ASTONJADRO

pISSN 2302-4240
eISSN 2655-2086

Volume 15, Issue 1, March 2026, pp.0243-0249
DOI: http://dx.doi.org/10.32832/astonjadro.v15i1.21105 http://ejournal.uika-bogor.ac.id/index.php/ASTONJADRO

Thermoplastic Waste Composite Brick as an Environmentally Friendly Material

Hendramawat Aski Saafrizki[1], Iwan Ristanto[1], Senot Sangadji[2], Muhammad Febrialdi Karno[1], Amelia Putri Dewi[1]

[1]Civil Engineering Department, Universitas Veteran Bangun Nusantara, Sukoharjo, INDONESIA
[2]Civil Engineering Department, Universitas Sebelas Maret, Surakarta, INDONESIA

E-mail: hendra.mawat@gmail.com

| Submitted: July 21, 2025 | Revised: August 17, 2025 | Accepted: October 09,, 2025 |

| Published: March 04, 2026 |

ABSTRACT

The background of this research is that plastic waste is abundantly available around us and has not been optimally utilized. Pedestrian which is also the right of pedestrians with disabilities has not been well organized in Indonesia. The use of plastic waste materials is an alternative to solving environmental problems. The utilization of plastic as a substitute for cement will also reduce the carbon effect of cement as a building material. With its light weight when compared to disabled terrazzo tiles on the market, it is hoped that it can facilitate the application of smart pedestrian blocks as pedestrian paths and disabilities. The purpose of this research is the utilization of plastic waste as used as composite thermoplastic waste brick as well as an alternative eco-friendly material. The experimental method used normal paving, 45% plastic waste, 55% plastic waste, and 65% plastic waste. The test results show that the average compressive strength for paving with 45% plastic waste has a compressive strength of 9.16 MPa higher than normal paving which is only 8.56 MPa. This shows that the use of 45% plastic waste as an effective substitute for cement in paving is also an environmentally friendly solution. In addition to reducing plastic waste, it also reduces the need for cement.

Keywords: ecofriendly material, paving block, plastic waste.

INTRODUCTION

Pedestrian rights have been included in Government Regulation number 34 of 2026, in article 34 paragraph (4) which states the right of sidewalks for pedestrians. The existence of the GR [1] also implies the obligation to provide pedestrians. The current pedestrian path is currently a small part equipped with a disability path. [2] Syifa et al 2019, stated that concrete block paving is a cost-effective road construction method suitable for roads with medium to low traffic (pedestrians), The paving technique is still being developed in accordance with the utilization of environmentally friendly materials.

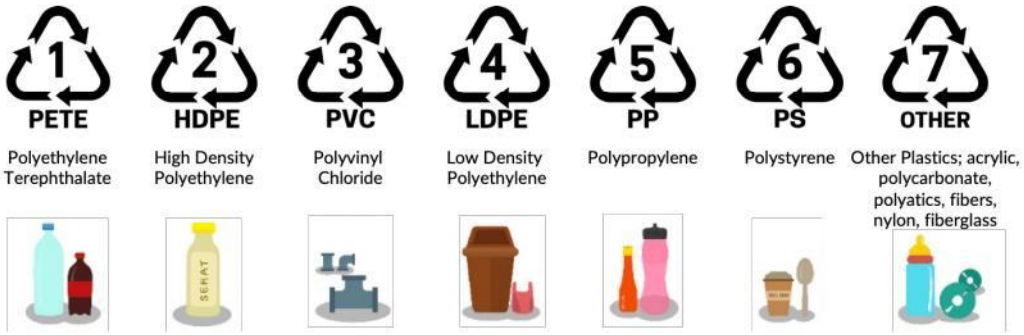

Figure 1. Grouping of plastic types [8]

Concrete paving is a pavement used to build pedestrian walkways, pedestrians, parking areas, and floors for sports activities [3-5]. Paving blocks are generally manufactured from cement, coarse

aggregate, fine aggregate or sand, and water in sizes of 100 mm x 100 mm x 200 mm [2,5]. Due to its high strength, long-term performance, economical use, ease of maintenance, and aesthetic appearance, a growing demand for its use for lightweight pavement purposes has emerged [3,5-7]. The types of plastics in circulation today consist of 7 groups as shown in Figure 1.

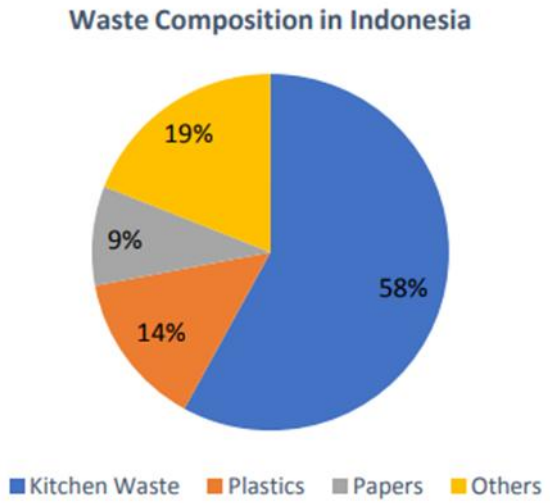

Figure 2. Plastic waste in Indonesia [9]

Based on Figure 2, sourced from BPS data, the amount of plastic consumption and the amount of plastic waste produced in Indonesia is quite high. Plastic waste production in Indonesia reaches 14% of the total daily stock or equivalent to 85,000 tons per year. 3.2 million tons of plastic waste is dumped into the sea. According to the World Economic Forum [10], 16% of plastic waste is recycled, but only 2% of plastic waste can be effectively recycled.

In addition, 14% of plastic waste is incinerated, 4% is landfilled in landfills (EDS)/ temporary disposal sites (TDS), and 32% pollutes the environment and disrupts the ecosystem. Different types of waste present different toxicities. Based on various studies as depicted in Figure 3, the most toxic type of plastic waste is PVC, followed by PET plastic.

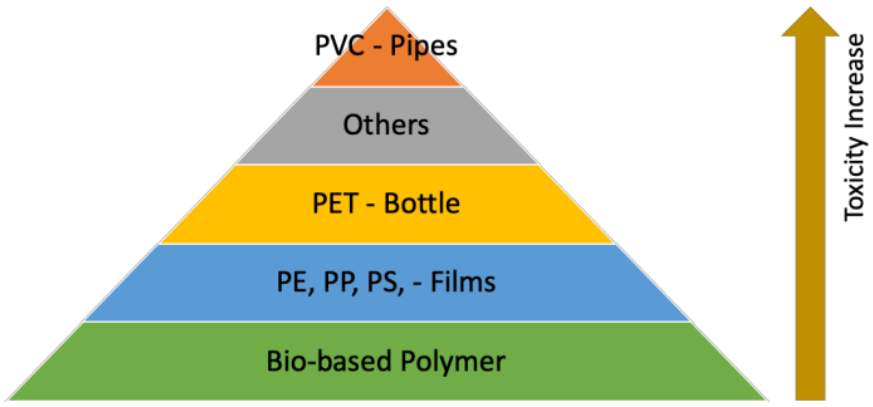

Figure 3. Toxicity levels of plastics [8]

Other researchers have utilized HDPE plastic waste as a mixture of Asphalt AC-WC [12] and concluded that HDPE plastic waste can be used as a material to reduce the use of asphalt. It was concluded that HDPE plastic bag waste can be used as an alternative to bitumen substitutes that meet the requirements of Bina Marga 2018 Revised Edition 2 and can be an alternative in waste management [12].

pISSN 2302-4240
eISSN 2655-2086
Volume 15, Issue 1, March 2026, pp.0243-0249
DOI: http://dx.doi.org/10.32832/astonjadro.v15i1.21105 http://ejournal.uika-bogor.ac.id/index.php/ASTONJADRO

Some of the utilization of plastic as other building materials include facade components [13] which of course can also be an alternative to reducing plastic waste or as a component of structural material [14]. Utilization of plastic waste in concrete mixtures can increase the compressive strength of concrete as a building material [14].

Figure 4. Plastic Paving from plastic bottle cap waste (HDPE)

The background of this research is that plastic waste is abundantly available around us and has not been optimally utilized. Pedestrian which is also the right of pedestrians with disabilities has not been well organized in Indonesia. The use of plastic waste materials is an alternative to solving environmental problems. The utilization of plastic as a substitute for cement will also reduce the carbon effect of cement as a building material. With its light weight when compared to disabled terrazzo tiles on the market, it is hoped that it can facilitate the application of smart pedestrian blocks as pedestrian paths and disabilities.

The purpose of this research is the utilization of plastic waste as used as composite thermoplastic waste brick as well as an alternative eco-friendly material.

Concrete production in construction follows a systematic process to ensure strength, durability, and workability. The first stage is material selection. Concrete is composed of cement, fine aggregate (sand), coarse aggregate (gravel or crushed stone), and water. The quality of each material is crucial because it directly affects the performance of the final product [15]. Clean water and well-graded aggregates free from organic impurities are essential for optimal bonding and strength development [16], [17]. The second stage is mix design. Engineers determine the correct proportion of cement, aggregates, and water based on the required compressive strength, durability, and exposure conditions. The water-cement ratio is particularly important; too much water reduces strength, while too little makes the mix difficult to place. Standard mix designs may follow national codes or project specifications [18].

RESEARCH METHODS

The methodology in this research is by mixing at hot temperatures a mixture of chopped plastic with sand as a smart pavement material and then molding/molding the pavement. The molding process is also carried out with a press / pressing process so that the resulting product has a uniform shape and strength at each manufacturing period. Then the product is removed from the mold for the testing stage. The research was conducted at the Civil Engineering Laboratory of Universitas Veteran Bangun Nusantara Sukoharjo.

The tools used during this research are very diverse and are designed to support each stage of the paving block making process. The tools used during this research include a 9.5 mm to 0.074 mm sieve, cup, spoon, rectangular mold with dimensions of 20 cm × 10 cm × 6 cm, scissors, scales, 1000 ml measuring cup, measuring flask, thermometer or thermal gun, pan, stove, oven, and digital compression machine.

The problem-solving approach taken is to utilize plastic waste available in the community so that it becomes a smart and environmentally friendly product that has economic value that is beneficial to the community later.

RESULT AND DISCUSSION

The selection and inspection of used plastic must be clean from dirt and then chopped manually using scissors. As for sand, the cleaning process involves several important steps. First, the sand is washed to remove impurities. Next, screening is done to separate unwanted particles. After that, the sand will go through a sieving process so that only clean sand remains. Finally, the sand needs to be dried until it reaches the right moisture content. This drying process can be done naturally with sunlight, making it more efficient and environmentally friendly.

Mix design

Mix design is done to produce the right proportion in making paving blocks. The composition of materials in the manufacture of normal paving blocks is 1 cement: 4 sand. While the innovation paving block uses plastic shreds of 45%, 55%, and 65% with each variation made 5 samples.The first step in mix design is to determine the weight of each material used. This calculation is very important because the volume of the mold will affect the amount of material needed. The calculation of the specific gravity of paving blocks is an important parameter as it can vary depending on the material composition used. Once the weight of the test specimen is obtained, the next step is to divide the total weight between the three main components, namely sand, cement and PET plastic.

Plastic melting

The process of melting plastic is done by burning pieces of plastic that have been mixed with sand on a pan that has been prepared. The pan containing the plastic and sand is then placed on a furnace that has been lit, with firewood as fuel. The melting process lasts for approximately 30-40 minutes at a temperature between 180℃ and 240℃, or until the plastic turns into liquid form completely.

During the plasticizing process, careful stirring is done to ensure that the mixture is well mixed and that there are no lumps of sand. Stirring continues until the temperature of the melted plastic decreases slightly by reducing the burning wood, resulting in a homogeneous mixture ready for use.

Figure 5. Mixing procedure

The well-mixed plastic and sand dough is then poured into the manual mold one by one. This manual mold is made of metal and then filled with dough manually by pouring and pressed by pressing it. After the mold is fully filled, the manual mold containing the dough is left for a few minutes so that the dough can solidify. Then, the mold is turned over and the paving block is carefully removed. Next, the paving blocks that have been molded manually are soaked in water for about 15 minutes. The aim is to reduce the temperature of the paving block due to the molding process. After soaking, the paving blocks are removed from the water and placed to dry and harden naturally. This drying process is very important, as it allows the water in the paving block to gradually evaporate, thus increasing the strength and durability of the material. This drying process can take several days, depending on the environmental conditions, such as temperature, humidity, and air circulation around the paving blocks.

pISSN 2302-4240
eISSN 2655-2086
Volume 15, Issue 1, March 2026, pp.0243-0249
DOI: http://dx.doi.org/10.32832/astonjadro.v15i1.21105 http://ejournal.uika-bogor.ac.id/index.php/ASTONJADRO

Figure 6. Drying process

Compressive strength testing

Compressive strength testing on paving blocks is carried out to determine the compressive strength value of the material. The results of this test are important to ensure that the paving block meets the specified strength standards. The compressive strength test of paving blocks in Indonesia refers to SNI 03-0691-1996 concerning Concrete Bricks (Paving Blocks).

The compressive strength of a paving block is the unit area load, which causes the paving block test specimen to be destroyed when loaded with a certain compressive force produced by a press machine. One of the quality characteristics that paving blocks must have is compressive strength. The quality of paving blocks is getting better if it has a high compressive strength.

This test is conducted to determine the compressive strength of the paving block test specimen. Testing the compressive strength of paving blocks using a Compression Test Machine tool. Compressive strength testing is stopped after the dial on the compression test tool reading stops.

Table 1. Compressive strength results

Plastic content (%)	Code	length	width	l x w	compressive force	Compressive strength	
		mm	mm	mm2	N	MPa	Average
0	N1	196,6	96,5	18971,9	158000	8,33	8,56
	N2	196,2	96,7	18972,54	178000	9,38	
	N3	196,2	96,6	18952,92	200000	10,55	
	N4	196,2	96,5	18933,3	108000	5,70	
	N5	196,2	91	17854,2	158000	8,85	
45	p1	195,5	91	17790,5	189000	10,62	9,16
	p2	196,5	99	19453,5	176000	9,05	
	p3	193	90	17370	166000	9,56	
	p4	198	90	17820	152000	8,53	
	p5	191	91	17381	140000	8,05	
55	p1	192,2	94,8	18220,56	145000	7,96	7,68
	p2	192,2	95,1	18278,22	151000	8,26	
	p3	192,8	94,8	18277,44	139000	7,61	
	p4	192,2	95	18259	134000	7,34	
	p5	192,8	95,1	18335,28	133000	7,25	
65	p1	192,2	94,8	18220,56	128000	7,03	8,58
	p2	193	94,7	18277,1	134000	7,33	
	p3	193,6	94,9	18372,64	126000	6,86	
	p4	193	94,7	18277,1	126000	6,89	

p5	192,7	94,5	18210,15	269000	14,77

Based on the table of compressive strength test results, a comparison chart between normal and innovative paving is made. From this graph, it can then be analyzed the quality of paving from innovations with plastic waste. The results show that almost all paving innovations are better than normal paving. Only paving with 55% plastic waste has a lower compressive strength value than normal paving.

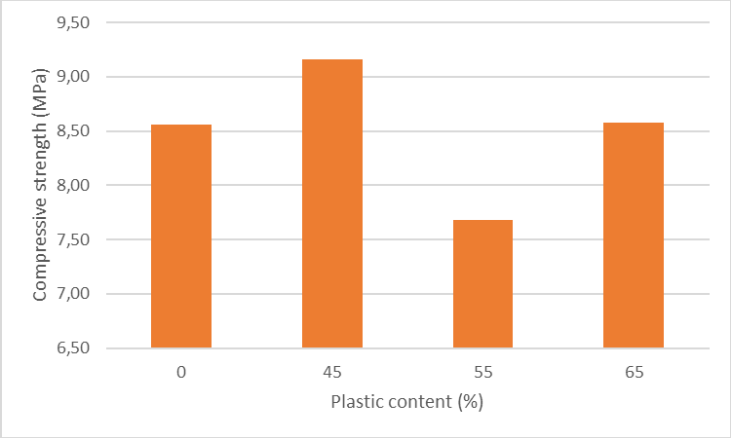

Figure 7. Compressive strength test results

CONCLUSION

Based on the results of compressive strength testing on normal and innovative paving blocks, it is concluded that the average compressive strength for nomal paving blocks is 8.558 MPa while the highest innovation paving is at 45% plastic waste with a compressive strength of 9.16 MPa. This shows that the use of plastic waste at 45% is effective on compressive strength. The use of plastic as a substitute for cement in paving is also an environmentally friendly solution. In addition to reducing plastic waste, it also reduces the need for cement.

ACKNOWLEDGEMENT

The author would like to thank the Institute for Research and Community Service (LPPM) of Universitas Veteran Bangun Nusantara for assisting the implementation of this research through the University Competitive Research scheme according to Decree No. 4/061016/PKU/LPPM/Univet.Btr/2025. The author is also grateful to those who have helped in the implementation of this research.

REFERENCES

[1] Peraturan Pemerintah (PP) tentang Jalan nomor 34 tahun 2006. n.d.

[2] Syifa DJ, Gumilang PD, Lestari AD, Gunawan LI, Safarizki HA. PapPavement : Paving Pavement Dengan Bahan Tambah Limbah Kertas. J Ilm Teknosains 2020;5:113–6. https://doi.org/10.26877/jitek.v5i2.3893

[3] Gamage S, Palitha S, Meddage DPP, Mendis S, Azamathulla HM, Rathnayake U. Influence of Crumb Rubber and Coconut Coir on Strength and Durability Characteristics of Interlocking Paving Pavements. Buildings 2022;12:1001. https://doi.org/10.3390/buildings12071001.

pISSN 2302-4240
eISSN 2655-2086
Volume 15, Issue 1, March 2026, pp.0243-0249
DOI: http://dx.doi.org/10.32832/astonjadro.v15i1.21105 http://ejournal.uika-bogor.ac.id/index.php/ASTONJADRO

[4] Sambucci M, Valente M. Ground Waste Tire Rubber as a Total Replacement of Natural Aggregates in Concrete Mixes: Application for Lightweight Paving Pavements. Materials (Basel) 2021;14:7493. https://doi.org/10.3390/ma14247493.

[5] Yeo JS, Koting S, Onn CC, Mo KH. An overview on the properties of eco-friendly concrete paving Pavements incorporating selected waste materials as aggregate. Environ Sci Pollut Res 2021;28:29009–36. https://doi.org/10.1007/s11356-021-13836-3.

[6] Chan D, Poon CS. Using recycled construction waste as aggregates for paving Pavements. Proc Inst Civ Eng - Waste Resour Manag 2006;159:83–91. https://doi.org/10.1680/warm.2006.159.2.83.

[7] El Nouhy HA, Zeedan S. Performance evaluation of interlocking paving units in aggressive environments. HBRC J 2012;8:81–90. https://doi.org/10.1016/j.hbrcj.2012.09.003.

[8] Agustina Hidayat Y, Kiranamahsa S, Arya Zamal M. A study of plastik waste management effectiveness in Indonesia industries. AIMS Energy 2019;7:350–70. https://doi.org/10.3934/energy.2019.3.350.

[9] BPS. Statistics Indonesia (2017) Number of large medium-sized industrial companies according to sub-sector (2 digits KBLI) 2017. https://www.bps.go.id/dynamictable/2015/09/14/896/jumlah-perusahaan-industri-besar-sedang-menurut-subsektor-2-digit-kbli-2000-2015.html (accessed March 31, 2023).

[10] World Economic Forum (2018) The World's plastik problem in number 2018. https://www.weforum.org/agenda/2018/08/the-world-of-plastiks-in-numbers (accessed March 31, 2023).

[11] Mudjanarko SW, Arshad MF Bin, Harmanto D, Nurmianto E, Artaya IP, Rasidi N, et al. Eksperimen Ecofriendly Paving Plastik HDPE. E-Journal Spirit Pro Patria 2023;9.

[12] Pinem HKWB, Pristyawati T, Safarizki HA. Analysis of the influence of additional plastik waste (HDPE) as Mixed Asphalt AC-WC on Marshall Parameters. Astonjadro 2022;11:669. https://doi.org/10.32832/astonjadro.v11i3.7507

[13] Oktavia V, Kususma NR. Plastik material as building façade. IOP Conf Ser Earth Environ Sci 2020;452:012116. https://doi.org/10.1088/1755-1315/452/1/012116.

[14] Daftardar A, Patel R, Shah R, Gandhi P, Garg H. Use of Waste Plastik as a Construction Material. Int J Eng Appl Sci 2017;4:148–51.

[15] Setia Romadhon, E., Antonius, A., & Sumirin, S. (2022). Design of Low Alkali Activator Geopolymer Concrete Mixtures. ASTONJADRO, 11(3), 627–638. https://doi.org/10.32832/astonjadro.v11i3.7484

[16] Iqbal, M., Bachtiar, E., Gusty, S., Indrayani, P., Marzuki, I., & Chaerul, M. (2025). Analysis of the Utilization of Hair Fibers as an Eco-Friendly Concrete Construction Material. ASTONJADRO, 14(3), 737–744. https://doi.org/10.32832/astonjadro.v14i3.17921

[17] Husin, A. E., & Rohman, M. N. (2025). Value for Money-at-Risk Analysis Model for Green Batching Plant Benefit based National Ready Mix Co Association (NRMCA) Method. ASTONJADRO, 14(2), 376–392. https://doi.org/10.32832/astonjadro.v14i2.17051

[18] Paikun, P., Anugrah Amdani, S., Arie Susanto, D., & Saepurrahman, D. (2023). Analysis of the Compressive Strength of Concrete from Brick Wall Waste as a Concrete Mixture. ASTONJADRO, 12(1), 150–162. https://doi.org/10.32832/astonjadro.v12i1.8145