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The Effect of Compressive Strength Paving Blocks Utilizing Polypropylene Plastic Waste

Vanessa Regina Vetryx[1]*, Andi Marini Indriani[2], Gunaedy Utomo[3]
[1,2,3] Civil Engineering, Civil Engineering and Planning, Universitas Balikpapan, Indonesia
*Corresponding author, e-mail: vanessareginavetryx@gmail.com

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ABSTRACT

Waste is a big problem for every country in the world, including cities. Currently, the city of Balikpapan is experiencing rapid economic and population growth, of course the growth also brings challenge in waste management, especially plastic waste. The type of plastic waste than we often encounter especially in coffe shops is Polypropylene (PP). In this research, pp type plastic waste is recycled as a substitute for cement in paving blocks with a composition of 30%, 40%, 50% to sand. The test conducted on this research is compressive strength. The purpose of this research is to determine the effect of PP plastic melt mixture on paving block mortar on increasing compressive strength. From the research results obtained the maximum compressive strength value for the composition of 50% Polypropylene : 50% sand with a compressive strength value of 11,83 Mpa. Similiarly, with the composotion of 40% Polypropylene : 40% sand, this value of is included in the quality D which can be used for parks according to SNI 03-0691-1996. While the 30% composition is not included in the quality.

Keywords: *Polypropylene; Paving Block; Waste; Compressive Strength.*

INTRODUCTION

The problem of waste, especially plastic waste, has become a major problem for all countries in the world, even cities. Balikpapan City is experiencing economic growth and the number of population. However, this growth also poses challenges and waste management, which leads to environmental, public health, and tourism sector decline. Waste volume is increasing every day due to the increasing population and tourism activities while adequate waste management infrastructure and technology is still not available. The total daily waste production in Balikpapan City reaches 514.73 tons [1]. One of one type of waste that causes environmental pollution, due to its very large and increasing amount, is waste which is very large and continues to increase, is plastic waste. The big impact of this abundant amount of waste occurs because the waste is not managed properly [2]. The use of plastic waste as a concrete mixture is one of the efforts to overcome the problem of plastic waste that has not yet been solved [3]. Overcome the accumulation of plastic waste, one way is to recycle the waste is to recycle the waste into usable products, such as products that can be used, such as paving blocks [4].

Currently, many consumers prefer paving block than other types of pavement such as concrete or asphalt [5]. Concrete brick (paving block) is a building material made from a mixture of Portland cement or similar hydraulic adhesives, water, and aggregate, and possibly other

additives that do not affect the quality of the concrete. that do not affect the quality of the concrete. Based on their physical properties, paving block is divided into several grades. Quality A with min 35 compressive strength, Quality B with min 17 compressive strength, Quality C with min 12.5 compressive strength and Quality D with min 8.5 compressive strength (National Standardization Agency, 1996). min 8.5 [6]. Similar to concrete, paving blocks have a fairly high compressive strength, but are less resistant to tensile forces. high compressive strength, but less resistant to tensile and shear forces [7].

The Society of Plastic Industry (SPI) in 1988 classified plastics into seven types and gave codes for each type based on the material and its uses. This code is usually located at the bottom of the of the package in the shape of a triangle, along with a number and the type of plastic. The types of of plastic are: 1. PET/PETE (Polyethylene Terephthalate); 2. HDPE (High-density Polyethylene); 3. PVC (Polyvinyl Chloride); 4. LDPE (Low-density Polyethylene); 5. PP (Polypropylene or Polyethylene); 6. PS (Polystyrene); 7. Other (O) [8].

The use of plastics in everyday life has become However, the side effect is plastic waste that is difficult to decompose by soil. Utilizing recycled plastic bottles in construction materials such as concrete not only reduces the accumulation of plastic waste that is difficult to decompose, but also adds value by utilizing existing resources [9]. The increase in plastic consumption is largely due to the growth of the food and beverage industry, which uses plastic to package its products. This use of plastic certainly increases the amount of plastic produced [10].

PP plastic is one type of plastic that is often used to package dry snacks. Most cafes use Polypropylene (PP) plastic. In cafe activities, there are two types of PP plastic that are commonly used, namely clear cups and clear screen printing cups [11]. Polypropylene (PP) material is widely used by people for various needs. This plastic is known for its flexible and non-toxic nature, making it very safe to use in packaging food and consumer products [12].

Research on the utilization of plastic waste as a mixture in the manufacture of paving blocks has been carried out many times before, including the use of polypropylene plastic waste as a mixture in the manufacture of concrete bricks (paving blocks) showing that the composition of 40% PP plastic and 60% sand produces the highest average compressive strength of 12.85 MPa, which is included in quality C and can be used for pedestrians [13].

The purpose of this study is to determine how the effect of PP plastic mixture as the basis for making paving blocks in terms of compressive strength and to determine whether paving blocks with pp plastic mixture enter the quality standard according to SNI 03-0691-1996.

METHOD

This research will discuss about making paving block using PP plastic waste is experimental method, which is conducted at Construction Material Laboratory of Civil Engineering of Balikpapan University. This research is conducted in stages to facilitate the research. The following are the stages in this research.

The data for this research was collected through lab tests and by reviewing relevant journals and scientific articles. This approach helps to develop the issue and incorporate various perspectives and factors that influence the research. The test data needed for this study is shown

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in Table 1.

Tabel 1. Implementation of Testing

No	Types of Testing	Test Methods
1.	Fine Aggregate Sieve Analysis	SNI 03-1968-1990
2.	Specific gravity and absorption of fine aggregate water	SNI 1970:2008
3.	Fine aggregate moisture content	SNI 1971:2011
4.	Standard Compaction Test	SNI 1742:2008
5.	Compressive Strength Paving Block	SNI 03-0691-1996

Material

The equipment used in the research "The Effect of Compressive Strength Of Paving Blocks Utilizing Polypropylene Plastic Waste" are paving block molds, scales, pans. The materials used consist of two materials, namely fine aggregate/sand from Samboja, Kutai Kartanegara Regency, East Kalimantan Province and Polypropylene (PP) plastic from used coffee shop cups in Balikpapan City area.

Polypropylene Plastic

PP plastic in this study uses used beverage cups that will be melted. Making paving blocks using a mixture of polypropylene plastic waste acts as a binder for fine aggregates without any cement mix. PP plastic that has been melted as a material mixture with percentage variations of 30%; 40%; and 50%. The cups are obtained from coffeshops in the Balikpapan area.

Figure 1. Polypropylene Plastic

The total number of test samples for compressive strength of the paving blocks is shown in Table 1.

Table 2: Sample

No	Variation of PP Plastic (%)	Sample
1	30%	3
2	40%	3
3	50%	3
Total Number of Test Specimens		**9**

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Preparation of The Mixture

In this study, 9 specimens were used with variations of 30:70, 40:60, and 50:50 PP plastic mixtures. Each variation consisted of 3 specimens. The shape of the mold is a diamond with a size of 15 cm x 15 cm x 8 cm. The process of making this test specimen involves several stages as follows. The sample making stage is carried out by following the planned composition variations. The first step is to cut the plastic that has been cleaned so that the melting process is more efficient. The plastic we use is an ex-beverage cup that has been obtained from a coffee shop. Next, the plastic was melted by burning it in a pan on the stove for about 10 - 20 minutes to a temperature of 240 or until it was completely melted.

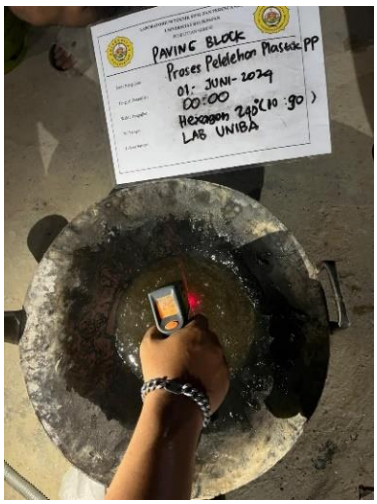

Figure 2. Plastic Melting Process

The mixing process between melted plastic and sand is carried out according to the pre-planned composition. Sand is poured into the melted plastic and stirred until evenly mixed. Before putting the mixture into the mold, the mold is preheated on the stove to prevent the mixture from drying too quickly when compacted. Next, molding the mixture with a paving block molding tool.

Figure 3. Dough Mixing Process

Before putting the dough into the mold, apply oil to the mold to prevent the dough from sticking. Make sure the mold is clean to avoid mixing with other substances. After the mold is filled with dough, do the compaction manually by pressing the mold using a lid and hitting it with a hammer. After that, let the paving blocks that are still in the mold cool down, then carefully remove them from the mold.

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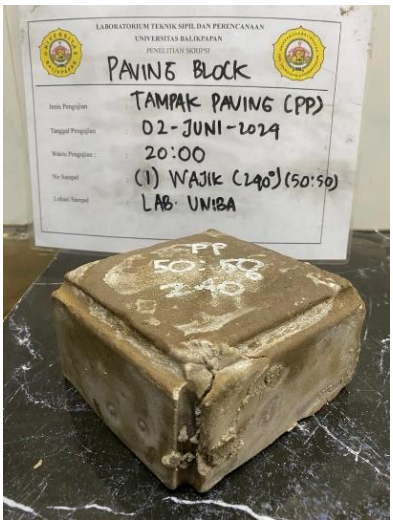

Figure 4. Product

The composition in this study is divided into several variations, as shown in Table 3.

Table 3. Composition Variations

No	Variation Code	Composition	PP Plastic (g)	Sand (g)	Total
1	W1	30:70	383	1978	3
2	W2	40:60	511	1695	3
3	W3	50:50	639	1413	3
	Total		**1.919**	**9.890**	**9**

To determine the weight required to make one paving block, the trial and error method was used for a composition of 100% PP plastic waste. Based on the trial and error results, the dry weight of PP plastic waste required to make one paving block measuring 15 cm x 15 cm x 8 cm is about 1.278 gr/cm3.

RESULTS AND DISCUSSION

Compressive Strength Test

The test was conducted at Construction Materials Laboratory, Faculty of Civil Engineering and Planning, Universitas Balikpapan. Testing of test specimens in the laboratory refers to SNI 03-0691-1996. Tests were conducted to measure the compressive strength of paving blocks using an Analogue Compression Machine with a capacity of 1,200 kN, operated in a horizontal (flat) position.

The compressive strength testing procedure was carried out with the following steps: Take the test specimens from the treatment area and make sure the surface is saturated surface dry. Next, measure the weight and size of the specimen, then place the specimen on the concrete press tester. Turn on the compression tester and continue until the specimen shows signs of damage or rupture. After that, record the manometer reading when the concrete starts to break to determine the maximum value of the compressive strength of each specimen.

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Figure 5. Compression Machine Analogue

According to SNI 03-0691-1996 the formula used for testing compressive strength is as follows.

$$f_c' = \frac{P}{A} \quad (1)$$

Description:
fc' = Compressive Strength (MPa)
P = Press Load (N)
A = Test Piece Area (mm2)

Fine Aggregate Testing Results can be seen in Table 4.

Table 4. Fine Aggregate Testing

No	Testing Type	Result
1	Sieve Analysis	Zone IV
2	Specific Gravity	2,5
3	Water Absorption	0,9
4	Water Vapor	2,44
5	Standard Compaction Test	1,682

The compressive strength test is carried out in accordance with the SNI 03-0691-1996 method. Testing the compressive strength of paving blocks is carried out with the aim of seeing the durability of paving blocks against the compressive strength given. Based on the data obtained as shown in Table 5.

Table 5. Compressive Strength of Paving Blocks

No	Mixed Variations PP : Sand	Average Compressive Strength (MPa)	Quality
1	30 : 70 (W1)	7,70	-
2	40 : 60 (W2)	9,37	D
3	50 : 50 (W3)	11,83	D

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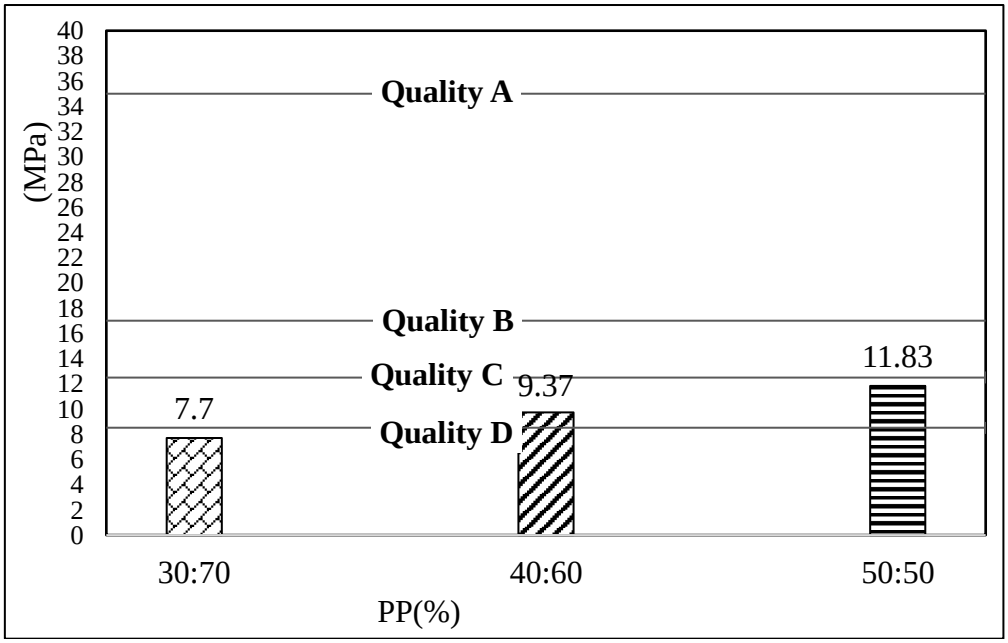

Figure 6: Graph Of Age Relationship of Paving PP Plastic Mixture With Compressive Test of Press

From Table 5 and Figure 6 above, it can be seen that the quality of paving blocks made from PP plastic is in accordance with the SNI 03-0691-1996 standard, namely at quality D, and can be used for parks. In the 30:70 mixture composition, the lowest compressive strength value is 7.70 MPa, not included in the quality.

In the W1 variation, the resulting compressive strength did not meet the quality classification because the bond between the components did not function properly. As a result, there are many voids or empty gaps that make the paving block less dense when tested [14]. While 40:60, the average compressive strength increases to 9.73 MPa which is included in quality D. Paving blocks with a 50:50% mix composition show the highest compressive strength value, also included in quality D and suitable for use in garden areas.

One way to increase the compressive strength of concrete is to make the concrete extra dense through the use of good aggregate gradation. If the aggregate has a finer and more varied grain size, the pore volume in the concrete will be reduced. In other words, the variation in aggregate size can fill the empty spaces, resulting in denser paving blocks. In conclusion, the use of aggregates of varying sizes can fill the empty spaces with each other, making the paving blocks denser [15].
After conducting the overall compressive strength test, the next thing to do is to compare the compressive strength of the paving block for each composition The results of the comparison of the compressive strength of the PP paving block composition 30: 70 and 40: 60 composition is shown in Figure 7.

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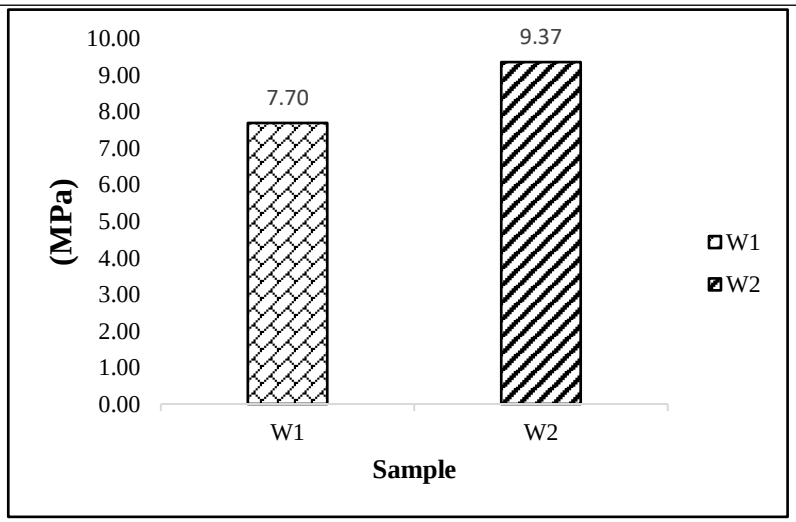

Figure 7. Relation Between W1 and W2 Variation with Compresssive Test

The results of the W1 and W2 compressive strength tests showed that the addition of 40% composition increased by 40% with a compressive strength value of 9.37 Mpa. According to [16]. increasing the compressive strength of concrete can be done by making extra dense concrete using well-graded aggregates. When the aggregate has a finer grain size and shows size variation, the pore volume of the concrete is reduced. In addition, the use of plastic as an aggregate provides exceptional resistance to impact and ambient temperatures as well as being lightweight and durable making it an excellent choice for additional aggregate in the production of paving blocks. Comparative results of compressive strength of PP paving blocks of 40: 60 and 50: 50 is shown in Figure 8.

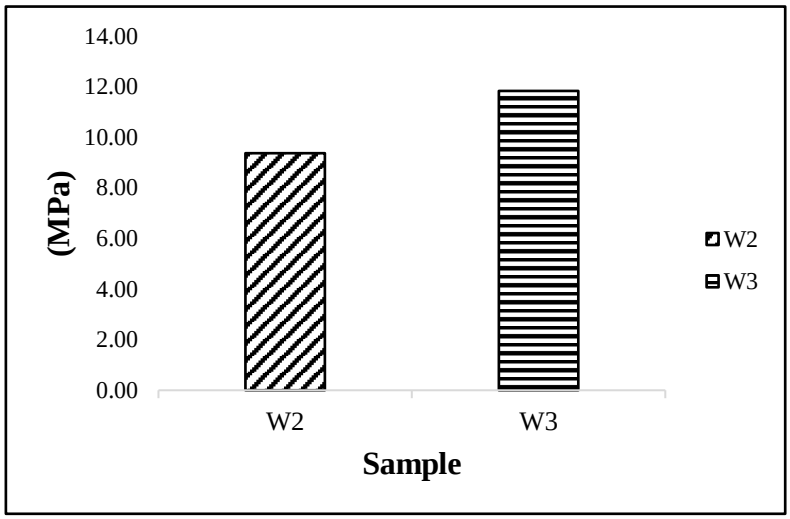

Figure 8: Relation Between W2 and W3 Variation with Compresssive Test

The compressive strength test results of W2 and W3 showed that the addition of 50% plastic composition increased by 20.79% with a compressive strength value of 11.82 Mpa. This shows that PP (Polypropylene) plastic has a superior compressive strength in resisting pressure when compared to PET (Polyethylene terephtalate) and PS (Polystyrene) plastics. With more elastic and flexible properties, pp plastic is able to withstand loads more effectively. These characteristics make it the right choice for paving blocks that require high pressure resistance. In addition, PP plastic is known for its resistance to extreme weather conditions and exposure

to harsh environments such as UV rays, humidity, and temperature fluctuations. Research by Dr. Donal R. Paul, a Professor in chemistry and chemical engineering at the University Of Texas revealed that PP plastic offers good rigidity, thus providing structural strength in various applications [17].

CONCLUSION

Through research on the compressive strength of paving blocks with the use of PP plastic in the manufacture of paving blocks, it can be concluded that the average value of the compressive strength of paving blocks using polypropylene (PP) plastic waste melt for each percentage composition is as follows: at 30% composition of 7.7 Mpa which means it does not meet the quality classification, at 40% composition of 9.83 Mpa with quality D, while the highest average compressive strength value is found in the mixture at 50% composition of 11.83 MPa also with quality D used for parks. This research still requires further studies to use different compositions and perform paving block treatments. As well as evaluating how the heating temperature affects the average compressive strength value of paving blocks from PP plastic waste.

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