Specific Gravity of Plastic Waste	0,91 gr/ml

From the results of the fine aggregate gradation test it produces images in the form of graphical curves and as well as gradation limits as shown in graph 2 below:

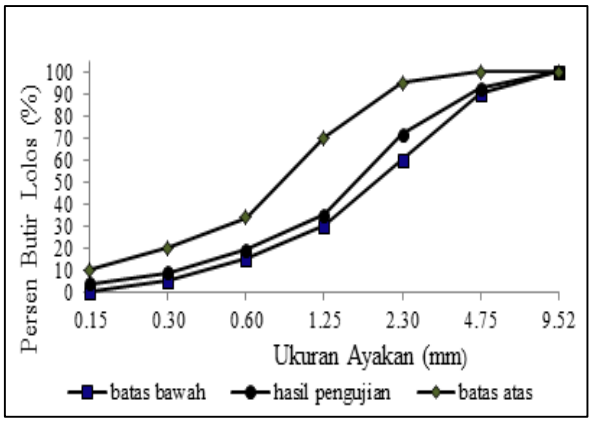

Figure 2. Plastic Waste Gradation Graphic Curve

b. The need for paving block materials

The process of making the test object begins by calculating the required weight of the materials needed, namely: portland cement, sand, plastic waste and water requirements. To calculate the need for each material, an examination of the specific gravity (BJ) of each material is first carried out. The

following is the specific gravity of each material after being examined in the laboratory.
Specific gravity of cement = 3.02 gr/ml
Specific gravity of sand = 2.598 gr/ml
Plastic specific gravity = 0.91 gr/ml
The material requirement for 1 (one) paving block is obtained by the following calculation:
Volume : 6 x 10 x 20 = 1200 cm^3
For the proportion of mixing paving blocks without the addition of plastic waste:
Cement volume = 1/6 x 1200 = 200 cm^3
Sand volume = 5/6 x 1200 = 1000 cm^3
Weight = volume x specific gravity
Cement weight = 200 x 3.02 = 604 gr
Weight of sand = 1000 x 2.598
= 2589 gr
The results of calculating material requirements for each material weight ratio are presented in table 3.

Table 3. Results of the Comparison of the Proportion to the Weight of the Test Material

Mixed Proportions	Material Weight Per Test Object (gr)		
	Cement	Sand	Plastic
1 PC : 5 Ps : 0 % PL	604	2589	0
1 Pc : 4,875 Ps : 2,56 % PL	604	2533	22,75
1 Pc : 4,75 Ps : 5,26 % L	604	2468	45,5
1Pc : 4,625Ps : 8,11 % PL	604	2403	68,25
1Pc : 4,5Ps : 10,11% PL	604	2338	91

b. Unit weight check
The following is the result of checking the average weight of paving blocks with various compositions of plastic waste mixtures and the size of the planned paving blocks measuring 10 cm x 20 cm x 6 cm has the following weight:
Paving blocks with a mixture of 1Pc : 5Ps : 0% PL have an average weight of 2421.3 g, and a volume weight of 1.99 g/cm^3
Paving block with a mixture of 1Pc : 4.875Ps : 2.56% PL has an average weight of 2410.8 g, and a volume weight of 1.8 g/cm^3
Paving blocks with a mixture of 1Pc : 4.75Ps : 5.26% PL have an average weight of 2597.4 g, and a volume weight of 2.16 g/cm^3
Paving blocks with a mixture of 1Pc : 4.625Ps : 8.11% PL have an average weight of 2301.3 g, and a volume weight of 1.9 g/cm^3
Paving blocks with a mixture of 1Pc : 4.5Ps : 10.11% PL have an average weight of 2405.5 g, and a volume weight of 2 g/cm^3

b. Compressive strength testing
The compressive strength of paving blocks will increase with increasing age of the paving blocks. Therefore, as a standard for the strength of paving blocks, paving blocks are set at the age of 28 days to be tested for compressive strength. The compressive strength is calculated based on the amount of load per unit area, where loading is carried out until the test object is destroyed when loaded with the maximum load produced by a hydraulic press.

From the compressive strength test data, a graph is obtained that illustrates the comparison of the compressive strength of paving blocks from the results of testing the replacement of fine aggregate volume with plastic waste on 28 days old which can be seen in the following 3 graphs:

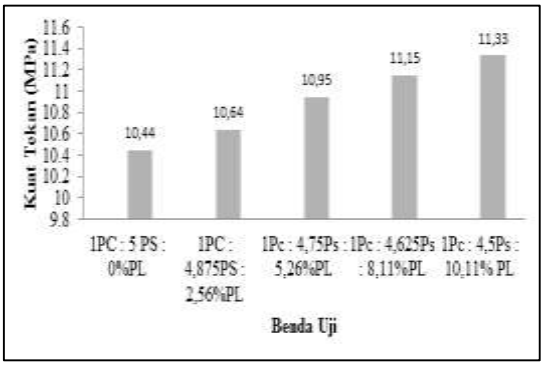

Figure 3. Graph of average compressive strength comparison

The graph above explains that the compressive strength of paving blocks will increase with increasing plastic content in the proportion of the mixture. The highest compressive strength occurred in paving blocks with a mixture of 10.11% plastic waste, a compressive strength value of 11.33 MPa.

Figure 3 shows a comparison of the compressive strength of paving blocks with the percentage of mixed plastic waste 0%, 2.56%, 5.26%, 8.11% and 10.11% at 28 days old. Based on SNI-03-0691-1996 Concrete Bricks (Paving Blocks) are detailed in table 4. Comparison of the average compressive strength with the following paving block quality requirements:

Table 4.Comparison of Average Compressive Strength with Quality Requirements

Mixed Composition	Average Compressive Strength (MPa)	Quality Level
1 PC : 5 Ps : 0 % PL	10,44	D
1 Pc : 4,875 Ps : 2,56 % PL	10,64	D
1 Pc : 4,75 Ps : 5,26 % L	10,95	D
1Pc : 4,625Ps : 8,11 % PL	11,15	D
1Pc : 4,5Ps : 10,11% PL	11,33	D

If classified according to SNI-03-0691-1996 paving blocks with a mixture proportion of 1Pc : 5Ps : 0%PL with a compressive strength of 10.44 MPa are included in the quality level D, a mixture of 1Pc : 4.875Ps : 2.56%PL with a compressive strength of 10 .64 MPa is included in quality level D, 1Pc mixture : 4.75Ps : 5.26%PL with a compressive strength of 10.95 MPa is included in quality level D, 1Pc mixture : 4.625Ps : 8.11%PL with a compressive strength of 11, 15 MPa is included in quality level D, a mixture of 1 Pc : 4.5Ps : 10.11% PL with a compressive strength of 11.33 MPa is included in quality level D. Concrete brick with quality level D can be used for gardens.

D. CONCLUSION

From the results of testing the compressive strength of paving blocks with a mixture of plastic waste 0%, 2.56%, 5.25%, 8.11%, and 10.11%, the compressive strength was obtained respectively 10.44 MPa, 10.64 MPa , 10.95 MPa, 11.15 MPa, and 11.33 MPa. Based on the test results, it can be concluded that there is an influence of the compressive strength of paving blocks according to the increase in the percentage of plastic mixture. Increasing the compressive strength of normal paving blocks (0% mixture of plastic waste) to paving blocks mixed with plastic waste of 2.56%, 5.26%, 8.11% and 10.11% obtained an increase of 1.83% respectively, 4.6%, 6.35% and 7.86%. The highest compressive strength occurs in paving blocks with a mixture percentage of 10.11% plastic waste, according to the SNI-03-0691-1996 standard the compressive strength is included in the quality level D which can be used for parks and other uses.

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