Influence Plastic Polyethylene Terephthalate as Strong Adhesive Press Paving Block

Rosalin Delia Anggraeni [1*], Gunaedy Utomo [1], Andi Marini Indriani [1]

[1] *Department of Civil Engineering, Faculty of Civil Engineering and Planning, Balikpapan University, Balikpapan 76114, Indonesia*

**Corresponding author: rosalindelia11@gmail.com*

ABSTRACT

As the population growth and human needs rise, the amount of plastic product waste was increase. *Polyethylene Terephthalate* (PET) plastic waste is difficult to naturally decomposed, but it can be recycled by using it as a mixture for paving blocks. Paving blocks, commonly utilized in urban infrastructure, present an opportunity for incorporating recycled materials, addressing environmental concerns while maintaining structural integrity. Therefore, this study aims to assess the effectiveness of PET as adhesive and partial replacement for cement in paving block mixtures. Compressive strength was conducted according to SNI 03-0691-1996 standards on paving block containing PET plastic. The experimental test was conducted at the Civil Engineering laboratory of Balikpapan University. The test was carried out using three different mixture compositions, including 30% PET : 70% sand, 40% PET : 60% sand, and 50% PET : 50% sand. The compressive test result showed that mixture of 30% PET: 70% sand produced the highest average compressive strength of 15.87 MPa, which meets the C quality standard and is suitable for pedestrian use. Meanwhile, a mixture of 50% PET: 50% sand produced an average compressive strength of 10.0 MPa, which meets the D quality and is suitable for parks and other uses.

Keywords : Paving Block , Compressive Strength, PET

1. INTRODUCTION

Plastic waste is a type of waste that is very difficult to decompose and often causes environmental pollution. This plastic is lightweight and its shape is not easily changed. Polyethylene, which is a type of plastic, is produced through a polymerization process, where ethylene gas molecules combine to form long chains that eventually become plastic (polymers). In [1]a study conducted in several schools, the Bali Environmental Education Center (PPLH) stated that plastic bottles and plastic cups made from *Polyethylene Terephthalate* (PET) is the largest contributor to plastic waste, which is 26% [2]. Plastic use increases from year to year. so that the plastic waste produced also increases. Other materials have also been used in previous research using 30% fly ash (FA) as a substitute cement with demonstration variations of blood cockle shells (CK) as a substitute for coarse gradations in making porous paving blocks include conventional porous paving blocks [3]

This type of plastic waste ranks second with a total of 5.4 million tons per year. Indonesia also ranks second globally as one of the main contributors of plastic waste to the sea, with a total of 187.2 million tons, second only to China, according to Indonesian domestic waste statistics [4]. The use of waste materials as additives in concrete mixtures is increasingly receiving attention in recent research. One type of waste that is widely studied is PET plastic bottles (*Polyethylene Terephthalate*) [5].

PET is a type of thermoplastic polymer resin that is included in the polyester category. Usually, PET is used in the manufacture of various transparent and translucent plastic bottles, such as bottles for mineral water, juice, cooking oil, soy sauce, chili sauce, and various other types of beverage bottles. It is recommended to use PET for single use only, because repeated use , especially at high temperatures, can increase the risk of cancer [6]. This plastic begins to soften at 180°C and completely melts at 260°C. PET is not ideal for storing warm or hot water and should only be used once. Its use is not recommended for storing food at temperatures below 60°C. [7]. In other research PET modified of asphalt the Penetration Index value tends to fluctuate, this instability is caused by the nature of PET plastic [8].

The results of the explanation above encouraged researchers to conduct research by adding 30%, 40% and 50% plastic and using plastic as a substitute for cement, so that the compressive strength characteristics of *paving can be known. block* using plastic waste combined with samboja sand to utilize local materials from East Kalimantan. This involves reprocessing plastic waste to be used as the main ingredient in making paving block. In this context, the aim of the study was to investigate the possibility of using PET plastic waste as a component in paving block mixing, as an environmentally friendly option with optimal performance. By delving

deeper into this topic, the hope is to find innovative solutions that not only reduce the negative impacts of PET plastic waste, but also increase sustainability and efficiency in the construction industry.

2. RESEARCH METHODS

This research utilizes experimental method, and conducted at the Construction Materials Laboratory of Balikpapan University. This experimental method aims to obtain the influence of certain sample variations on other variables in order to obtain reasonable results. The object of this study is to conduct research on paving block with n *Polyethylene Terephtalate* (PET) plastic as an adhesive with a percentage of 30%, 40%, and 50% having the aim is to determine the compressive load maximum on paving block.

2.1 Data Collection Techniques

This study applied experimental test to obtain primary data. Primary data was obtained from the results of several tests conducted as presented in Table 1.

Table 1Type of Test

No.	Type Testing	Testing Methods
1.	Sieve analysis aggregate fine	SNI ASTM C136-2012
2.	Specific gravity and water absorption of fine aggregate	SNI 03-1970-1990
3.	Water content of fine aggregate	SNI 1971-2011
4.	Compaction test standard	SNI 1742:2008
5.	Compression strength test of paving block	SNI 03-0691-1996

2.2 Proportions Paving Block Mix

Compressive strength test was carried out on paving test specimens. diamond-shaped block with dimensions of 15 cm x 15 cm x 8 cm. There are three variations of the mixture composition tested, namely 30% PET: 70% sand, 40% PET: 60% sand, and 50% PET: 50% sand. For each variation of the mixture, three test objects were taken, so that the total number of test objects used was nine. Details of the number of specimens and materials used in the study can be seen in Table 2.

Table 2Number of Test Objects and Material Requirements for Paving Blocks

Form	Variation (%)	Number of Sample	Plastic weight (grams)	Aggregate weight (grams)
Diamond	30 : 70	3	524	1978
	40 : 60	3	699	1695
	50 : 50	3	874	1413
Total Test Objects		**9**	**2,097**	**5,086**

2.3 Research Stages

This research was conducted through several structured stages to ensure smooth and effective implementation. The stages of the research were designed to facilitate each step in the research process. The stages are as follows: First, the preparation stage of tools and materials, where all equipment and materials needed for the research are prepared and checked to ensure that everything is ready to use. Next, a material inspection is carried out to ensure the quality and suitability of the materials to be used in the research. After that, the planning of the test object mixture is carried out, which involves the formulation of the material mixture that will be used to make the specimen. The next stage is the molding of the test object, where the planned specimen is molded according to the specified specifications. Then, the test object treatment stage is carried out to ensure that the specimen is properly treated to achieve the desired strength and characteristics. After the specimen is treated, the test object testing stage is carried out to measure and evaluate the performance of the specimen based on the specified parameters. The data obtained from the test is then analyzed and discussed in the data analysis and discussion stage, which aims to understand the results and their implications. Finally, the research ends with the preparation of conclusions and suggestions, which are based on the findings of the analysis and discussion.In this study there are two variables, namely free variables and dependent variables. The independent variable in this study is the PET (Polyethylene Terephthalate) plastic bottle. The PET plastic used comes from used mineral water bottles which are collected, cleaned, and chopped into smaller sizes to melt faster. In this study, the planning of concrete mixtures using the SK SNI 2384-2000 method and in the planning of concrete mixtures with the treatment of test objects for 7, 14, 21, and 28 days.

3. RESEARCH RESULTS AND DISCUSSION

Before conducting compressive strength testing on paving test objects block. first testing is carried out on the materials used to assemble the paving block. This material testing was conducted at the Civil Engineering and Planning Laboratory of Balikpapan

University which aims to determine the physical properties or characteristics of fine aggregate. Paving material components block is sand and *Polyethylene plastic Terepthalate* (PET). In sand testing refers to testing fine aggregates of concrete materials, while in plastic testing only bulk density testing is carried out for other plastic characteristics using secondary data from PET plastic materials. The results of the laboratory testing results that have been carried out are as follows:

3.1 Sieve Analysis Inspection Data Aggregate Fine

The sieve analysis test on Samboja sand applies the SNI ASTM C136-2012 standard to obtain the gradation limit of fine aggregate grains and to find out whether the aggregate used meets the specified specification zone. The results of this test can be seen in Figure 1.

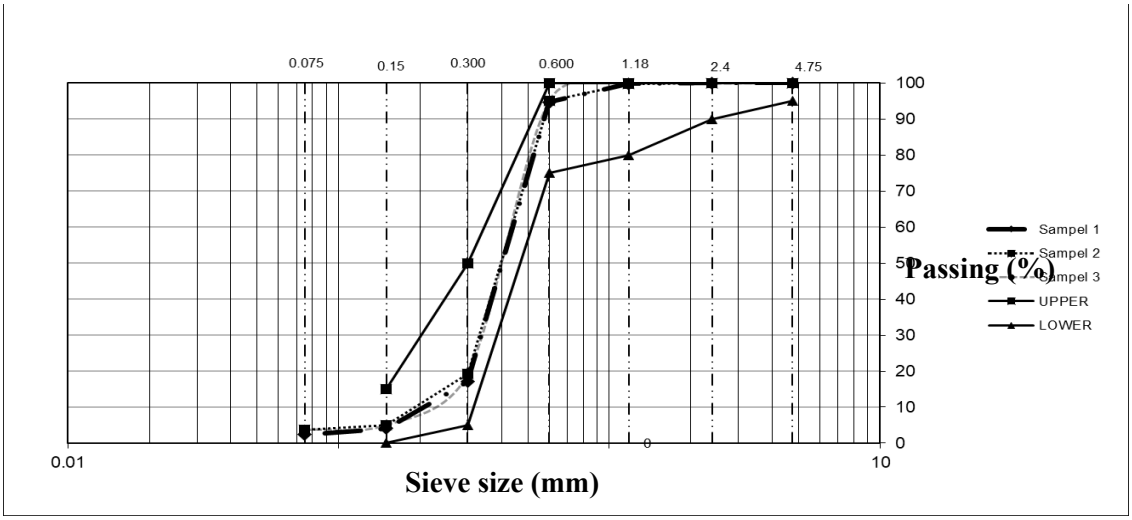

Figure 1*Graph of the Relationship Between Grain Size and Percentage of Passing the Sieve*

The sieve analysis test aims to determine the grain size of fine aggregate in a set of sieves. The test results show that the fine grain modulus (FPM) obtained from the gradation analysis of fine aggregate material is 2.75. This value is within the required range, which is between 1.5 and 3.8. Therefore, it can be concluded that Samboja sand is included in the fine sand category in area IV, because the test results are between the upper and lower limits of the gradation area IV. Therefore, this sand can be classified as fine sand that meets the requirements for use as a material in paving construction block.

3.2. Fine Aggregate Test Result

The results of fine aggregate test conducted at the Civil Engineering Laboratory of Balikpapan University are shown in Table 3. Based on the results of the Samboja sand fine aggregate test data that has been carried out, it can be concluded that Samboja sand meets the specified standard requirements, except for the water content. However, the water content can be corrected during the mixing process by adjusting the amount of water added to the mix as needed.

Table 3Test Results Fine Aggregate

No	Type of Test	Results	Condition	Mark
1.	Sieve analysis	Grade IV	Gradation I, II, III, IV	Fulfill
2.	Specific gravity (gr/cm ^{3})	2,587	1.6 – 3.3	Fulfill
3.	Absorption (%)	0.73	0.2 – 2	Fulfill
4.	Water content (%)	2.44	3 – 5	Does not meet the requirements
5.	Compaction Standard (gr/cm ^{3})	1,682	1.4 – 1.9	Fulfill

3.3. *Polyethylene Terephthalate* (PET) Plastic Test Result

The PET plastic used comes from mineral water bottles waste that are collected, cleaned, and shredded into smaller sizes so that they melt faster. PET Plastic test was conducted only to obtain its weight. This is done by making paving block uses 100% plastic, and from this result, the weight of plastic used for one volume of mold can be obtained. From the test, the amount of plastic needed for one volume of diamond mold is 1747 grams.

3.4. Results of the Compressive Strength Test of Paving Block

After physical testing of paving materials block, the process continues with mixing and making test objects according to the variations and quantities required. The main aspects in material selection include material quality, availability, and production costs. These three factors directly affect the strength, durability, smoothness, and efficiency in construction projects. [9]. Test specimen samples were made using paving molds, block shaped wajik and then tested using a compressive strength tester in the laboratory [3]. The results of the compressive strength test for each paving variation block can be seen in Table 4.

Table 4. Compressive Strength Test Result

No	Proporsion PET Sand	Compressive Strength Average (MPa)	Standard 03-0961-1996 (min)	Quality
1	30 : 70	15.87	12.5	C
2	40 : 60	14.28	12.5	C
3	50 : 50	10.0	8.5	D

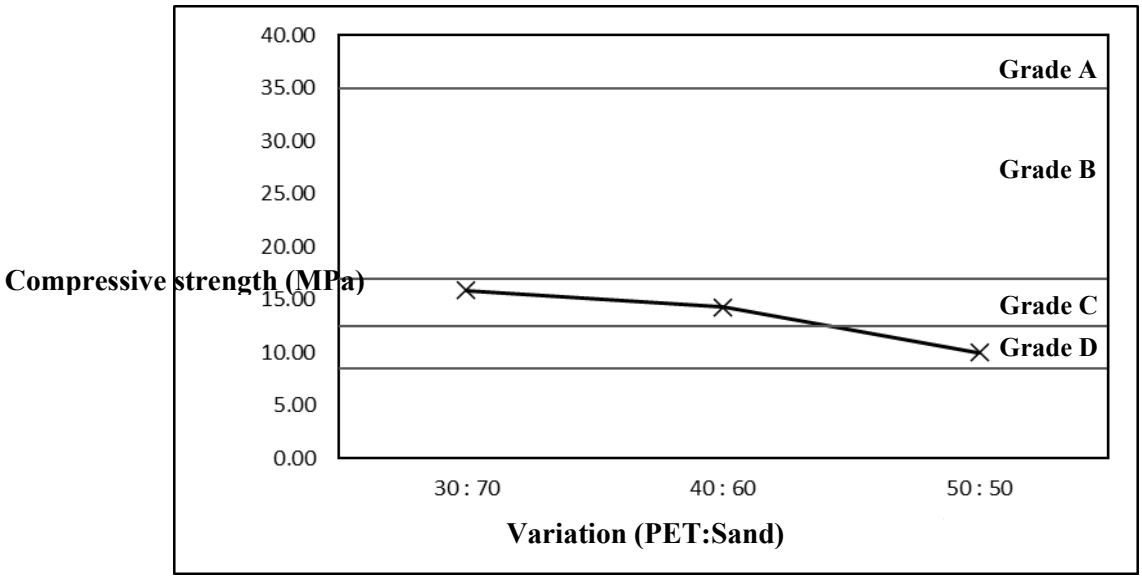

Figure 2Variation Relationship Graph PET Composition Against Compressive Strength

Figure 2 clearly shows that increasing the percentage of PET plastic aggregate significantly affects the compressive strength value of paving block. It can be seen that with the increasing percentage of PET plastic aggregate added to the mixture, the compressive strength value of the paving block tends to decrease progressively. For example, in a mixture composition of 30:70, an average compressive strength value of 15.87 MPa was obtained, which is the highest compressive strength value among all variations tested. This composition meets the C quality standard, The quality of paving blocks is not only determined by its compressive strength, but also by its water absorption and wear resistance, but in this study will focus on the presence of plastic waste, such as polyethylene terephthalate [10]. So that paving blocks produced from this mixture are considered suitable for use as pedestrian material. At a mixture composition of 40:60, the average compressive strength value was recorded at 14.28 MPa, which also meets the C quality standard and is still suitable for use by pedestrians. On the other hand, at a mixture composition of 50:50 , the average compressive strength value obtained was 10.0 MPa, which is the lowest value compared to other variations. As a result, this composition only meets the D quality standard, so that paving The resulting blocks are more suitable for use in gardens and other applications that do not require high compressive strength.

Compressive strength of *paving block* is influenced by the composition of the basic materials used. Strong enough press high occurs because the composition allows for a strong bond between the concrete components and PET. This good bond strength will certainly increase the compressive strength of the concrete itself [11]. Strong downward pressure shows that the more plastic is added, the compressive strength of *the paving blocks* of PET plastic waste will continue to decline. This is because lack of effective bonding between sand and PET, resulting in existence cavity air in sample. Cavity This air can reduce density and strength of the material, resulting in decline on the compressive strength. This finding is also in line as in[12] that the addition of 30% PET plastic to 50% PET plastic overall decrease along with the increase PET content, indicating that there is The optimal limit for adding PET to paving blocks to maintain strength structural. Reference [13] show The increase in the percentage of PET plastic waste aggregate has a significant impact on the compressive strength value of concrete, where the higher the percentage of PET plastic waste aggregate

addition, the lower the compressive strength value of the concrete. Reference [14] said that PET plastic can break become piece small when experience impact or high pressure. Combustion also becomes more difficult Because PET plastic hardens more fast, which causes the printing process become not enough effective and makes paving blocks more susceptible to cracking, thus reducing strong the resulting pressure. Reference [15] show waste plastic can be used to make pavement blocks. This modified pavement block can be used for pedestrian construction, public buildings, governmentbuildings, educational facilities and other low-traffic spots for parking. Thewaste that's left in the block is plastic. For fine aggregate, various quantities of waste plastic are utilized for varied workability, durability, and compressive strength and, most importantly, to minimize the amount of plastic waste.

4. CONCLUSION AND SUGGESTIONS

Based on the results of research and analysis of paving block using PET plastic material, it can be concluded that the composition of 30:70 produces an average compressive strength value of 15. 87 MPa, which is the highest value among the variations tested. Thus, this composition meets the C quality standard and is suitable for use as a pedestrian material. Meanwhile, the composition of 40:60 produces an average compressive strength of 14. 28 MPa, also meets the C quality standard and is suitable for pedestrian use. In contrast, the composition of 50:50 produces an average compressive strength of 10.0 MPa, which is the lowest value among the variations tested, so it only meets the D quality standard and is more suitable for use in parks and other applications that do not require high compressive strength.

Based on the conclusion obtained from the research that has been carried out, the highest compressive strength value that was successfully achieved using PET plastic was 15.87 MPa. Given these results, there is significant potential to improve the quality of paving. block through the use of PET plastic. Therefore, it is important to conduct further research on the use of PET plastic waste as a partial replacement for cement in the paving production process block. This further research will provide deeper insight into how PET plastic can affect the final quality of paving block, as well as exploring the potential environmental and economic benefits of using this material.

BIBLIOGRAPHY

[1] F. Achidah, A.M Indriani, & G. Utomo. “Pengaruh Penambahan Cacahan Plastik Pet (Polytethylene Terephthalate) Pada Beton Menggunakan Agregat Kasar Batu Petangis Terhadap Kuat Tekan”. *Media Bina Ilmiah*. Vol. 8, no. 6, pp. 1439-1442. Doi: 10.33758/mbi.v18i6.687

[2] Alfirahman, R., & Widodo, S. Efek Penambahan Serat Limbah Botol Polyethylene Terephthalate (Pet) Dan Fly Ash Terhadap Hasil Uji Ultrasonic Pulse Velocity Pada Self Compacting Concrete. *Teras Jurnal : Jurnal Teknik Sipil*, Vol. 13, no. 1, 2023. Doi: Https://Doi.Org/10.29103/Tj.V13i1.795

[3] D. Mayasari, T. Yuhanah, Y. Zuriatni. “Analisis Laju Infiltrasi Dan Kekuatan Porous Paving Block Substitusi Fly Ash Dan Cangkang Kerang Darah”. *Potensi.* Vol. 24, no. 2, pp. 78-85. 2022. Doi: https://doi.org/10.35313/potensi.v24i2.4120

[4] D.I Damayanti, A.M Indriani & G. Utomo. Influence Utilization Waste Plastic Polyethylene Terephthalate On The Flexural Strength Of Concrete With Use East Kalimantan Aggregate. *Journal of Civil Engineering and Covation Education*. Vol. 10, no. 3, pp. 766-776. 2023 Http://Cived.Ppj.Unp.Ac.Id/Index.Php/Cived766

[5] K. Fadli, A. M Indriani, & G. Utomo. “Analisis Kuat Lentur Beton Menggunakan Plastik Jenis Polyhyhlene Terepthele (PET) Sebagai Rigid Pavementt”, *Konferensi Nasional Teknik Sipil (KoNTekS).* Vol 1, no. 2. 2023. Doi: https://doi.org/10.62603/konteks.v1i2.27

[6] F. Patriotika, S.S. Pulungan, N. Siregar. “Uji Kesesuaian Kuat Tekan Paving Block Menggunakan Bahan Dasar Sampah Plastik PET dan LDPE Dengan Sni 03-0691-1996”. *Borneo Engineering.* Vol 6, no. 3, pp. 217–225. 2022. https://doi.org/10.35334/be.v1i1.2864

[7] S. Arafah, S. Bahri, A. Muarif, & N. Islami. “Kajian Paving Block Campuran Limbah Plastik Pet Terhadap Kuat Tekan Dengan Standard Sni 03-0691-1996”. *Malikussaleh Journal of Mechanical Science and Technology*. Vol.73, no. 2, pp. 115–119. 2023. Doi: 10.29103/mjmst.v7i2.13657

[8] R. Utami, A. Novia, S.N. Mahfuzah, A.A. Zahra. “Sensitifitas Aspal Modifikasi Terhadap Temperatur”. *Potensi*. Vol. 23, no. 1, pp. 26-32. 2021. Doi: https://doi.org/10.35313/potensi.v23i1.2298

[9] T. W. Widianto, A.M. Indriani, & G. Utomo. “Kuat Lentur Beton Menggunakan Agregat Batu Petangis Dan Pasir Semboja Dengan Penambahan Botol Plastik”. *Jurnal Manajemen Teknologi & Teknik Sipil*, Vol. 6, no. 2, pp. 112-122. 2023. Doi: https://doi.org/10.30737/jurmateks.v6i2.4989

[10] N. Chusilp. C. Laksanakit. Effect Of Recycled Plastic Content As Fillers On Mechanical And Durability Properties Of Concrete. *International Journal of GEOMATE.* vol. 22, no. 92, pp. 56–63, April. 2022.

Doi: https://doi.org/10.21660/2022.92.3154

[11] Y. Wahyudi, A.M Indriani, G. Utomo. “Analisis Kuat Tekan Beton Modifikasi Polyethylene Terephthalate (Pet)”, *Konferensi Nasional Teknik Sipil (KoNTekS).* Vol 1, no. 6. 2023. Doi: https://doi.org/10.62603/konteks.v1i6.133

[12] E. Kridi, & H. Mac-Eteli, M.B. Alagba.”Modelling Water Absorption Index And Compressive Strength Of Paving Stone Composites With Polyethylene Terephthalate (PET) As Total Binder Replacement”. *International Journal Of Advances In Scientific Research And Engineering*. vol. 10 no.4, pp. 01–12. 2024. Doi: 10.31695/IJASRE.2024.4.1

[13] Asrar, E. Bachtiar, S. Gusty, F. Rachim, Ritnawati, & A. Setiawan. “Pemanfaatan Daur Ulang Limbah Plastik Polyethylene Terephthalate (Pet) Sebagai Pengganti Agregat Kasar Pada Beton”. *Jurnal Kacapuri : Jurnal Keilmuan Teknik Sipil*, vol. 3 no.2, pp. 156–164, 2020. http://dx.doi.org/10.31602/jk.v3i2.4076

[14] R.I. Cahyani , D. Irfaniyah, A.A Fikri, F.H. Kusumah. “Paving Block Quality With Several Types Of Plastic Waste On Compressive Strength”. *Jurnal Ilmiah Multidisipline*. vol. 1 no.12, pp. 110–116, 2023. Doi : https://doi.org/10.5281/zenodo.10428700

[15] V. Piyush, Patil. “A Survey of the Plastic Waste used in Paving Blocks”. *International Journal of Innovative Scienceand Research Technology*. vol. 9 no.4, pp. 807–810, 2024. Doi : https://doi.org/10.38124/ijisrt/IJISRT24APR940